"Engineering Education Reform for the Japanese Consulting Engineer"

Dissertation

Patricia D. Galloway, P.E., PMP, MIRCS

Doctoral Candidate-Infrastructure Systems Engineering

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I. HYPOTHESIS

1 INTRODUCTION

The Japanese Consulting Engineer faces an immediate challenge to raise the image of its own profession in Japan in order to shape the future of Japan and to be competitive in the global market. One of the fundamental concepts which must be understood by the Japanese Consulting Engineer if he or she is going to succeed in today's global society is globalization. Globalization includes the knowledge and ability to:

- Understand that the world economy has been tightly linked with much of the change triggered by technology;
- Understand other cultures and social elements;
- Effectively work in multi-national teams;
- Effectively communicate-both orally and in writing-in the international business language of English;
- Recognize issues of sustainability;
- Recognize the importance of transparency with the local population;
- Understand the importance of public policy issues around the world and in the country where one is working; and
- Understand the principles of project management and risk management.

The "global" international consulting engineer is well respected and well versed in project management, dispute resolution, communication skills and leadership skills. Japanese industries such as car manufacturing, electronics and Information Technology (IT), made significant strides in understanding how to compete globally and have established themselves as formable competitiveness industries all around the world. However, the Japanese construction industry did not recognize the changes needed to move into the 21st Century and thus, Japanese Consulting Engineers are no longer equipped with the necessary skill sets to compete in the global marketplace. The current Japanese Consulting Engineer simply does not possess many of the needed skills in order to compete internationally or to move the domestic construction market ahead in Japan. As a result, the image of the consulting engineer in Japan has declined over the years to the extent that few Japanese Consulting Engineers hold prominent government positions, leadership positions, or even have the ability to stamp drawings in the name of the engineer versus the prefecture.

2 PERCEIVED PROBLEM

The reason for the perception that there is a current problem in Japan is due to:

- The low image of the Japanese Consulting Engineering domestically;
- Issues of transparency;
- Lack of independence from the government;
- Selection of consulting engineering services based on price and not qualifications;
- The Japanese Consulting Firms losing their competitive edge in the global marketplace that has been in previous years;
- Projects not being awarded to Japanese Consulting Engineers; and/or
- Japanese Consulting Engineers finding themselves in issues of disputes without the abilities and/or project record to defend positions and as such suffer significant financial losses.

The basis for this perception is based upon the author's:

- Personal work for the Japan Ministry of Land Infrastructure and Transport (MLIT) regarding retention of consulting engineers and a study conducted for the MLIT regarding public contracting reform;
- Survey conducted of Japanese Consulting Engineers;
- Personal work experience for Japanese companies both domestically and internationally; and
- Extensive personal experience on international construction projects-management consulting, risk management and disputes-throughout the world, including Asia.

3 PURPOSE OF THE STUDY

The purpose of the study was to:

- Identify the problems facing the Japanese Consulting Engineer;
- Determine what skill sets are required for the Japanese Consulting Engineer to be competitive in the global marketplace;
- Determine what skill sets the Japanese Consulting Engineer currently lacks;

- Determine if Japanese engineering education has focused on the future and the changes that are forthcoming in the 21st Century;
- Analyze and evaluate other forms of engineering education and engineering training from the U.S., Europe and other parts of Asia; and
- To solve the problem, propose a graduate level program that would allow the Japanese Consulting Engineer to gain the necessary skills to gain image, independence and remuneration domestically and to be able to compete in the global marketplace.

4 HYPOTHESIS

Japanese engineering education has not focused on the future and the changes that are forthcoming in the 21st Century. Japanese Consulting Engineers continue to be strong on technology but are weak at management capabilities and communication. Japanese Consulting Engineers continue to be considered a “commodity” and technicians, not professionals. Japan must design its future considerations on economical and cultural interdependency on a global scale. Globalization forces Japanese companies to shift to a more globally competitive management system. If Japan is going to remain competitive on the world market, it must reform its engineering education.

Research has demonstrated that the reason for decline of the image of the Japanese Consulting Engineers stems from the lack of project management courses within the engineering curriculum of the Japanese universities. The word “engineering” when translated into Japanese characters means “technology” and “science”.1 In the western world, “engineering” means a profession, but in Japan it has only been regarded as a science for technology or engineering science. Japan has long been unaware of the definition gap.2

Japan underwent major reforms during the Meiji restoration in 1868 including the establishment of higher education. Engineering education on the university level was started in 1873 when the Engineering College was founded and produced engineering leaders who led Japan through economic reform. However, with the laws of accounts that were enacted in 1890, engineers performing consulting work on public contracts were retained based on price and not on qualifications. This action, still not changed as of today, resulted in consulting engineers being treated as “support staff” and not as professionals such as the medical and accounting professions.

After World War II Japan again emerged as a world leader, taking pride in its technological advancements. In the 1980's, Japan was one of the world leaders in competitiveness and boasted about its Japanese management style with life-long employment and in-house training. However, today, the economic situation in Japan has now reversed. Engineering education has taken a similar fate. During Japan's development stages, Japan was at the forefront of technology advances and its engineering technical competence was highly regarded world-wide. However, Japanese engineering education did not focus on the future and the changes that would be forthcoming in the 21st Century.

While Japanese Consulting Engineers are strong on technology, they are weak at management capabilities and communication skills. Japanese engineers continue to be regarded as a "commodity" and, as is being experienced in other parts of the world, as technicians, not professionals. With the internet, the borders of countries have become obliterated and today's world and new business environment is challenging the way civil engineering is practiced.

In 1995, the World Trade Organization (WTO) was formed and took initiatives to remove the barriers that not only restricted free trade of commodities, but also services. In 1996, the Human Resources Development of the Asia Pacific Economic Cooperation (APEC) began work for the establishment of a common regional engineering qualification called the APEC Engineer. The first registration was in 2001 with the accreditation programs announced in 2002.[3] Japan must design its future considerations on the economical and cultural interdependency on a global scale. The globalization forces Japanese companies to shift to a more globally competitive management system.

Japan's engineering education at the graduate level must convert from teaching engineering science to building on fundamental capacities of:

1. Engineering Basics
2. An Understanding of Globalization
3. Ethics and Professionalism
4. An Understanding of Diversity and Multidisciplinary Teams
5. Oral and Written Communication Skills
6. Understanding of Leadership Principles

7. Understanding of Public Policy
8. Project Management Skills
9. Risk Management Skills
10. Dispute Resolution Skills

It will be these fundamental capacities that will allow the Japanese consulting engineers to develop into independent professional engineers capable of working both domestically and globally, respected by the public and regarded by the government as professionals whose services are to be based on qualifications and not price.

While actions are underway in Japan, modeled after the U.S. and UK systems for certification of engineers and progress is being made in accreditation of universities for consistent engineering programs in Japan; there currently does not exist within Japan a proper education system for the Japanese Consulting Engineer. There is not an engineering education program for teaching these above mentioned principles at either the undergraduate or graduate level. However, there are programs underway in countries such as the United States whose programs can be modified for use in Japan. By developing a proposed education program through modifications of successful programs to meet the needs of the Japanese Consulting Engineer, it will enable the Japanese Consulting Engineer to gain the necessary skills to enable it to function in the world economy and to continue to grow within the domestic construction market in a more transparent manner.

5 PROOF DEVELOPMENT

The research was performed to perform the following tasks:

- Determine how the research can be used in the development of a program that will fully address the skill sets needed for the global engineer.
- Address how each of the ten skill sets meets the requirements for the APEC engineering certification as well as the present Japanese professional certification per the “Professional Engineers Act” in effect since April 2001.
- Comparing graduate programs in other countries, ASCE’s Body of Knowledge, the NAE “Engineer of 2020”, PMI PMBOK, and personal experience, determine which meets the requirements for gaining the skills required to perform in a world economy and to improve transparency and respect with the Japanese public.

- Test whether a revised graduate engineering program to address the "global consulting engineer" will result in the ability to develop consulting engineers to meet Japan's opening of its construction market as required by WTO, allow the government to revise its legislation to quality-based selection and the transparency movement and compete in the global marketplace
- The hypothesis is that reforming the Japanese education system for the Japanese Consulting Engineers by developing a proposed program will achieve these goals.
- The hypothesis will be tested by identifying what are the current problems with the Japanese engineering education program at a graduate level and how these problems can be overcome with the proposed program.

Since the spin-off of public universities from under the wing of Education, Culture, Sports, Science and Technology Ministry on April 1, 2004, management opportunities now exist for universities to make the most significant change to Japan's higher education system in more than a century.

6 EXPECTED RESULT

The conclusion of this research has been the development of a proposed graduate level program for the "Japanese Global Consulting Engineer" based on international standards. The program will be broad enough to address the APEC Engineer certification in such a way that other Asian countries could adopt the program as they look towards reforming their own engineering education programs. The skill sets that are determined to be required for the "global" engineer have been researched and described as to their importance to engineering education and inclusion in a graduate level program. The program will then include the ten basic skill sets that have been discussed above and are described herein as to an introduction of what they are, why they are important for the Japanese Consulting Engineer to obtain and how the educational curriculum must be reformed in order to accommodate these new skill sets. The program is envisioned to include 30 credits obtained through a combination of:

- On-Campus study (through special lecture series and/or laboratories);
- Distance-Learning via the means of the internet; and
- In-house consulting courses either designed by the consulting firm and both tailored to meet their own firm's requirements as well as certified by a Japanese Institution or by

university professors teaching courses at the location of the consulting engineer's office and/or via web-based seminars.

The concept of engineering education reform is a topical subject around the world. As noted in the "The Engineer of 2020-Visions of Engineering in the New Century", written by the National Academy of Engineering in the United States,

> *In the past, changes in the engineering profession and engineering education have followed changes in technology and society. Disciplines were added and curricula were created to meet the critical challenges in society and to provide the workforce required to integrate new developments in our economy. Today's landscape is little difference; society continually changes and engineering must adapt to remain relevant. …While certain basics of engineering will not change, the global economy and the way engineers will work will reflect an ongoing evolution that began to gain momentum a decade ago. The economy in which we will work be strongly influenced by the global marketplace for engineering services, a growing need for interdisciplinary and system based approaches, demands for customerization, and an increasingly diverse talent pool. The steady integration of technology in our infrastructure and lives calls for more involvement by engineers in the setting of public policy and in participation in the civic arena. The external forces in society, the economy, and the professional environment pose imperatives for change that may exceed those to come from the changes expected in the technology engineers will have at their disposal in 2020. …if the engineering profession is to take the initiative for its future, it must 1) agree n an exciting vision for its future; 2) transform engineering education to help achieve the vision; 3) build a clear image of the new roles for engineers. Including broad based technology leaders, in the mind of the public and prospective students who can replenish and improve the talent base of an aging engineering workforce; 4) accommodate innovative developments from nonengineering fields; and 5) find ways to focus energies of the different disciplines of engineering toward a common goal.*

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[1] Ohashi, Hideo, "Engineering Education as the Entrance to Lifelong Engineering Center", 4th Roundtable Meeting of Engineering Academics, September 19-22, 2000, Awaji Island, Japan
[2] Ibid
[3] Ohashi, Hideo, "Establishing Engineering Profession in Japan", 3rd ASEE International Colloquium on Engineering Education, September 7-10, Beijing, China

II. THE CONSULTING ENGINEER

1 DEFINITION OF CONSULTING ENGINEER

In defining a consulting engineer, one must first define engineering. Engineering, as defined by the Royal Academy of Engineers in the UK, is:[4]

> *…the knowledge required, and the process applied, to conceive, design, make, build operate, sustain, recycle or retire, something with significant technical content for a specified purpose: a concept, a model, a product, a device, a process, a system, a service, a technology.*

The UK report goes on further to note that engineering has two components: *engineering knowledge*, the 'know what', and *engineering process*, the "know how". Since the engineering process is about decisions and optimized solutions, the 'know how' requires skills that are not traditionally taught in engineering education. The 'know how' requires:[5]

- Knowledge of the relevant constraints, such as economic, social, hazard, environmental, and legal areas.
- Awareness of the interaction with humans, their behavior, and the human body.
- The ability:
  - ➔ To reach into the domains of science, finance, and markets, to seek and apply relevant knowledge and information
  - ➔ To manage projects small and large, be it research, design, start-up, or construction
  - ➔ To form and lead effectively, multi-disciplinary teams
  - ➔ To operate in a non-structured environment
  - ➔ To manage uncertainty
  - ➔ To assess and manage risk
  - ➔ To bring to the endeavor an aesthetic sense of shape, form, beauty, as well as functionality.

It is the 'know how' that is not clearly recognized in either the academic institutions or within the engineering profession. As a result, the public image of engineering, both in the UK, the US and Japan is not as high as other professions such as the medical and legal professions. Further, the visibility of the profession is low and confused and it is often difficult for non-engineers to gain information about the profession.

One of the primary reasons for the low image of the engineering profession in many developed countries around the world is that during the 20th century, engineering moved from a relatively small number of defined disciplines to a splintering of the engineering profession as a whole and a greater number of diverse activities, including telecommunication and information technology. Engineering itself has had to embrace a number of other professions that have not previously been associated with engineering as our world becomes more multi-disciplinary and multi-cultural. In fact, it is that technology, created through the process of engineering that is now recognized by both governments and corporations around the world as being the driving force for profitable growth and sustained societies. However, the role and benefits of engineering to society and in the economy are not evident to the public at large, who tend to confine engineering to merely manufacturing and building works, and see it as a boring, uncreative profession associated with the 'old economy.' The word engineering has become lost somewhere between science and technology.[6]

Thus, there is an immediate need for engineers to be trained in order to obtain these skill sets necessary to communicate with the public and to lead projects. Consulting engineers are ideally suited for this challenge. Consulting engineers have been around since the 18th century in Europe with the Industrial Revolution. Thus, by the early 1800s, consulting engineers were considered a well established profession in Europe. The consulting engineering profession in the United States did not come until much later, when it too went through its own industrial revolution. In Japan, consulting engineers arose even later, after World War II when the Japanese infrastructure was devastated. However, before discussing consulting engineers and what attributes a consulting engineer requires working in today's global marketplace, it is first necessary to define what a consulting engineer does.

Review of consulting engineering definitions from around the world demonstrates that there is a common understanding and expectation of what a consulting engineer should do in his or her career. For instance, the Kentucky Engineering Center defines a consulting engineer as:[7]

- *Consulting Engineers are individuals who, because of training in one or more engineering specialties, are licensed professional engineers in private practice.*

- *They serve private and public clients in ways ranging from brief consultations to complete design and coordination of a project. They are often the technical liaison between architects, process specialists, contractors, suppliers and the client.*
- *A Consulting Engineer's specialty may be anywhere in the broad spectrum of engineering technology, including the fields of civil, electrical, structural, mechanical, chemical, metallurgical, geotechnical and highway engineering. A firm may also concentrate in specific fields such as soil mechanics, sanitation, hydrology or petroleum.*
- *A Consulting Engineer can provide general consultation, feasibility reports, design, cost estimates, rate studies, project development, patent assistance, and preparation of environmental impact statements.*

The Association of Consulting Engineers of Hong Kong indicates that a consulting engineer provides services in five broad categories:[8]

- Pre-Investment Studies
- Design and Supervision Services for Construction
  - ➜ Pre-design engineering
  - ➜ Basic Design engineering including preliminary, detailed and advise for tendering and award of contracts
  - ➜ Special services including resident supervision of construction
- Specialized Design and Development Services
- Project Management
- Advisory Services

In Japan (under Section 19, Article 3 of the Law concerning Advance Payment Guarantee Undertakings for Public Works, Law No. 184 of 1952), a civil engineering consultant is defined as "*An entity awarded or commissioned to engage in surveys, studies, planning, designs, and advice with respect to the construction of civil works*." The Japan Civil Engineering Consultants Association (JCCA), in turn, defines a civil engineering consultant as "*An individual or a firm who renders civil engineering consulting services by making use of their expertise for the benefit of a client upon request of the client, and with receipt of appropriate remuneration or the services"*. Further, JCCA indicates that Japanese civil engineering consultants *'carry out the conceptual planning, preliminary studies, analysis and evaluation planning, design and construction supervision, etc. that maintains and develops the basic infrastructure and resources that are the social assets of the country, and they ensure projects are carried out smoothly and efficiently.*[9]

JCCA notes that the distinctive features of JCCA member consulting firms, compared with those of the U.S. and UK are that their work seldom includes architectural design services and that the proportion of private sector work is relatively small with even fewer members engaged in international consulting. In May 1989, the Japan Economic Affairs Bureau of the Ministry of Construction issued a "Mid to Long-Term Vision for Civil Engineering Consultants (ATI Scheme). This vision delineates the role and tasks to be fulfilled by civil engineering consultants from the client's perspective, as engineers move into the 21st Century. It sets out the framework for consulting engineers to become an attractive, technologically competitive, and independent, intelligence based industry (the ATI concept). In order to better promote this scheme a "Mid Term Action Plan of Civil Engineering Consultants (ATI-21) was issued in October 1996. The Plan includes: "Aiming to be an agent of clients", aiming for civil engineering consultants who contribute towards a new era of construction based on trust and responsibility, securing and improving technical capacity, quality control systems and maintenance, and responding to internationalization, as part of 13 basic policies it promulgates.[10]

The National Academy of Engineering (NAE) in the United States has adopted what it believes is the definition of the Engineer 2020, which will encompass all engineers, including consulting engineers:[11]

> *Engineering is problem recognition, formulation, and solution. In the next 20 years, engineers and engineering students will be required to use new tools and apply ever-increasing knowledge in expanding engineering disciplines, all while considering societal repercussions and constraints within a complex landscape of old and new ideas. They will be working with diverse teams of engineers and nonengineers to formulate solutions to yet unknown problems...The engineers of 2020 will be actively involved in political and community arenas. They will understand workforce constraints, and they will recognize education and training requirements necessary for dealing with customers and the broader public. Engineering will need to expand its reach and thought patterns and political influence if it is to fulfill its potential to help create a better world for our children and grandchildren.*

The practice of engineering continues to grow increasingly more complex. Due to the rapid rise in information technology, the explosion of knowledge in engineering and construction, enhanced public awareness and involvement in engineered projects and the growing complexity of civil infrastructure systems around the world, the job performed by the consulting engineer continues to become more demanding. This trend is likely to accelerate, not slow down, in the future. Consulting engineers are expected to possess both greater breadths of capability and greater specialized technical and managerial competence than was required of previous generations.[12] These requirements will thus require a new skill set in order to get the job done, yet still remain a profession that is respected by the public.

1.1 Skills Required for the Consulting Engineer of the 21st Century

The world has changed more in the past 100 years than all those proceeding. By the end of the 20th Century, the developed world had become a healthier, safer, and more productive place where engineering through technology, had made a permanent imprint on the lives of everyone.[13] However, today's world is fundamentally challenging the way engineering is practiced.[14] Countries around the world are recognizing that merely having an engineering degree is not enough to allow the engineer to take a leadership position in society and to gain the public confidence of what the engineer can do in improving the quality of life for an ever increasing world population. Engineers have become to be treated as "commodities" or "technicians" and are not necessarily considered to be "professionals" in the same view as those individuals in the medical, legal and/or accounting professions.

The National Research Council (NRC) in the United States recently published a report citing three "serious concerns" with engineering graduates: (1) Many have "little knowledge" of the design process; (2) "inadequate knowledge of the role of technology in their professions"; and (3) "little knowledge of business, economics, and management."[15]

Scientific and engineering technology doubles every ten years.[16] The idea that a person can learn everything that he/she needs to know in four years is not true and never will be. Not even the "fundamentals" are fixed, as new technologies continue to emerge. Engineers are going to have to accept responsibility for their own continued reeducation and engineering schools are going to have to prepare engineers to do so by teaching them how to learn.[17] While engineers have increasingly become better and better at technical skills with emerging technologies and inventions occurring at an ever increasing rate, engineers have had little to no training in the "soft" skills required in today's world to deal with business, people, and global projects. Although engineering is considered a respected profession, it is the lack of certain skills that have kept the image of the engineer lower than other professionals, which in turn has resulted in lower positions and lower enumeration for the services rendered.

The need for raising the image of the engineer has become paramount and is reaching a stage of crisis necessitating a major change in engineering education reform for engineers around the world. *"Engineering education must avoid the cliché of teaching more and more about less and less, until it teaches everything about nothing*."[18] While the future remains uncertain, engineering will not operate in a vacuum separate from society in this Century any more than it does now. However, the world's natural resources are continued to be stressed by population increases. Engineers will need to be more aware of the need to work in teams, consider social issues, understand political and economic relations between nations and their peoples, understand intellectual property, project management, multi-lingual influences, cultural diversity, global/international impacts, and cost-benefit constraints as all these factors will drive the engineering practice of the 21st Century.[19] Engineers will need to know how and when to incorporate social elements into a comprehensive systems analysis of their work.[20]

The American Society of Civil Engineer (ASCE)'s Committee on Academic Prerequisites for Professional Practice (CAP^3) published the First Edition of the "Civil Engineering Body of Knowledge for the 21st Century" (BOK) in May 2004[21]. The BOK is being prepared to establish the knowledge, skills and attitudes necessary for graduates to effectively enter licensed practice. The BOK report proposes building upon the existing 11 U.S. Accreditation Board for Engineering Education and Technology (ABET) EC2000 outcomes, by adding four additional outcomes to those incorporated within existing accredited undergraduate curricula. The additional outcomes include additional technical engineering depth in one or more areas and additional breadth in the following areas: project management; finance; business and public policy and administration; and leadership. The additional breadth components might eventually be incorporated into undergraduate engineering curricula, leaving additional education beyond the bachelor's degree to consist of a flexible program of additional depth and breadth in engineering and professional practice topic areas.[22]

Similar skills are outlined in the APEC Engineer's Manual. APEC considers it important for the APEC Engineer to possess skills for:

- General Management
- Project Management
- Quality Assurance and total quality management
- Marketing of engineering products or services
- Financial or human resource management

- Design and delivery of training programs
- Policy development
- Regulation development

The APEC Manual further notes that these activities will normally involve leadership, teamwork, oral and written communications, presentations, and interpersonal skills in the practice of all engineering disciplines.[23]

Similar skill assessments were discussed at a Society of Petroleum Engineers (SPE) Sixth Colloquium on Petroleum Engineering Education (CPEE 2004) held in August 2004 at the Colorado School of Mines in Golden, Colorado in the U.S. The three day round table was attended by academia, industry and the service sector to discuss how universities, in partnership with industry, service companies, and government could help fill the needs of enhance engineering education. The assessment was to determine how the world could come together on the establishment and global acceptance of certification standards, innovation teaching programs and agreement as to the skills and attributes required for the "new engineering professional." The skill sets being sought today include effective writing and oral communication skills, teamwork abilities, analytical and problem-solving skills, judgment and decision-making capabilities, adaptability, initiative and motivation, project management, leadership, organization and planning, understanding of work lifestyle, information technology, and an understanding of ethical, quality/health/safety/environment, legal and business aspects-all in addition to the technical and professional knowledge. The goal is for universities to develop a more "holistic" curriculum.[24]

In 1997, the Institute of International Education published *Towards Transnational Competence: Rethinking International Education*. This work specifically focused on the US and Japanese interactions and expanded its consideration into the principles and concepts behind efforts at increased internationalization. The concept of transnational competence (TNC) is defined as "*…the ability of individuals, organizations, communities, and governments to effectively cope with the rapidly changing transnational environment and to realize their goals.*"[25] The six core elements of TNC include:

- Ability to imagine, analyze, and creatively address the potential of local economies/cultures;
- Knowledge of commercial/technical/cultural developments in a variety of locales;

- Awareness of key leaders (and ability to engage such leaders in useful dialog);
- Understanding of local customs and negotiating strategies;
- Facility in English and at least one other major language, and facility with computers; and
- Technical skills in business, law, public affairs, and/or technology, and awareness of their different nature in different cultural contexts.

In addition, the Japan Business University Forum members interviewed top executives of major private companies in Japan asking what they wanted from university graduates. The answers provided similar responses of what bodies around the world now consider critical for engineering education reform:[26]

- Creativity
- Flexibility, the ability to adjust to different situations and a wide range of skills
- A sense of responsibility and ethics in team activities
- Leadership, cooperativeness and the ability to function and a group member.

As noted by Yutaka Takahashi, former professor at the University of Tokyo:[27]

> *The most important thing to accomplish is to develop the foundations that enable engineers to speak, discuss, and debate issues with people outside of the civil engineering profession. It is becoming increasingly important for engineers to actively seek the company of people outside their professional circles and to be able to accurately explain the technologies and projects involved in civil engineering while making every effort to establish a receptive mindset for opinions and logic of other fields.*

This quote was not too distant from the observations of the Japan Society of Civil Engineers (JSCE) first President, Kimitake Furuichi (1854-1934) who is known for his studies abroad in France from 1875-1880 where he received his degree in civil engineering and became the first foreign student in the Japanese Ministry of Education. Not only did Furuichi develop the framework for the Japanese engineering administration in Japan and enacted engineering works and administration, he became the first Dean of the College of Engineering at Imperial University in Japan. As President of JSCE, he noted:

> *…I do not believe in highly specialized classifications. One should not be restricted by or intimidated by the word "specialized classification". I feel particularly strong about this in the civil engineering field. It is extremely common*

in civil engineering to require strong leadership in the supervisor, not a mere specialist. Civil engineering draws on the other fields. Thus, civil engineering must possess the ability to utilize the skills of engineers in other fields.

Japanese Consulting Engineers today are also looking towards the future and have indicated that the following skill sets are needed for the Japanese Consulting Engineer to be able to effectively compete in the 21st Century:[28]

- Feasibility studies
- Planning
- Design
- Management
- Contract management
- Team management
- Presentation and communication skills
- Report writing
- Operations knowledge
- Cost estimation and control
- Practical site experience
- English capability

The author's survey of Japanese Consulting Engineers concluded that Japanese Consulting Engineers do not have the sufficient capabilities for the execution of international projects. Japanese consulting engineers do not have communication skills, English capability and/or dispute resolution skills. International projects are significantly different from domestic projects in many aspects including project delivery, contract system, and the role of the consultant, technical standards, and language. None of these skills to handle these differences are currently taught to the Japanese Consulting Engineer in the standard engineering curriculum.

While the early pioneers of engineering had a vision for what skills an engineer needed to possess, engineers have somehow lost their ability to stand up and be accounted for. Reviewing the "visions" of multiple organizations throughout the world, several common elements emerge relative to what skills are "missing" from the Japanese Consulting Engineer's tool kit but are essential for the future of the profession:

- Engineering basics
- An understanding of globalization
- Ethics and professionalism
- Communication skills
- Diversity and multi-disciplinary teams
- Leadership skills
- An understanding of public policy
- Project management skills
- Risk management skills
- Dispute Resolution Skills

Much of the reasoning behind the engineer's current low image from the public issue lies in the education system for engineering. Engineering education has focused on the technical and research aspects of engineering, but has focused little on the practical side of engineering and the lack of education in these critical areas. Thus, it has become necessary to reform engineering education.

The author made an investigation of Japanese Consulting Engineers' activities using a questionnaire survey. The Japanese Consulting Engineers stated that they do not have a chance to study project management the universities as it has not been viewed as a "scientific" subject and thus deemed inappropriate for engineering education. Yet project management is strongly recognized in many industrial sectors and needs to be applied to other industries as well, including the construction industry. Responses from Japanese Consulting Engineers also note that neither planning nor cost control skills education programs are well equipped in Japan and that there has been a wide belief that engineers are not required to worry about cost and that if good merchandise is developed, it will sell itself. The same concepts have moved into the construction industry where the government has appreciated the good design of say, the bridge, without considering cost or other aspects of the construction works. Communication skills programs are also not well equipped in the Japanese engineering education curriculum. Presentation skills have never been acquired since in Japan, the teaching professor gives only a lecture with little opportunities for students to present their papers or opinions in class. [29]

1.2 The Japanese Consulting Engineer

1.2.1 The "Birth"

Japan remained isolated in the Edo period and it was not until the Meiji restoration period in Japan that the country was opened up to foreigners. The Meiji government was modernized largely on the model of the 19th century west. Ministries most like those of western governments were set up. The Ministry of Home Affairs, the Ministry of Railways, and the Ministry of Agriculture and Forestry employed many engineers in the pre-war era. The Education Ministry embarked upon an ambitious program of universal education that took some three decades to be put fully into effect. Modern courts were set up on both French and then German models. Banking systems were created and the monetary system was reformed with the yen as its units. Lighthouses were built, port facilities improved and the country was tied together through the telegraph and the railroads which were constructed. To carry out all the great innovations at the time, the government sought advice from foreign engineers to assist in 'building' Japan's infrastructure and dispatched students abroad to acquire new skills in addition to hiring the western experts.[30] It is this basis to accept the western modern science and civilization that were ready made and fully prepared on the foundation of Japanese culture to respect education, and accumulated traditional techniques and experiences that is considered to have resulted in the surprising developments that Japan was able to achieve and the reason for the success of modernization.[31] The salaries paid for employed foreigners at the beginning of the Meiji Era were several hundred yen per month which was unprecedented high. As such, there was "awareness" by the Japanese of the value that these skills brought to society.

However, the Japanese technology at that time was incapable to responding to the challenges the country was facing with these massive infrastructure projects. As a consequence, Japan looked to the west for assistance. Many foreign engineers came to Japan to assist with the public works projects. Mr. Henry Dyer, who assisted greatly in the public works area, was an English engineer and brought the thought of engineering education to Japan. Japanese engineers also began to travel abroad to gain knowledge and learn about infrastructure projects in Europe. Together with the foreign consultants in Japan who were totally dedicated to their works in Japan with the Japanese engineer's ability to absorb education from other parts of the world, heightened the awareness of the importance of engineering.

In 1870, the Japanese government formed the Kobusho, or Ministry of Public Works, to administer a new policy to increase production and promote industry, with the main focus at that time on mining and railways. In 1873, the Naimusho, or the Ministry of Home Affairs was founded within which the Doboku-ryo, or Public Works Department was organized the next year. This was later reorganized into the Dobuku-kyoto, or Public Works Bureau in 1877 and remained the most important administrative office for civil works until the Naimusho was abolished in 1947. With government formation of engineering departments and the rapid rise of Japanese who were now "trained" in the areas of public works engineering, the number of foreigners started to decrease year by year after peaking in 1874.

Several Japanese young individuals recognized the value of obtaining foreign education and thus left Japan to obtain education that could not be obtained in Japan. One Japanese engineer who studied abroad was Torakichi Yamada. He went to England at age 15 and by age 17, he entered the Ecole Centrale des Arts et Manufactures in France and graduated in 1876. When he returned from France, he served as the Technical Officer of the Ministry of Home Affairs and later became what was known as the first Japanese Consulting Engineer when he formed his own company, Torakichi Yamada Industry Company in 1890. His experience in France led him to become an entrepreneur. He believed in the modernization of social infrastructure and believed that the consulting business would be very promising in the future. His ideas were in line with the basics of what is presented herein for the Japanese Consulting Engineer of the 21st Century.

In 1879, the Japan Federation of Engineering Societies (JFES) was founded. The organization evolved and in 1914 was formed as the Japan Society of Civil Engineers (JSCE). However, despite the entrepreneur Yamada San, in 1890, the laws of accounts were enforced for public works and all contracts were to be decided by competitive bid. Further, the plans/designs for the public works were primarily handled by the government/official administration offices and the consulting business was treated merely as assisting/supporting jobs.[32]

When World War II ended, the traditional system had problems responding to the rapid increase in demand for civil engineering work precipitated by the need to rebuild industry, establish facilities for the Occupation Forces, and improve services to allow efficient administration by the Occupational Forces. This then highlighted the need for construction consulting firms that could play a role in the infrastructure development.[33] Japan had had a long period of seeking out technical advisors with practical experience and thus the role of the ‘consulting engineer’ appeared in Japan during the period 1945-1950 with the public works restoration. In 1945, Japanese Engineer Kiyomi Utsumi set up an association of engineers specializing in hydropower development and established the Construction Technology Research Institute as a business base for construction consultants.[34] During this period three consulting firms were founded: CTI Engineering Co. Ltd., in 1945; Nippon Koei Co. Ltd., in 1946; and Pacific Consultants Co. Ltd. in 1951. Pacific Consultants was founded as a joint venture with a U.S Company by Fukujiro Hirayama who had found the U.S. consulting system interesting and proposed the introduction of a construction consulting system in Japan. Before he established Pacific Consultants, he began preparations for the Japan Consulting Engineers Association (JCEA) and began drafting the Consulting Engineers Law, enacted in 1949; just a year after the Ministry of Construction was formed.[35]

In 1950, The Japanese government enacted the Foreign Capital Law, designed to encourage active support of advanced foreign technology to help reconstruct the economy. It guaranteed continued freedom to remit currency abroad in exchange for technology imports. This law marked the start of a process which the concept of technology began as a tradable item in society. The works for Japanese Consulting Engineers in this period was enhanced by Macarthur’s Five-Year Plan for the Maintenance and Repair of the Japanese Road and Highway Network. Consultant studies were performed on the Japanese tax system and establishments of local governments were made. Various U.S. missions visited Japan to raise interest in systems governing the consulting engineering practice, guided by the U.S. Consulting Engineers Association, and already founded in the United States as well the professional qualification system for engineers by individual state laws.[36] The desire to establish a similar body in Japan resulted in the launch of the Preparatory Committee for Establishment of the Consulting Engineering Association in December 1950. This committee formalized the phrase “gijutsu-shi” as the Japanese translation of “Consulting Engineer”. The JCEA was “officially” established in June 1951.[37]

The main aim of the JCEA was to persuade the central government to enact a law covering construction consultants, thus providing a legal basis on which consulting engineers could operate. While years went by in an attempt to determine what division of government should handle the JCEA, when the Science and Technology Agency was set up in May 1956, this new agency served as the agency for the new law, which was finally enacted as the Professional

Engineers Law in 1957 [Law No. 124]. JCEA set forth 10 principles to clarify the characteristics of consulting businesses and suitable methods for settling contracts and fees while maintaining neutrality.[38] Moreover, in 1958, JSCE stated that the construction consultant should not be selected by competitive bidding. However, subsequent transition showed that the "negotiated" contract was on an exception basis and that the basis of competitive contract was the guiding principle as dictated by the Ministry of Construction in 1970.[39]

In January 1959, the Ministry of Construction issued a circular entitled regarding "Contacting Method and Other Matters When Entrusting Design and Other Works Related to Civil Engineering Projects", which addressed the regional construction bureaus, in the name of the Vice Minister of Ministry of Construction, with instructions on handling the method of design, contract, standard contract form, calculation method for prearranged prices. The Ministry of Construction made the industry aware of this publication. The primary reason for the circular was to separate the construction consultants from the contractors and to guarantee the economical status of the consultants. The advantage was that it increased the number of construction consultants from only 70 in 1960 to 220 in 1965.[40] In addition, the circular included an article that the selection of the construction consultant was to be made by negotiated contract, meaning that the owner decides a price based on past performance and capability.

With the assistance of the U.S., aiding Japan after the war, Japan based its consulting system on that of the United States. Japan's economy began to move at an accelerated pace and by the mid 1950s, the Japanese had regained their per capita production levels of the prewar years. By the late 1950s, the Japanese economy was racing ahead and for more than a decade, thereafter, averaged annual growth rates around 10 percent in real terms a record that no other nation had ever attained. The Japanese economy was actually doubling every seven years and by the 1960s, the Japanese were considered one of the most prosperous nations in the world.[41] As the work being provided to consulting engineers was merely simple work involving calculations and drawings, in April 1960, seven companies joined together to found the Construction Consultant's Association. Lacking a legal mandate, it began with a membership of 12 consulting companies and later in March 1962, it became a legal entity under the supervision of the Minister of Construction.[42]

Japanese consulting firms began to increase and in 1963 the Japan Civil Engineering Consultants Association (JCCA) was founded. It was the devastation of World War II on the

Japanese infrastructure that created a demand for outside specialists who could assist in-house government engineers. With this demand, for the first time, civil engineering consultants appeared as the specialist engineers and it is these engineers who pioneered the way for the establishment of the Japanese Consulting Engineer.[43] To encourage the development of consulting firms in Japan, the Ministry of Construction issued a notification called “Specification for Registration of Construction Consulting Firms” in 1964. This document recommended the use, in public works, of consultancies registered according to the rules.[44] By February 1965 there were 226 registered consultants and by 1992, there were 2,336 registered construction consulting firms with a combined business of approximately 716 billion yen.[45]

Major changes in both the domestic and international business environment resulted in a major reform of the tendering and contracting system for public works which was announced at the end of 1993. The reform came into effect in July 1994 as the Japanese Government’s first step in its reform program. While the reform was to “open” competition in the construction industry to foreign competition, little has progressed to date and the mandates of WTO loom over Japan to act fast-action that will have a direct impact on the Japanese Consulting Engineer.

1.2.2 Current Status of the Japanese Consulting Engineer

The Japanese Consulting Engineer today is experiencing difficulties that have never been experienced before primarily caused by the globalization of the Japanese economy.[46] In the early 1990s, the engineering consulting industry had matured in Japan. In 1998, when the industry was at its peak, 2,900 firms employed 110,000 engineers and administrative personnel. JCCA representing the major independent entities had 510 member firms, employing 45,000 engineers.[47] However, since 1997, there has been a significant decrease in the consultant’s profitability, productivity and stability. In 1997, ordinary profits decreased by 16.5% and ordinary profits of the fiscal year decreased by 22.2% in 1997 as compared to 1996.[48]

While the excitement for new works and a new identity within Japan was increasing after the post war era, the role, image, and remuneration for the newly defined consulting engineer was decreasing. The standard work day is fixed by the government and there is a standard fee scale. As a result of the economic bubble burst, the biggest area of concern besides the shrinking market is the system upon which consultants are selected. Quality Based Selection (QBS) is not well understood in Japan by those retaining consulting engineers. While movement is occurring in Japan relative to the selection of the consulting engineer through a proposal method, this is not the same concept as QBS. QBS is important because in this system, quality is warranted for the client and the fees to provide quality is secured for the consultants. The Japanese Consulting Engineer has been unsuccessful in fighting the Cost-Based-Selection (CBS) or price competition system in place. This system, which selects the Consulting Engineer based on price instead of qualifications, dates back to 1889 when the Public Procurement Act (Kaikei Hou) was enacted and there were no independent consulting engineers. In 2003, regarding MLIT works; the consulting engineer was selected by the following procedure:[49]

- Nominated 39% (114 bill yen)
- Proposal (QBS) 17% (48 bill yen)
- Competitive bid (OCS) 44% (129 bill yen)

As a result, it is necessary for Japanese Consulting Engineers to take a more firm stance within the domestic market and become more active in overseas projects.

While significant progress had been made in the development of the Japanese Consulting Engineer from its initial formation in 1945, the profession of the construction consultant cannot be said to command the public respect it deserves. Some possible reasons for this situation include:[50]

- The lack of a law governing the profession means there is no firm business base;
- The limited advertising carried out by consultants, partly because of constraints on the profession; and
- The generally low level of public awareness of the involvement of construction consultants.

In the author's survey of Japanese consulting engineers[51] taken in 2004, respondents concluded that the Japanese Consulting Engineer domestically was primarily engaged by central and local governments, MLIT, and the Japan Highways Authority. Only a few work for private companies. Domestically, the consulting engineer is viewed in Japan as:

- Having a more limited role to its counterparts in the EU and the U.S. and are not recognized as professionals;
- As a servant to public clients, and at most an assistant;

- Only performing design;
- Non-existent to the public; and
- Not independent and connected to public clients.

There are several factors which limit the ability of the Japanese Consulting Engineer. First, Japanese Consulting Engineers have a weak management base due to the Japanese cultural tradition of not appraising human knowledge. Japanese consulting engineers tend to be "shy" and instead of being proactive, have a tendency to wait for instructions from the client, shift responsibility to the client and have a lack of proposal initiatives.[52] As noted earlier, the Japanese Consulting Engineer does not have a systematic knowledge of project management technologies. This has been confirmed from both the author's experience over the past 20 years of working with Japanese Consulting Engineers, Japanese Construction Companies, the MLIT and association with professional engineers met during professional JSCE meetings as well as the author's survey she conducted of Japanese Consulting Engineers.

The situation is going to become worse before it gets better. The public infrastructure economy in Japan does not look promising for the near future. The current Koizumi administration appears eager to continue budget cutting in the area of public works. Trends suggest that future infrastructure projects will not be funded by the government at all, but rather through a more decentralized approach, prompting more projects to be delivered by means of Private Finance Initiatives.[53] In response to these challenges, JCCA has published a *Declaration for Reformation-Profession for the Next (Kaikaku Sengen).* It suggests that the change of demand for consulting services will lead to a reformation of the structure of the industry. Unlike the consulting engineers in the U.S. and Europe, Japanese Consulting Engineers in Japan have primarily served in supporting roles and have not been involved with giving their opinions with respect to judgment of business, estimates of the works, and selection of contractors. Accordingly, Japanese Consulting Engineers have not been performing such works as offering advice on accountability, qualification examination of contractors, examination of adequacy of estimation and bidding price, management of progress payment, payment to contractors, all which have traditionally been roles of consulting engineering in the U.S. and Europe.[54] Japanese Consulting Engineers domestically are not in a position to draft up construction contracts and instead use what the client creates or use the standard form of contract as developed by the government. As such, the Japanese Consulting Engineer has little concept of contracts, contract clauses and/or the importance of a contract in management of the works.

This is a major disadvantage in the Japanese Consulting Engineer's knowledge for international work.

The primary reason that Japanese Consulting Engineers have a low capability of project management is because they do not have the chance to obtain the appropriate education regarding project management and other professional skill sets that are now required to compete in an international marketplace. There is another reason why Japanese Consulting Engineers have a low capability of project management. Contractually they are not required to be in a position to handle project management. This will be explained later. Japanese Consulting Engineers will need to mirror their counterparts in the U.S. and Europe, and together, all the engineers around the world will need to collaborate in order to reform engineering education to provide the skill sets for managing and leading and being able to provide the "think tank" service to clients anywhere in the world. The recent President of the JCCA suggested five issues needed for structural reform for the civil engineering consultant in Japan:[55]

1. Development and expansion of new scope of service
2. Re-mapping business structure
Design consultants
Engineering consultants
Comprehensive consultants
3. Formation of a competitive engineering service market and technology development
4. Transition the stakeholder from companies to individuals
5. Adherence to corporate ethics and personal ethical standards of the engineer.

Reasons for reform center on the problems that Japanese Consulting Engineers face in today's global economy including:[56]

- Japanese Consulting Engineers are strong on technology but weak at comprehensive powers and management capability. They are not good at managing power which is inevitable for international business, especially the ability to handle claims.
- Japanese Consulting Engineers are not good at expressing themselves. It is not just a lack of completing understanding the English language, but also a lack of understanding the social and industrial background differences. This is especially critical when it comes to communication and making timely positive presentations and speeches, areas where the Japanese Consulting Engineer lacks ability.

1.3 The Problem in Japan

There is an urgent need to change the image of the consulting engineer in Japan based on the following current situations:[57]

(1) Japan is currently undergoing a major period of social change and reform which has been triggered by the end of the economic growth, the destruction of the post-war political system, and the requirement for Japan to open its market to foreign competition.
(2) Lack of the public's trust for the "public system" due to scandals in the early 1990s, the public's questioning of the effectiveness of public works projects as a result of the 1995 Great Hanshin earthquake, recent accidents with the nuclear power plants and recent issues regarding bid rigging in the Construction Industry.
(3) The increasing difficulty in adjusting to the various trends in the Japanese society such as aging, diversification, the information technology age, globalization, and environmental problems.
(4) Conceptual reforms that engineers have yet to undergo in their mind set, despite advances in construction production systems.

The Japanese Consulting Engineer faces an immediate challenge to raise the image of its own profession in Japan in order to shape the future of Japan and to be competitive in the global market. The Japanese people have lost confidence in the construction industry. One of the reasons appears to be the lack of knowledge of the public that the infrastructure is necessary for their lives.[58] Another reason of the lack of public confidence stems from the confusion between the definition of engineering and technology as well as the difference in what engineers and technicians do. These confusions seems to be caused by an improper translation and improper understanding of the term "Engineering" to "Kogaku " in the early stage of the history of modern science and technology of Japan in the Meiji era, followed by a domestic progress on research and education in Kogaku. Kogaku is the subject of science, while engineering in the western world is much more application oriented. The word technology is used to describe a complete system, a capability, or a specific device. Engineering is the knowledge required, and the process applied, to conceive, design, make, build, operate, sustain, recycle or retire something of a significant technical content for a specified purpose, a concept, a model, a product, a device, a process a system a technology.[59] Typical definitions of engineering and technology in Japan appear in Japanese dictionaries: *Engineering* is a discipline of the research on items of industry. *Technology* is 1) skill, technique, or 2) means to apply theories to practice. *Engineer* is a person who uses the skill as profession. *Engineering* is located between science and technology in Japan. Engineering is the technology which is formed into the discipline. *Technology* is "kagakugijutsu " and a discipline developed in the U.S. and has a wider meaning than technology and engineering.[60]

Japan itself is at the largest crisis since the Meiji era although most of the Japanese people do not seem to recognize the issue.[61] Japan, suffering from inherent lack of physical resources, is falling behind the American and European countries, not only in industrial competition, but also in fostering of human resources. Materially affluence and an abrupt decrease of a younger population have brought about the lack of academic competition and aspiration which coupled with a more relaxed education policy by the government has generated concerns over intelligence.[62] When Japanese industries boasted their competitiveness on the global market in the 1980s, Japanese style management, featuring lifetime employment, in-house training and seniority-based wages, received world attention. However, the same management style is criticized today as the culprit of the declining industrial power.[63] Engineering education has followed a similar state. While once thought as the driving force making industrial development, it was merely meeting the demands of the Japanese industries which did not expect job-readiness from graduates or value for future development. New graduates were merely considered raw material which each company could forge to powerful components.

However, though the collapse of the bubble economy is said to be responsible for the current stagnation, the lack of innovation may have been the root cause. Even the successful IT industry has quickly lost a balance and Japan is wrestling with an economic slump.[64] Manufacturing in Japan has only shown a recent recovery, however, the future does not appear to be promising. In the post-bubble economy, advanced technologies have failed to be handed down to the next generation and/or easily flowed out overseas. As a result, the basis of manufacturing itself may be weathering.[65] Every nation must design its future in consideration of the economical and cultural dependencies on a global scale. This has forced each nation to make its system transparent to outside and compatible with global standards. Now, Japanese management must undergo rigorous reforms to adjust itself to the new circumstances. The globalization forces Japanese companies to shift to more globally competitive management system: "Re-engineering."[66]

In order to recover, Japan must focus on a "third knowledge". The first knowledge was the system developed though the practice of "making things" and through knowledge that evolved from it. This practice knowledge then became formal knowledge taught in Japan. The first knowledge of making things served Japan well; however, it had to pursue a sophistication of this knowledge. The second knowledge was to integrate making thinking with the software into a system which linked new businesses and allowed Japan to excel into a leading position in IT innovation. However, in order to translate this second knowledge into a third knowledge, it is necessary to transcend concepts of one's own company to creating new business concepts. This third knowledge is essential for Japan to win in the global marketplace.[67]

The current Japanese Consulting Engineer does not possess many of the needed skills in order to compete or "win" in the global marketplace or to move the domestic construction market ahead in Japan. As a result, the image of the Consulting Engineer in Japan has declined over the years to the extent that few Japanese Consulting Engineers hold prominent government positions, leadership positions, or even have the ability to stamp drawings in the name of the engineer versus the prefecture.

The primary reason for decline of the image of the Japanese Consulting Engineer stems from the lack of courses within the engineering curriculum of the Japanese universities that go beyond merely the technical aspects of engineering. As previously noted, when the word "engineering" is translated into Japanese characters, it means "technology" and "science".[68] In the western world, "engineering" means a profession. Japan has long been unaware of the definition gap.[69] Young Japanese engineers are also not highly motivated in what they do. They do not try to understand or deduct by considering deeply when they face a new problem. They are one-dimensional in the way they look at things and poor at applying their knowledge to derive new ideas or make estimations. Young Japanese engineers are also not good at visualizing things just from drawings. Japanese engineers are trained to solve problems by only applying standard, textbook format and educated primarily through classroom lectures. They lack practical experience.[70]

Further, while Americans and Europeans are used to a constantly changing world and are prepared to accept challenge, the Japanese have been used to a world where life is planned and chartered and where the greatest threat comes from the unknown.[71] Instead of admitting that one does not know about a subject or the matter being brought before him/her by a client, Japanese will provide an impression that they do understand and are knowledgeable about the subject being discussed. There is a “fear” of shame if one is not knowledgeable on a subject that they personally believe they should be. This is best explained by the Japanese concept of “Giri ”. The engineer, in “giri” cannot let anyone know that his assets are seriously depleted or that the plans for his organization have failed. In all, such “giri” usages, there is extreme identification of a person’s work and any criticism of one’s competence becomes automatically a criticism of one’s self. But it goes much deeper in that a person cannot tell a person to his face in so many words that he has made a professional error.[72] Japanese have also not recognized the value of individualism-which is where creativity often begins-refined by team discussion. The word *individualism* (kojin-shugi) itself has always been in ill repute in Japan. It suggests to the Japanese selfishness rather than personal responsibility. As a consequence, the Japanese tend to use other terms such as “subjectivity” (shutaisei).

In addition to not being able to recognize his or her individual value, the Japanese Consulting Engineer may have come to neglect the society due to the inability to combine the two views of “academic studies” and of “the practitioner.” It appears in Japan that the two groups of people view engineering from their own respective sense of values and their own respective worlds. However, in order to understand the realistic images of society, things must be viewed from both the academic and practitioner views.[73] In addition, the specialization and fractionalization of engineering is further preventing engineers from focusing on their primary target-the public.

So why doesn’t an education program of project management for Japanese Consulting Engineers currently exist in Japan? Based on the author’s research of the consulting engineers history and current work in Japan, the author’s experience with Japanese Consulting Engineers, the survey that she performed of Japanese Consulting Engineers and her work with MLIT, the primary reason is based on the fact that up to this point in time, the method of contracting and method of designing and constructing a domestic infrastructure project in Japan has never required a systematic approach or education of project management. The construction industry has simply not required the need for project management skills based on its unique philosophy of contracting as compared to other countries.

The primary difference in the way Japan operates in its domestic construction industry as compared to the rest of the world is the basis of the two-party structure and the basis of “mutual trust.” The two-party system in Japan in basic terms is a one-page contract between the owner (primarily the government) and the contractor. Especially in heavy civil public projects, the designer and consulting engineer are not separate contracting entities nor autonomous in the process. For instance, in most countries, when an infrastructure is conceived, a contract is entered into between the owner and the consulting engineer whereby the consulting engineer prepares the design, stamps the drawings with the consulting engineer's initials and company name and these plans and specifications are then issued to the contractor for tender. Once the tenders are received and a contract awarded, the contractor signs a contract with terms within that include specific requirements for schedule preparation, progress monitoring and reporting and payment applications which are based on progress achieved. Progress as well as conformance to design is carried out by the consulting engineer. The consulting engineer plays an integral role in the construction process and the monitoring of the project and execution thereof is performed via a three-party system. In some instances, an owner may employ a construction manager, (who would also employ consulting engineers) who would strictly be responsible for the project execution and monitoring while the design consultant would be responsible for answering Requests for Information (RFIs) and design questions as well as potentially inspecting the construction in a QA/QC role for compliance to the plans and specifications.

However, under the Japanese system, the designer is not typically recognized and the drawings are merely stamped with the prefecture stamp with no identification of who the actual designer or company was that prepared the drawings. The government basically takes over and the consulting engineer has little to no role in the actual project execution. Under the Japanese form of Contract, there is no practice of having a consulting engineer as so defined in the FIDIC Book who acts as the owner's agent during execution of the project as well as adjudicator of the disputes between the owner and the contractor.[74] Further, the contract which is signed between the government and the contractor has little more than a total dollar amount and a due date for completion. Given the fact that a large prepayment is made with no further monies being paid to the contractor until completion, little incentive remains for either party to monitor cost or schedule, especially knowing past trends have been to resolve any "issue" that arise on a project with a single change order at the project completion which is resolved by "mutual consultation."[75] Thus, under this situation and two-party system, there has been little reason for the Japanese Consulting Engineer to have an identity or to have any reason to acquire project management skills.

British and FIDIC construction contracts traditionally provide for "the Engineer" for engineering works among whose responsibilities is to also resolve disputes as they arise on a contract. Most international construction contracting concepts are based on the concept that the consulting engineer has a dual role; *i.e.* he acts as an agent of the owner and, at the same time, as an independent certifier. Under both the British ICE and FIDIC Conditions, the consulting engineer is vested with a special role to act as a "pre-arbitrator". The consulting engineer reviews and gives "decisions," upon request of either the owner or the contractor, on issues in dispute.

Unlike British standard forms of construction contract or the FIDIC contract, the Japanese contracts do not provide for the consulting engineer. Instead, the owner assigns its staff member, or sometimes may employ a third party, as a site representative of the owner or an agent acting on the owner's behalf. He supervises and certifies the Works and assesses any adjustment to the contract price or the extension of time for completion.

GCW Conditions, Article 10 "Superintendent" reads as follows:

> *(1) The Owner upon appointment of the Superintendent shall notify the name of the Superintendent in writing to the Contractor. Provided that the same shall be done for the replacement of the Superintendent.*
>
> *(2) The Superintendent will have authority stated as follows in accordance with the Design Documents in addition to authority specified in the other clauses of this Conditions and entrusted to the Superintendent by the Owner as deemed necessary by the Owner so to carry out of all his authority under this Conditions.*
>
> > *(a) Instructions and approvals to and negotiations with the Contractor or the field representative of the Contractor with regard to the execution of the Contract.*

> *And, for instance, Article 18 "Change in the Work, Suspension of the Work" reads as follows:*
>
> *(2)* *(a) As to change of the time for completion and the Contract Sum, the Owner and the Contractor shall determine these by negotiation.* [Emphasis supplied]

Therefore, under GCW Conditions, "the Superintendent" does not have the right or obligation to negotiate and agree with the contractor. In practice, the Superintendent is the owner with whom the contractor negotiates. The Superintendent, of course, obtains approval (or instruction) from his organization, i.e. his senior who is in a position being capable of making decisions, before or during negotiating with the contractor.[76]

While the current domestic contracting system in Japan may appear internally “to work,” the current system has a very short shelf life in the face of WTO requirements and the shrinking infrastructure construction market. Public works are the main source of the civil engineering construction business. The MLIT is the typical and the largest customer procuring public works contracts. However its procurement system consists of two distinguishing features: the Designated Competitive Tendering System and the Ceiling Price.

The MLIT selects a certain number of bidders for a particular project and even designates the combination of members for joint ventures. While it is said that this system has served well for purposes of fair distribution of contract awards among contractors, it is not clear to the public how the MLIT has selected bidders or joint venture members in reference to other contractors who obviously are capable of performing the project. There is no transparency and this is not a system of fair competition in which any contractor within the eligible classification may participate in the bidding.[77] Further, recent indictments regarding bid rigging in certain sectors of the Japanese Construction Industry has led to further public mistrust.

The estimate made by the MLIT’s officers becomes the budget and hence the Ceiling Price for purpose of the award of contract in accordance with the law of government's accounting system. This Ceiling Price is not made public. Construction contracts are procured as lump sum contracts, and a tender submission is nothing more than a piece of paper in which a lump sum contract bid price is written. If there is no tender who is below the Ceiling Price, the submittal of prices is repeated up to three times without any changing of the tender conditions announced by the owner side, after which a new set of tenderers is selected by the MLIT. It is almost always the case that some tenderer goes below the Ceiling Price and is awarded the contract on the first round of the bidding. The procurement system of other public authorities is similar to that of the MLIT.[78]

These two features of the public works procurement system have been recently criticized, as they tend to create bad business practices, in fact, such as unlawful trusts ("Dango"). Transparency is being called for by the public to avoid any further corruption in order to learn the Ceiling Prices in advance is sometimes reported in the press.[79]

If Japan is to sustain a healthy and sustainable construction industry and become competitive on the open market, the system has to change. The MLIT has begun to make some strides in this area. The author has worked with the MLIT on researching public contracting methods and concepts as well as procurement concepts for both Japanese Consulting Engineers and Japanese Contractors in other parts of the world. The MLIT is taking steps to procure outside consulting engineering services, has taken some steps in allowing in some cases for consulting engineers to be recognized in the construction documents and has even started some “pilot projects” where a construction manager has been retained. The slow but steady changes in Japan's construction industry are due to the following three major reasons:

1. Outside pressure, *e.g.,* the Japan-U.S. Structural Impediment Initiative, to open Japan's construction market and assure fair competition

2. Public demand for fair competition

3. The natural tendency of the construction industry itself to demand a truly open market amid persistent economic recession

These reasons for urging truly fair and open markets and resulting substantial changes are valid for other industries, too. The struggle towards substantial change is producing other phenomena, among which is an increase in litigation and arbitration, with a corresponding increase in the number of lawyers qualified each year. These changes in Japanese society can be seen as a continuation of a trend begun with the Meiji Restoration: heading towards "internationalization" in its business and contract practices.[80]

Thus, one can expect to see a development of Japanese forms of construction contracts along "international" lines. Japan's first form of construction contract was based on the then RIBA form, some eighty years ago. The ENAA[81] form of turnkey contract is heavily based on "international" concepts, methods and forms, and is in English language. Future domestic Japanese forms also can be expected to follow "international practices": Contract conditions will be clearer; procedural requirements will be more precise and open; and the process of making decisions on differences arising from the performance of the contract will be modeled on "international" methods. All of these changes in the Japanese forms will serve to improve the effectiveness of contracting process because the more truly competitive and open the market is, the more important the role of the written contract.

However, this evolution of methods and forms towards "international ways" should not be seen as some form of abandonment by Japan and its people of their culture. It best can be understood as an economic occurrence. Japan's economy progressively increases its linkage with the economic of other nations; Japan's trading surpluses bring increasing pressures for the opening of Japan's domestic market to competition from outside Japan; with increasing exposure of Japan's people to more open and more competitive practices in other societies; Japan's people increasingly press for introduction of truly competitive procurement practice to be used in Japan. Just as many other Japanese practices, whose roots lie in pre-Meiji restoration eras have gradually altered since Japan's "opening" of itself to the rest of the world, so may we expect many of the construction industry's past practices to be replaced by practices more conducive to true competition. Such change doubtless will include the adoption of various contract forms, concepts, and methods which other nations have developed in fostering greater competition within their markets. As construction is a major industry in Japan, it is to be expected that that industry will among the Japanese industries most affected by such change.[82]

With the internet, the borders of countries have become obliterated and today's world and new business environment is challenging the way civil engineering is practiced. The engineer's role in Japan has been different from that in Europe and the United States. Further, because the engineer's role is so varied within Japanese companies, problems as to how to grasp one's responsibilities or how to know one's range of responsibility to society has to be identified. In Japan, it is thought to be a serious social issue of how to bridge the gap between one's social duty as an individual and one's job as an employee in an organization.[83]

A further difficulty is with respect to the concept of "competition'. While in the western world, competition is a "good thing" and stimulates people to do their best work with performance increasing, in Japan, tests show the opposite. Japanese show to do better when measured against their own performance and not as compared to others.[84] However, as the Japanese Consulting Engineer prepares for working in a global environment, the very nature of competition must be understood and if the Japanese are going to successfully push ahead, it will be important that the education system identify the strengths of competition as a reality for work into today's constructed environment.

Various activities for enhancing the engineering profession in Japan started around 1995 which was triggered by the initiatives of the WTO and APEC Summit meetings to accelerate the global mobility of professional like accountants and engineers.[85] In 1995 when the WTO was formed and took initiatives to remove the barriers that not only restricted free trade of commodities, but also services. In 1996, the Human Resources Development of APEC began work for the establishment of a common regional engineering qualification called the APEC Engineer. The first registration was in 2001 with the accreditation programs announced in 2002.[86] Japan must design its future considerations on the economical and cultural interdependency on a global scale. The globalization forces Japanese companies to shift to a more globally competitive management system.

As the MLIT begins to make steps towards opening its market and changing its public contracting processes, it will need to continue to also hasten the number its learning of project management and its application to public works projects. While it has started internal projects in having its own engineers becoming Project Management Professionals (PMPs), the only way to assure a complete and effective method towards bringing consulting engineers to the forefront and to bring Japan back to its world competitive market, is to increase the education of project management and professional skills necessary to compete both domestically and in the global marketplace. This will be best accomplished by the reform of the engineering education system and the introduction of a Master's Degree level program in Professional Engineering Management which will cover the project management and professional skills that are now required of a 21st Century consulting engineer. By using this program, Japan and the Japanese Government will be able to educate the engineers of governmental organizations as well as private consulting firms and private owner companies. It is essential that Japan revise its standard conditions of contract and move from a two-party system to a three-party system together with reforming its engineering education for increasing the Japanese Consulting Engineers' capabilities.

If the problem in Japan is to be solved and if Japan is going to remain competitive on the world market it must reform its engineering education that consists in the conversion from teaching engineering science to building on the fundamental capacities of:

1) An understanding of globalization;
2) The importance of ethics and professionalism;

3) An understanding of diversity throughout engineering and the multi-disciplinary team;

4) Effective oral and written communications;

5) An understanding of leadership principles and attitudes;

6) An understanding of public policy;

7) Project management skills;

8) Risk management skills; and

9) An understanding of dispute resolution skills.

It will be these fundamental capacities that will allow the Japanese Consulting Engineers to develop into independent professional engineers capable of working both domestically and globally, respected by the public and regarded by the government as professionals whose services are to be based on qualifications and not price. The following chapter addresses the issues with engineering education today and the need to incorporate these fundamental professional skills necessary for today's 21st Century Engineer into the engineering curriculum.

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III. ENGINEERING EDUCATION REFORM

1 INTRODUCTION

> *It's the curse of the tribe. Engineers are just doomed to a stereotype that they haven't been able to shake free for years. In the past, engineering educators haven't done much to help these fledging graduates promote that cause outside the university inner sanctums. They have understandably relied on coursework heavy on technical analysis.*[87]

The content of engineering education has decreased across the globe over the past Century in an effort to reduce the cost burden to students and to turn out more engineers. While this may have increased a focus on the technical aspect of engineering, it has deleted the most critical aspect of the engineering education and studies fundamental to the very reason engineers exist-to improve the quality of life, and to serve the public with the obligation to protect the public health welfare and safety. If the engineer is not trained in public policy, ethics, leadership, communication and management skills, how does an engineer really provide for the service to the public for which the public depends and trusts?

As noted by the United States National Academy of Engineering in its recent 2005 publication *Educating the Engineer of 2020: Adapting Engineering Education to the New Century*, [Phase II Report to its previous Report *Engineer 2020]* it is noted:[88]

> *Today, the practice of engineering needs to change further because of the demands for technologies and products that exceed existing knowledge bases and because of the changed professional environment in which engineers need to operate. That change must be encouraged and facilitated by change in engineering education.*

The issue of engineering education reform is not merely a topic discussed in the U.S., the UK or Japan. It is a dilemma that has occurred for decades. For instance, as will be discussed in later chapters, one of the best well known engineers in Russia during the early part of the 1900s was Peter Palchinsky. He was a visionary and believed that engineers need to have training in social and economic skills. However, after Palchinsky's execution, and after the 1930s, engineers in the Soviet Union turned away from the broad social and economic questions that Palchinsky believed were intrinsic to the engineering task. This was derived primarily from fear which in turn resulted in engineers avoiding controversy. The education system in Russia also changed. The training of engineers was taken away from the Ministry of Education, which had been interested in broad education, and instead was turned over to the industrial ministries, whose institutes set restricted and instrumental goals for their graduates. Professors at the universities avoided issues such as politics and social justice and only concentrated on science and technology. The engineering institutions began to produce a new breed of engineers in great numbers and these engineers replaced the engineers of the pre-Revolutionary education. In the decades after 1930, the Soviet Union trained more engineers that any other country in the world, yet these engineers were more narrowly focused that their colleagues in other countries and neglected all other factors which had previously been considered paramount for an engineer to learn.[89] The same was true for Japan where the government in essence controlled the university system and the apparent goal was to develop technically oriented engineers as Japan competed primarily in manufactured products. Little has been taught in Japan regarding the societal and/or business aspects of engineering-now critical elements to both domestic and international competition.

As with Japan, engineering students in the Soviet Union had received a stunted and narrow education, were intellectually impoverished, politically tendentious, socially unaware and ethically lame. This direction did not change in Russia until the early 1990s when the disaster at Chernobyl shocked the world. Following the Chernobyl accident were several other events that rocked Russia including technical failures with submarines, transportation accidents and environmental disasters. Mikhail Gorbachev, who was trained as a lawyer, identified their cause as “human factor” using the same term as Peter Palchinsky had done years before. Gorbachev began calling for new approaches to technology with attention to social issues, economics, safety, worker benefits, environmental risks and managerial practices that took into account psychological and sociological factors. The ghost of Peter Palchinsky had come back to haunt Russia and to warn what happens when engineers ignore the practical side of engineering and the public.[90] With the nuclear accidents in Japan, similar “shock waves” have hit Japan, especially in the eyes of the public which have lost confidence in engineers. Time is of the essence-to develop engineers that understand risk, understand their ethical responsibility to society, and have the capability to understand economics. These factors must be integrated into the Japanese engineering education system.

The engineering profession is moving towards commoditization. Changing this course will take real industry leadership and a rethinking of what value is delivered to clients and how. As noted by Ralph Peterson, CEO of the world-wide engineering company, CH2M Hill: [91]

> *It's not enough to simply design and build projects. We must 1) grasp the totality of our client's mission, 2) develop solutions that add value to the client's mission, and 3) link our compensation to the value-added outcomes as defined by our clients…. No single firm can move the industry, but if our profession takes on the challenge….together we can make a difference….as the developing and developed worlds strive to improve their economic prospects and quality of life, we will come to grips with the fact that we live in a finite world. Our profession's leadership challenge is to reposition itself as an effective steward of natural resources and the environment.*

Engineering education must be transformed for the 21st Century. The transformation is being driven by the changing global environment in which the engineering profession and engineering education are embedded. While some basics of engineering will not change, the explosion of knowledge, the global economy and the way engineers will work in the future, drives the immediate need to change the way in which engineers are currently educated. The economy will be strongly influenced by the global marketplace for engineering services, a growing need to interdisciplinary and system-based approaches, and a different talent pool of engineers than exists today.[92] As the speed and pervasiveness of communication and transportation technologies have brought the world's people closer, expectations rise, and until more nations develop their own tools to solve their own issues, join the global economy, share in the benefits thereof, global stability is threatened.[93] Engineers must be at the forefront to solve these problems and to do so; their skills sets must be broadened. The engineers of the future will need communication skills, the ability to work in teams, the capacity to design complex systems, to relate effectively to other cultures, and to converse in multiple languages.[94]

In order to effectuate change, it is the engineers themselves who must take action. Engineers have to reinforce and restructure their own profession and professional practice to improve their public purpose. As technology becomes increasingly integrated into every facet of our lives, the convergence between engineering and public policy will also increase. This new level of interrelationships necessitates that engineering and engineers develop a strong sense of how technology and public policy interact. To date, engagement of engineers in public policy issues has been limited at best.[95] Reinventing engineering education reform requires the interaction of engineers in industry and academe. This is critical since most engineers work in isolated locations or in “cubicles” in industry offices and do not interact with the public the way other professions do such as the medical, legal and accounting professions. Engineers need to develop iconic images that are easily recognizable by the public and for which the public responds in a positive way.[96] Engineers should not only be enforcing their own state and/or country licensing laws to eliminate usage and/or unethical practice, but engineers must reform their educational system by:[97]

- Lengthening the content of education in order to be a “Professional Engineer” so as to mirror the other publicly known professions such as the medical, legal and accounting professions;
- broadening its economic and cultural base so that graduates can better supervise multi-disciplinary and multi-cultural teams and consortiums; and
- Including instruction in management, leadership, ethics and professionalism so that they can service society more efficiently.

Judith Ramaley, in her June 2004 ASEE Distinguished Lecture on “Engineering as the Practical Expression of Liberal Education”, summed up elegantly that the engineering education for today must seek to foster “richer social networks” in order to broaden the education into a deeper understanding of civic responsibility and international justice, about human capacity and world cultures. She recommends an approach to engineering education that:[98]

- *Develops the intellect and the capacity and inclination for lifelong learning;*
- *Shapes ethical judgment and the capacity for insight and concern for others, the world we live in, and the future we will bequeath to our children and their children;*
- *Fosters an increased understanding and openness to other cultures, languages, and societies and the connections that bind us together as fellow travelers on an increasingly connected globe;*
- *Builds an understanding of the effect of the human presence on the land and the effects of the systems we build to advance our efforts as a community;*
- *Expands our scientific horizon and our appreciation of the influence of new technologies on our lives, both as individuals and as we live them in community with others;*
- *Supports our capacity to nurture democratic and global knowledge and engagement, and…..hardest of all….helps us acquire the ability to reach out to our adversaries and those who seek to harm us and to understand why they act as they do.*

Engineering education is an investment in any nation’s future. There is an ever increasing need for a holistic breed of engineer, one that can work across borders, cultural boundaries, and social contexts and with non-engineers.[99] As we continue to move into a global and knowledge based society, the practice of engineering must be changed and this must be accomplished through engineering education reform. The engineering curriculum can no longer look like it has for essentially the past 40 years. The concepts of globalization, diversity, world cultures and languages, project management, communication, leadership, and ethics must be a core part of the overall engineering education just like physics and mathematics. To be competitive in this global and knowledge based economy and to assure that the quality of life improves for everyone around the world, engineers must be educated for jobs that will be, not the jobs that are or were.[100]

2 THE FOUR-YEAR BACHELOR’S DEGREE IS NO LONGER ADEQUATE

Comparing the historical education requirements of the medical and legal professions to the engineering profession may serve as the basis for engineers to recognize the problem. For example, American physicians in 1900 required only three years of collegiate professional sturdy with a one year of internship to graduate. In 1900 the legal profession only required two years of collegiate study. In contrast, engineering, at that time required four years of college and was recognized as the most difficult profession to enter. However, despite 100 years of experience, in 2005, not only is the engineering degree still based on a four-year program, but the number of credit hours required to receive an engineering degree has significantly decreased. Just a few decades ago, the average credit hours in the United States for an engineering degree was 140 credit hours. Today in over 50% of the curricula, requirements are 128 hours or less.[101] The engineering profession no longer mirrors the other professions and as such, its image has been degraded. Further, the public does not view engineering to be “tough” since it’s is only a four-year requirement and as such views engineers as “technicians” and not professionals. As noted by Brent Strong in his article “Beat Back the Nerd and Awaken Your Inner Leader-Why Engineers Should Read Shakespeare”, there is a disturbing tendency among engineers to just simply comply with general education requirements and not to seek a real understanding of the world, an interdisciplinary understanding based in liberal arts and humanities, one that brings enrichment.[102] Strong equates the ability for an engineer to acquire these professional skills and understand how the liberal arts and humanities embrace engineering to be akin to a “Renaissance Man or Women”.

In many ways, this is exactly what the medical profession did with its necessity to understand human behavior and to develop “bed-side manners” in order to be more effective with their clients and to develop a trust relationship with those that they serve. The medical profession found it essential to increase its collegiate study to include four-years of pre-professional study plus four years of a professional program and a year’s internship for general practice. Physicians aspiring to practice as a specialist were obligated to take an additional two-three years of study and residency in a hospital.[103] The legal profession also increased its collegiate study to seven years by 1972, four of which are at the BS or BA level.

Engineering education has many objectives which simply cannot be conveyed in a four-year study period. As Dan Pletta noted in his book *The Engineering Profession*, the objectives to which the engineering profession should aspire include:[104]

- To educate novices for the responsible practice of a specified professional art
- To transmit applicable existing knowledge after first “distilling” it for concise presentation
- To search for new knowledge that enhances the art involved
- To convey a sense of ethics and professionalism
- To motivate novices for public advocacy roles to protect its health, safety and welfare and resources and environment
- To groom societal leaders for a technological civilization that will protect freedom

Much of the reason for the lack of focus on engineering education has primarily been due to the splintering of engineering into major specialties such as civil, mechanical, chemical, nuclear, mining, electrical, metallurgical, etc. In 1980, ABET listed 21 programs in engineering and 48 in technology. Unlike the medical, legal, accounting and scientific professions which have a voice under one primary professional organization, engineering has splintered off into dozens and dozens of specialty professional associations. The U.S. National Science Foundation (NSF) whose purpose is to provide funding for research in the scientific and engineering areas, finds it difficult to evaluate individual engineering proposals when the outcome will only affect a few hundred thousand engineers, when the scientists have come together in unity with proposals that will benefit millions. The issues with engineering today is that the engineering profession has not come together to focus its efforts on what is best not only for the profession, but for the public to which it serves.

In addition, we are now entering an age of "distributed intelligence", an era in which knowledge is available to anyone, anywhere, at anytime; in which power, information, and responsibility have moved away from centralized control to the individual.[105] Within the context of a knowledge based society, engineers will play an increasing role in improving the current system of engineering education and training and therefore must equip tomorrow's engineers and professionals to shoulder growing responsibility and pursue emerging opportunities in order to balance the challenges of the world's global engineering problems such as sustainability, global warming, capacity building, the mobility of engineers and engineering education. Today's engineers are faced with challenges much different from those experienced by engineers of the last half-century. The intellect required for engineers today extends well beyond the traditional technically-based focus curriculum. The factors influencing this change include global commercial competition, opportunities offered by "intelligent technology", an ever-constantly changing work environment-all calling for astute interpersonal skills. The post graduate degrees of today must have a stronger connection to industry and to the social, economic, and management sciences. Engineering has become much more than a 4-year degree. It requires strengthening the talents for innovation and creativity and to prepare engineers to thrive through change.[106]

Engineers are all too aware that the engineering education has a half-life of at most ten years. Considering the importance of obsolescence to business and industry, to the individual and to higher education, it is not surprising that there is essentially no fundamental understanding of the dynamics of this issue. Research has demonstrated that the most engineers with master's degrees held up at least ten years longer than those with bachelor's degrees only. Thus, it is critical to look beyond the current four years of engineering education. In response to the rate of change of technology and the need to cope with the increased breadth and complexity of modern practice, major constituencies are calling for more topics in both the undergraduate and graduate curriculums. These topics include:[107]

- Management courses, including finance, leadership, and the management of human resources
- Probability
- Team work
- Communication skills-both orally and written
- Interdisciplinary project work

- Foreign language and cultural studies to compete in the global marketplace

Practically, the whole emphasis of engineering education has always been on the technical content with very little accent, if any, on professional obligations to the public. Engineering education also tends to be developed by educators instead of practitioners, and a combination is essential for the complete understanding of what is required for an engineer to best serve society. The consistent lack of emphasis on professionalism, ethics and leadership, even through doctorial study, has prevented engineers from serving society with greater efficiency. If these subjects had been included in the curriculum and emphasized in the engineering curriculum, the technical crisis of today would have been less severe and with full consciousness of their responsibility to the public, less inclination to design for obsolescence as well as the wasting of material and energy.[108]

A 2001 ASCE report entitled “Engineering the Future of Civil Engineers” noted significant and rapid changes confronting the profession.[109] Almost all discussion of educating the Engineer of 2020 presumes additions to the curriculum-more on communication, more of the social sciences, more on business and economies, ore cross-cultural studies, more on information technologies, etc.[110] Unfortunately, the typical undergraduate engineering program already requires 10% more course work than other non-technical degree programs and thus simply adding these new elements to the four-year curriculum is not the solution.[111] The 2001 ASCE report as noted above concluded that the current four-year bachelor’s degree is becoming inadequate as formal academic preparation for the practice of engineering at the professional level in the 21st Century.[112] ASCE specifically noted that civil engineering must restructure its 150-year old education model to meet the challenges of the 21st Century. Education beyond the four-year bachelor’s degree will provide the knowledge, skills and attitudes necessary to ensure the high standards of the profession and protect the public safety, health and welfare.[113]

The United States National Academy of Engineering in its 2005 Phase II report on *Educating the Engineer of 2020: Adapting Engineering Education to the New Century* recommends that the four-year bachelor program merely be considered a pre-engineering or “Engineer in Training” degree and that a Master’s Degree be considered that is accredited and universally recognized and promoted by both schools and engineering societies as a “professional degree: similar to that of a Masters in Business Administration, but geared towards the needs of the Engineer of the 21st Century.[114] It is interesting that this recommendation is in reverse of what was recommended by W. McGuire, a professor at Cornell University in 1989 when he indicated those wishing to study engineering should have a pre-engineering undergraduate degree that emphasizes humanity, social studies, mathematics, basic engineering sciences to them be followed by a professional program which was more akin to the progression of study in the medical and legal professions.[115]

While the current thinking is more focused to meet the needs of knowledge based society, the need for the professional skills has been debated for decades. It is now time to end debate and execute. It is the intent of this author to propose a Master's Degree program which would meet the NAE's recommendations. The remaining chapters set out the subjects that would be covered in the proposed Master's Degree and the last chapter sets forth the recommended curriculum.

3 ENGINEERING ACCREDITATION IN THE UNITED STATES

The American Association of Engineers in the 1920s established the Committee on Accredited Schools and called for more comprehensive and discriminating standards for evaluating engineering schools. Recognition of the quality of education pulled together the National Council of State Boards of Engineering Examiners (NCEES) and other national engineering organizations to form a joint committee to set up improved standards for accredited schools. The committee called for the formation of the Engineers Council for Professional Development which later became known as the Accreditation Board for Engineering Education and Technology (ABET). In the United States, ABET is an organization of member societies in engineering and engineering-related fields. As part of its mission, the ABET accredits educational programs and promotes quality and innovation in education. Its purpose as noted in the ABET Constitution is:

> *The purpose of this organization shall be the promotion and advancement of engineering education with a view to furthering the public welfare through the development of the better-educated and qualified engineer, engineering technologist, engineering technician, and others engaged in engineering or engineering related work.*

In 1995, ABET set out the draft of "Engineering Criteria 2000 (EC2000)" as a mandate to educators to design curriculums that could produce engineers with the right skill sets to enter the job market. On November 2, 1996, the ABET Board of Directors approved what was initially known as the Engineering Criteria 2000 but is now known simply as the ABET engineering criteria. In the new criteria, there are a set of eleven outcomes that all engineering baccalaureate graduates should possess. The goals for the criteria were universally and simplicity. The criteria writers concentrated on what it was that all engineers should be able to do which resulted in eleven desirable outcomes, no matter what the discipline. The criteria can be divided into two categories: “hard skills” and “soft skills” or what is becoming increasingly better known as “professional skills”. Six of the eleven outcomes address the professional skills including:[116]

- an ability to function on multi-disciplinary teams
- an understanding of professional and ethical responsibility
- an ability to communicate effectively
- the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental and societal context
- a recognition of the need for, and an ability to engage in lifelong learning
- a knowledge of contemporary issues

The American Society for Engineering Education’s (ASEE) 1994 *Engineering Education for a Changing* World calls for these professional skills.[117] The ABET EC2000 accommodates the ASCE “Body of Knowledge” discussed earlier.[118] However, while curriculums at many colleges and universities and corporations have been tweaked and even overhauled in some cases in response to ABET’s criteria, the quandary is how fast are the new approaches being woven into the coursework? In general, there appears to be a frustration on both sides that it is not happening fast enough.[119]

The most difficult piece to address has been basic communication skills. The issue has also been that those in the past that have been attracted to engineering have not necessarily been individuals that are naturally proficient in these skills. An understanding of the mere technical nature of engineering will today only get you so far. Engineers must now be well-versed in technical writing, oral presentation skills, people skills, marketing skills, consensus building, and real world survival techniques, no matter what their discipline. ABET continues to work though these issues in order to better the curriculum, however, many universities are still struggling of how best to meet industry’s needs. According to ASEE, employers want an engineer to be able to do the following in his/her career:[120]

- An ability to apply their knowledge of mathematics, science and engineering to design, conduct experiments, and analyze data
- An ability to perform on multidisciplinary teams and communicate effective solutions in a global and societal context. That means a smattering of everything from history to sociology to psychology
- A yen for lifelong learning
- A bona fide knowledge of contemporary issues

The ABET EC2000 criteria is a first step, however, it is not possible to educate engineers in an undergraduate degree the full understanding that is required in the professional skills. While several recommendations and universities have made steps in integrating these soft skills within current engineering curriculum as described in a paper by L. Shuman, M. Besterfield-Sacre, J. McGourty, entitled "The ABET "Professional Skills"-Can They be Taught? Can They Be Assessed?" *The Journal of Engineering Education,* ASEE, January 2005, Vol. 94, No. 1, in order to fully educate engineers to be proficient in the professional skills required to lead and to become policy makers, it will be necessary as recommended by the US National Academy of Engineering to have a Master's Degree which will then provide in-depth studies on these issues. It will then be necessary for ABET and other accrediting bodies of the world to recognize these degrees and universities that provide them as an accredited program. Only in this way will graduate engineers be willing to go back to school for a Master's Degree in this area of engineering education. It will be necessary for ABET (or other government body accreditation institutions) together with industry and engineering professional societies to work together on this critical issue and in concert with one another, promote the benefits of such a degree and encourage all engineers to go forward with higher education. Only in this way will the engineering profession protect its members, the engineers, from becoming a commodity on the world market and to gain the public trust and recognition that is required to move engineers to a higher plateau.

4 ENGINEERING EDUCATION AND ENGINEERING ACCREDIATION IN JAPAN

In the Meiji restoration period, education was paramount. It was an Englishman, Henry Dyer of Glasgow in the UK who in 1873 founded the Engineering College.[121] He promoted the establishment of the engineering college indicating that there were two different ways to educate engineers. One system was based on the Franco-German method based on theory.

However, Dryer believed that the only way to produce competent engineering personnel was to have a combination of both practical and theory and he did so in the Japanese engineering college. This college was transferred to the Ministry of Education from the Ministry of Works in 1885 and in 1886 was merged with the Imperial University. The school was reorganized into the engineering college in 1877 under the direction of the Ministry of Works.[122] Tokyo University grew out of an amalgam of three shogunal schools inherited from the Tokugawa period - a Confucian academy (later dropped), a school of medicine and a school of foreign language, which after several reorganizations was named Tokyo University in 1877.[123] In the same year, Tokyo Kaisei School joined Tokyo Medical School to form Tokyo University and the education to the civil engineer was provided in the section of the construction under the Department of Science. In 1885, the construction section was separated from the department of science to form the department of art/construction. One of these faculties later became the department of civil engineering.

In 1886, Tokyo University became the Imperial University, but in 1897, Kyoto Imperial University was founded and the Imperial University changed its name into Tokyo Imperial University. In the same year, the department of the art/construction of Tokyo University merged with the Institute of Technology to form the Technical University of the Imperial University and Kimitake Furichi, a civil engineer, became its first President. The Institute of Technology was set up in 1877 after the Engineering College of Department of Construction that was founded in 1871 was renamed and made more complete. [124]

When Japan's industrialization began to take off in the 1950s and 1960s, the demand for workers with a certain set of skills naturally increased. However, the Japanese system of education was poorly equipped to provide the kind of training that was desired by Japanese firms at the time. Despite the energetic strides towards modernizing the education system in Japan during the Meiji era, the education system was still heavily influenced by the oriental tradition, which means mastery of eastern classics and Chinese literature. While Japanese companies expanded during the period of high growth, the education system was not able to keep up with the rapidly expanding demand for skilled workers that the high growth required.125 While Japanese society may be dominated by engineers, few engineers in Japan are engineers in the western sense or even in the Asia sense as China moves its engineers towards a model of business oriented thinking.[126] Indeed many Japanese engineers are simply technicians. When a Japanese firm then needs to have specific skills, they merely train the engineers in-house to develop and acquire the skills that are needed to practice in that particular company.[127] The biggest difference between Japanese and U.S. students is that the Japanese students lack ambition and vitality.[128]

Many nations around the world have come to understand and appreciate the integration of industry with the universities in preparing today's engineers for the future of tomorrow. However, the concept of university and industry partnerships was not introduced in Japan until 1994. Tsukuba University's President, Dr. Leo Esaki, with partial support from Monbusho, established the first university-based organization in Japan that cultivated the interactions between academic institution, industry and government and was called the Tsukuba Advanced Research Alliance (TARA). To demonstrate the importance of the need for such a program, the annual operating budget at the time was 5 billion yen, with funding derived from funding by other government agencies and from contract and joint research with chemical, pharmaceutical and electronic manufacturers.[129] It is noted that the construction industry did not participate and still has little involvement in the university system.

Recognizing the success of this program, in 1996, the Japan Science and Technology Basic Plan was adopted which singled out university-industry cooperation as a key strategy for enhancing Japan's R&D infrastructure. In 1997, the Japan government proposed six major reform efforts that include education reform. Specific measures that were being proposed and under consideration at that time by the education ministry (Monbusho) and to be adopted by the Ministry of Education, Science and Technology included:[130]

- Enhancing information exchange between universities and industry
- Modifying personnel policies and intellectual property regulations, to enhance exchanges of personnel
- Promoting regional cooperation
- Promoting more effective utilization of research results.

In mid 1997, under support by Monbusho, a 4-year effort was launched for a university-industry program on Global Engineering Education (GEE) in order to provide a broad and modern engineering education experience for undergraduates, embodying many of the elements of the U.S. ABET EC2000. It was initiated by Professor H, Ohashi-President of Kogakuin University and a member of the Science Council of Japan and a past president of the Japan Society for

Mechanical Engineers where the university and industry worked together on an engineering curriculum focusing on: fundamentals of engineering, communication skills, and international perspective including ethics, creativity, and management skills. Thus, some models for some of the suggested course in the master's degree curriculum appears to have already been "tested" on a small scale in Japan and which may be able to serve as a foundation for course development in other Japanese universities.

In December 1998, the President of the Science Council of Japan (SCJ), Dr. H. Yoshikawa, made a public declaration in which the following issues were highlighted:[131]

- The safety and reliability of modern society depends heavily on artifacts (artificial products: buildings, vehicles, IT devices, and systems, etc)
- Engineers are totally responsible for artifacts, throughout planning, developing, designing, manufacturing, and operating phases, engineers must be qualified to accept such responsibility
- Society should recognize the role of engineers properly. To obtain the public understanding, there must be a publicly acceptable system that assures the professional qualification of engineers.
- The introduction of a Japanese version of Professional Engineers is urgent, that should match, of course with global standard.
- The introduction of an accreditation system of engineering education on university level is also urgent. Accreditation not only offers basic education for qualified engineers, but also generates strong driving force for improvement of university education.
- To maintain the lifelong expertise of engineers, the introduction of Continuing Professional Development (CPD) must also be incorporated.

A committee named "Global Engineers Education Committee" headed by Dr. Yoshikawa was founded in 1987. After much discussion over many years, on November 19, 1999, the Japan Accreditation Board for Engineering Education, or JABEE was founded.[132] The criteria mirror much of the same criteria as set up by ABET in EC2000. The introduction of engineering ethics and enhancement of communication capability are two areas that are to be highlighted in the Japanese engineering curriculum.

However, while steps have been taken, major engineering education reform is still needed in Japan if Japan is to remain competitive in both the domestic and the international markets. In order to move Japan ahead, the entire Japanese engineering education reform must center on four key areas:

- The need to have fundamental training in engineering basics with university global recognition through the JABEE accreditation process
- The need to develop engineers to become globally competitive in the ten basic skill sets
- The need to certify engineers both domestically and internationally and;
- The need to require life long learning with continuing professional development.

Today presents a unique opportunity for Japan, an opportunity that should be seized quickly before the opportunity passes it by. Japan is now in a transition period with engineering education. Up until 2003, universities have essentially been government institutions obligated to follow government rules and regulations which in most cases prevented them from doing anything new.[133] As discussed in the Heads of Research Councils in Asia, it is now time to reform the Japanese national university system. Three points of university reform were noted: (1) Merging national universities-being carried out to strengthen education and research, (2) Converting national universities to "Corporations" which will allow universities to have more control over their operations and management and (3) fostering universities of the world's highest standards in order to create universities with vitality and international competitiveness through participation in "The 21st Century Center of Excellence (COE) Program". [134] The COE program will allow Japanese universities to compete with each other for funding challenging them to raise their standards of education and research to the world's highest levels. The program started in 2002 with a budget in the first year of 150 million dollars and in 2003 increased to more than 280 million dollars.[135] It is recommended by the author that Japanese engineering universities take advantage of this COE program to further enhance the development of a Master's Degree program for engineers in order to provide the professional skills that are missing and are critically needed if Japan is to survive both domestically and internationally in consulting engineering services.

Japan and the United States have been two of the leading nations in the world in engineering education and practice. However, their systems for training and educating engineers display marked contrasts, resulting from each of their respective differences in economic and cultural environments.[136] A joint task force of the U.S. and Japan, organized by the Committee on Advanced Technology and the International Environment (Committee 149) of the Japan Society for the Promotion of Science (JSPS) and the Committee on Japan (COJ) of the National Research Council (NRC) worked together to determine the differences in educating engineers and how can engineering education in the two countries and around the world be improved? The panel also reviewed two critical issues that will affect engineering education in both countries in the future: the need to educate and train "global engineers" who can effectively work in international contexts, and the potential for information technology to transform engineering education in the future.[137]

The finding for Japan was that Japanese engineers will face significant challenges in the future, and their education and training must adapt to new realities in order to adequately prepare them. It was noted that Japanese industry and companies invest heavily in continuing education for employees and that this partnership with universities must continue in the future. This was recommended through visiting lectureships, internships, continuing education and global engineering training. Similar recommendations were made with respect to the United States. The report noted that both countries face similar challenges related to engineering education in the next century including attracting numbers of young people and particularly women and minorities. Both countries need to advance international cooperation and to build upon current strengths while at the same time provide education that produces engineers to possess not only a firm grasp on engineering fundamentals, but to have sufficient creativity to meet unfamiliar tasks, increase their skills and capabilities to operate effectively in a variety of international environments.[138]

A key common denominator throughout the past decade, is that university-industry collaboration is a cornerstone in the reemergence of industrial competitiveness in the US, and Japan must do the same for it to break out of the current economic situation, a situation characterized by rising unemployment, an aging population and growing government budget deficits.[139]

5 ENGINEERING MANAGEMENT/CONSTRUCTION MANAGEMENT EDUCATION IN JAPAN

Research regarding the teachings on construction management within Japan found the initial ideas centering on construction management dates back to 1976 when JSCE formed the working group on "Construction Management Problems." The work provided an opportunity for researchers in industrial, governmental, and academic fields to meet for discussion on problems of construction planning that had not previously been systematically investigated.[140] The JSCE Construction Management Committee was formed in 1985 with its research objective having been expanded from the field of construction work planning and management to cover construction project planning and overseas project management.

Construction management has begun to only evolve in Japan in the last decade. Prior to that time, civil engineering education in Japan was divided into five fields: structural engineering, hydraulics, soil engineering, planning in civil engineering, and concrete engineering. Thus, construction management studies were only a subset of the planning in civil engineering category. By contrast, universities in the U.S., Europe and Australia treated construction management as a separate field and with an entirely independent course study and in many cases, degree. It was not until 1993, that a lecture in construction management was offered at the University of Tokyo in the Department of Civil Engineering. Construction management research activities began at Kyoto University around 1970, but few researchers and educators actually specialize in this field.[141] By 1999, Tokyo University had a Construction Management department where primarily construction oriented project management was taught.[142]

In 1997, the Project Management Department was established at Chiba Institute of Technology and offered the first course, unlike the first lecture, teaching project management in a Japanese university. With an emphasis on practical education to prepare students for careers as project managers, there were three course options: Project Engineering Management, Software/IT Project Management and Project Business Management. One was expected to be the student's major and the other two their minors. The graduate school offers continuing education for undergraduate students but is designed to accept students from other departments.[143]

Engineering and construction companies operating in the oil and gas, chemical, industrial and large infrastructure projects are the main users of modern project management in Japan.[144] However, Project Management training is still mostly performed in-house at large contractor organizations. Three-week courses, including Project Management, sponsored by ENAA twice a year are well utilized. ENAA affiliated Japan Project Management Forum (JPMF) also has series of programs that are open to the public throughout the year. JPMF is a professional Project Management organization supported by ENAA. Its mission in 1999 was to establish a national center of excellence in project management. JPMF carries the following objectives:[145]

- To advance professionalism and individual and organizational capabilities of project management in Japan by utilizing those who practice project management, advocate increased business profitability and productivity through managing by projects, teach and research project management, and provide methodologies, technologies, and tools for project management.
- To help enhance the social and industrial recognition of the project management discipline and project management professionals.
- To provide forums for matters that concern project management.
- To cooperate with the world's project management community for cross-fertilization and global advancement of the project management profession and discipline.

In 1999, Chiba Institute of Technology was still the only academic institution which had a dedicated Project Management department. Project Management is also being taught in the engineering curriculum at several universities. As noted earlier, Tokyo University has a Construction Management department where unique construction oriented project management it taught.[146] The trend is positive. There is a growing interest in the Project Management Institute Body of Knowledge (PMBOK) and Project Management Professional (PMP) certification in Japan. Through discussions with the MLIT, the author notes that there is an increasing demand for MLIT engineers to become more knowledgeable in the area of Project Management and the PMBOK. The MLIT is also promoting PMP certification. Applications for PMP certification have increased dramatically over the last ten years.[147]

Now is the perfect opportunity for Japan to move ahead in engineering education reform and to incorporate project management into the engineering curriculum. On April 1, 2004, public universities were spun off from under the Education, Culture, Sports, Science, and Technology Ministry and are now independent nonprofit institutions with private-sector-style management. Schools must now submit six-year plans and pass regular evaluations in order to secure funds. The Japan Times calls the streamlining movement "the most significant change to Japan's higher education system in more than a century."[148] Accreditation in Japan is just beginning its sixth year of existence. Accreditation Chief Fukusaki has indicated: "Public Universities were alike with the same philosophy, now they have to redevelop their own goals and objectives."[149]

A survey of the Japanese engineering schools that was released in February 2004 by the leading business daily Nihon Keizai Shimbun, noted that several of the "traditional" schools such as the University of Tokyo, Kyoto University, Kyushu University and Hokkaido University did not make the top 10. They were replaced by upstart private schools strong in research, patent applications, and industry ties. Only two prestigious universities appeared in the top 10: Osaka University ranked first overall and Tohoku University ranked third. Osaka has been one of the leading centers for adoption of American-style, project-based learning (PBL) programs. Much of the ferment in Japanese engineering education seems inspired by events at MIT or Stanford, and recognition that the Japanese engineering education is deficient.[150] Thus, the author recommends that with the new freedom experienced by Japanese universities, that university Presidents take note of the proposed Master's Degree program suggested by the author and consider programs similar to that proposed which will include university and industry partnerships and will allow practicing engineers to reenter the education system while still working at their respective companies. In this way, Japan has the opportunity to regain its competitive edge on the world stage in consulting engineering.

6 STEPS FORWARD[151]

6.1 The Trend of Engineering Practice

The practice of engineering continues to grow increasingly more complex. Due to the rapid rise in information technology, the explosion of knowledge in engineering and construction, enhanced public awareness and involvement in engineered projects and the growing complexity of civil infrastructure systems in the U.S., the job performed by the engineer continues to become more demanding. Engineering is a global profession and engineers from multiple countries must work together to design and construct and manufacturer today's projects and products. Information technology has accelerated communication and has allowed the world to work together 24 hours a day, seven days a week. Interdisciplinary engineering is moving ahead as any project or product today combines multi disciplines of engineering. This trend is likely to accelerate, not slow down, in the future. Engineers are expected to possess both greater breadths of capability and greater specialized technical and managerial competence than was required of previous generations. Thus, the engineering practice is going to require engineers to take a broader view of their work environment and is going to require engineers to interact with the public and policy makers on a regular basis. This will require not only communication skills, but the ability to have negotiation skills while at the same time always remembering their ethical responsibility to society.

6.2 The Trend of Engineering Education

The trends of engineering practice demand a change in engineering education. Most of the senior members of our profession likely graduated from baccalaureate programs which required 145 to 160 credits for graduation. The norm today typically ranges from 120 to 135, and these requirements continue to be reduced steadily, not by engineering programs but by universities and legislatures. The effects of such reductions are significant on engineering programs and their coverage of technical and managerial subjects. This trend is also likely to continue into the future; there is no indication of its reversal. How can engineers continue to do more, with less education? The answer is they cannot and if engineers, academe and industry do not work with government to effectuate change, engineering will cease to be a profession and will be a trade on the world commodity market. The time is now and time is of the essence in which change must be made on a global front. Key nations, however, including the U.S, the UK and Japan must be the leaders in this change and must take action in collaboration with each other if we are to truly make a difference in the near future.

The ASCE Body of Knowledge (BOK) and the skills required to practice civil engineering at the professional level are not significantly less than the comparable knowledge and skills required by many other professions. Yet the minimum education requirement for civil engineering – a four year BSCE degree – falls short of the requirements for many other professions including accounting, architecture, occupational therapy, pharmacy, law and medicine. Accountants in the U.S. are nearing completion of a fifteen-year transition to require 150 semester credits for CPA licensure.

The combination of added educational demands and declining credit hour requirements has had a significant impact on undergraduate engineering education. There has been a decline in the required core engineering coursework which crosses discipline lines. Civil engineers are increasingly less likely to be required to take courses such as thermodynamics and electrical circuits, affecting the breadth of their technical education. Some engineers now take a one semester course entitled statics / dynamics. Basic engineering coursework requirements within disciplines are also decreasing in many universities, as evidenced by transportation engineers who haven’t had surveying and thus lack the basics of geometrics, or electrical engineers who understand power distribution but not controls, or vice versa. Further, the practice of civil engineering has become increasingly more complex technically in the past 30 years, yet the technical content of the undergraduate curriculum has not changed substantially during that period. *How can more complex technical issues, resulting from decades of engineering research and technology-driven changes in professional practice, be added to an otherwise over-full undergraduate curriculum in the face of declining credit hour requirements?* In ASCE's view, it's not possible in the future.

6.3 The Civil Engineering Body of Knowledge

A few years ago, ASCE's Committee on Academic Prerequisites for Professional Practice (CAP^3) published the First Edition of the "Civil Engineering Body of Knowledge for the 21st Century" (see www.asce.org/raisethebar). The BOK was being prepared to establish the knowledge, skills and attitudes necessary for graduates to effectively enter licensed practice. The BOK report proposes building upon the existing 11 ABET EC2000 outcomes, by adding four additional outcomes to those incorporated within existing accredited undergraduate curricula. The additional outcomes include additional technical engineering depth in one or more areas and additional breadth in the following areas: project management; finance; business and public policy and administration; and leadership. The additional breadth components might eventually be incorporated into undergraduate engineering curricula, leaving additional education beyond the bachelor's degree to consist of a flexible program of additional depth and breadth in engineering and professional practice topic areas.

It is important to note that the NCEES-sponsored Engineering Licensure Qualifications Task Force (ELQTF) came to a similar conclusion regarding engineering education. While the ELQTF recommendations have not been adopted by the NCEES, the Licensure Qualifications Oversight Group is also studying this recommendation.

7 ENGINEERING EDUCATION PROVIDERS OF THE FUTURE

ASCE's "raise the bar" initiative is intended to apply to all engineering graduates seeking licensure, not just those who choose or are able to attend graduate school. It is anticipated in the future that those attaining bachelor's degrees in engineering will be able to attain the additional required education in a variety of ways, including the increasing use of distance education from quality engineering institutions, and the use of in-house education programs in firms, agencies and technical societies able to provide educational experiences which are documented to be equivalent in content, rigor, learning and assessment to current engineering education. It is also ASCE's contention (this is part of another active ASCE initiative) that those who teach engineers should predominantly be licensed; a topic for another day and is discussed in more depth in the Ethics and Professionalism Chapter.

The move forward will require collaboration between academe, industry and professional engineering organizations. The issue of engineering education reform is being addressed the world over. The subject is of keen interest to the World Federation of Engineering Organizations (WFEO) and UNESCO. Concern by engineers the world over is that if engineers are not educated to deal with these professional issues soon, then the world itself is in peril since the increasing world population, especially in under-developed countries, will continue to challenge the world's resources. Sustainability and the understanding of globalization are critical to the survival of the world population as we know it today and to the premise of the idea that everyone is entitled to "a better quality of life". Engineers will have to develop solutions to deal with these new world problems. However, in order to do that, they must understand world politics and public policy, diverse team concepts, project management, as well as have the ability to communicate this information to others and become effective leaders. This can only be done through education and education beyond the undergraduate degree. It is now time to devise a Master's Degree that addresses these critical issues and to have accrediting organizations; industry and engineering organizations embrace such a degree in order to promote current and future engineers to embark on this critical engineering education.

8 CONCLUSION

> *As Engineering is the agent of progress and so the agent of transformation of human life, it is time not only to meditate but to change and to do effectively something to make it better.*[152]

If engineers are truly going to be prepared to work in a knowledge-based 21st Century Society, across all borders of the world, then there must be an immediate reform to engineering education. What is needed is a master's degree program that will provide the skill sets that are required to work in a global economy, but are lacking from today's engineering curriculum, either at a bachelor's or a master's level. Innovative and creative ideas must be considered in order to motivate both the employer as well as the current working consulting engineer to reenter the academic environment in order to gain the required skill sets that will result in a win-

win situation for both industry and academia and the individual. Thus, consideration must also be given to reaching beyond traditional forms of engineering education in order to accommodate the working consulting engineer. New forms of education include distance learning, cooperative education between industry and academia as well as special lecture series which can be accomplished in an intensive week of full day education requirements from practitioners in the industry. Effective master's programs require flexible structural characteristics, strong institutional and faculty support, and educational components that give students a sense of identify with engineering practice.[153] The new master's degree must still be structured within the required 30 credit-hour required program, but it is how those 30 credit hours of education is provided which is critical if the engineering profession is to truly revolutionize the way engineering education is taught and to prepare the Engineer of the 21st Century.

The chapters that follow present a more focused definition of the proposed professional skills for the 21st Century Engineer. While each chapter is not intended to be a stand-alone textbook on the subject, each chapter is intended to present the professional skill sets required and minimum knowledge to be included in a course on the subject. The specific course outline would need to be designed to best meet the needs of the individual university and industry focus. The chapter which follows the proposed professional skills is the author's proposed master's degree program and is based upon the skill sets outlined herein and the succeeding chapters.

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IV. GLOBALIZATION[154]

1 WHAT IS GLOBALIZATION?

1.1 Introduction

Globalization is a term used to describe the changes in societies and the world economy that are the result of dramatically increased trade and cultural exchange. Globalization refers to the increasing integration of nations through tariff, investment, transfer of technology, and exchange of ideas and cultures. As defined by the Canadian government on its Web site, "*the term 'globalization' describes the increased mobility of goods, services, labor, technology, and capital throughout the world. Although globalization is not a new development, its pace has increased with the advent of new technologies, especially in the area of telecommunications*." The process is characterized by an increase in the connectivity and interdependence of the world's markets and businesses. Globalization can be defined as "the conquest of the market economy all over the world". Ten years ago, the entire market economy population of the world was approximately 500-600 million centered in the United States, Canada, Japan and Western Europe. However, today, over 6 billion people live in the world "market economy.[155]

Globalization has become identified with a number of trends, most of which may have developed since World War II. These include greater international movement of commodities, money, information, and people; and the development of technology, organizations, legal systems, and infrastructures to allow this movement. Some of the trends include:[156]

- Increase in international trade at a faster rate than the growth in the world economy
- Increase in international flow of capital including foreign investment
- Greater transborder data flow, using such technologies such as the Internet, communication satellites and telephones
- Greater international cultural exchange
- Spreading of multiculturalism and better individual access to cultural diversity
- Erosion of national sovereignty and national borders through international agreements leading to organizations like the WTO
- Development of global telecommunications infrastructure
- Development of global financial systems
- Increase in the share of the world economy controlled by multinational corporations

- Increased role of international organizations such as WTO, World Intellectual Property Organization (WIPO), International Monetary Fund (IMF) that deal with international transactions
- Increase in the number of standards applied globally; e.g. copyright laws

Globalization has led to more companies pursuing the same customers. Customers have become more sophisticated and informed buyers. Information technology enables them to find and analyze products and services and allowed them to make more intelligent choices. The 21st Century will be written in the history books as the era of the knowledge based society. Knowledge and continuous learning are now critical elements of success. In this new economy, the knowledge component of services has increased dramatically in importance and has become the dominant component of customer value. The shift to the primary source of value makes the new economy led by those who manage knowledge technology effectively - who create, find, and input knowledge into new products and service faster than their competitors will survive and thrive.[157] The sharing of knowledge has been greatly enhanced by innovations to information technology. Innovation is the biggest factor affecting the economics of nations around the world. Innovation is the biggest driver to success and requires higher education in technical areas.

Today's interdependence among societies - economic, political and cultural - is unprecedented. The world's economy has become tightly linked with much of the change having occurred due to technology itself.[158] Much of engineering projects today are accomplished using a combination of both virtual as well as multi-cultural teams. These teams can often function across multiple time zones, multiple cultures, and multiple languages.[159] Information sharing can now be done 24 hours a day, 7 days a week and from anywhere around the world using the internet connectivity. The productivity of local engineering groups can be markedly enhanced by globally dispersed "round the clock" engineering teams.[160]

As the world becomes more global and as the world population increases, engineering will play a vital role in addressing concerns of the global community such as decaying infrastructure and deterioration of the environment. Engineers will change considerably from what engineers look like today as issues that control international trade of professional services-international licensing requirements, international codes and standards, and international treaties and trade agreements affecting engineers are created and finalized. Further, engineers must consider how international policies regarding intellectual property rights, emerging markets for engineering products and services, and other factors affect the practice of engineering and the education of future engineers.[161] Engineers will need to be leaders in the movement toward use of wise, informed, and economical sustainable development. Engineers will need to be prepared to adapt to changes in global forces and trends to ethically assist the world in creating a balance in the standard of living for developing and developed countries alike.[162] In the 21st Century, science and technology are key factors for the human well-being as well as global competitiveness. It may not be too much to say that they depend on engineers. To that end, quality of engineers should be more improved than ever before.[163]

Over the last century, the world's population has grown from 1.6 to 6.3 billion. Over the next 10-15 years, the world population is estimated to increase by another 1 billion. This increase will have a great impact on the health of the environment, the maintenance of infrastructure, waste management, and other significant health and safety concerns. New discoveries and inventions have enabled engineers to develop science and technology to the great benefits of humankind. As engineers embark on the new millennium, engineers must be acutely aware of global problems that we were ignorant of a few decades ago such as global warming, destruction of the environment, energy and water shortages, all which threaten the sustainability of our world.[164] One of the extremely important opportunities is that the world has agreed that sustainable development is more important that any other goal-the impact of the Rio conference, the impact of climate change in Kyoto, recent global warming, the ozone thinning, etc. Engineers need to figure out how to sustain, and then produce that spark to make a sustainable development real.[165] Engineers will need to develop innovative solutions using the latest relevant technology, and provide effective and efficient communication and transfer of data across national borders.

With this in mind, what is the role of the engineer in the area of globalization? Our role is to build the quality of life. But in building that quality of life, we as engineers must be the leaders in today's engineered and constructed Projects around the world. Globalization is a word that should be in our everyday language and a word which all engineers must not only understand, but learn how to incorporate in our everyday business and professional lives. Our mission, as engineers, is to ensure that there are no boundaries in how we build the quality of life. Globalization of the engineering profession will lead to greater access to world markets, competition and the freer flow of goods, services, capital and knowledge. However, the challenges facing the engineering profession due to increased globalization including defining engineering global ethics (see chapter on ethics), developing procedures for international licensing of engineers and increased mobility, the development of international standards, the need to develop a common understanding and common objectives for sustainability and the need for consistent engineering education which includes a global understanding of risk and project management in order to produce a consulting engineering professional who can work and compete anywhere in the world.

1.2 The New Business Landscape

There is a new global business landscape. And that business landscape – worldwide – is what will determine how and where we as engineers will conduct our business in this third millennium. So we, as engineers better realize, understand and appreciate that we are now working in a borderless world where the borders that used to enclose our particular discipline or industry have been obliterated. Obliterated by the need for total delivery packages which includes the planning, the financing, bonding and insuring, the design and construction, the construction equipment, as well as the installed equipment, the operations and maintenance and the ultimate re-use or disposal of the built environment. Obliterated by the belated recognition for our need for sustainability and improvements to the way we treat the world we live in.[166]

There is not a construction project today that is truly domestic, even if constructed in our home country. Financing, materials, special pieces of equipment, and/or engineering technology come from all over the world in any project constructed today. And for those of us that are involved on a global basis, we need to recognize that understanding the whole financial and commercial structure by which we get this kind of globalization to function is essential. We cannot sit inside a little engineering cocoon. Engineering excellence is merely a step. Engineering innovation and brilliance is merely a step. The true contribution of the engineer is that they know how to make all these concepts integrate and function together.

We are also living in a borderless world where the borders that still enclose our individual nations have been breeched. Significant progress has been made around the world since the General Agreement on Tariffs and Trade (GATT) was accepted in 1947. GATT has been the most significant international agreement contributing to the elimination of trade barriers. Average world tariffs have been reduced from roughly 40 percent to fewer than 5 percent. The world's trading nations have agreed to a set of rules covering trade practices, including government procurement practices.[167] However nations independently increased their reliance o other forms of protection, or invented new ways to shield favored domestic industries from competition.

To deal with these barriers and to cut tariffs further, the U.S. Reagan Administration in 1986 launched the Uruguay Round of trade negotiations among 117 countries. Final agreement was reached in 1993, and the act was signed on April 15, 1994. With the conclusion of the Uruguay Round and the creation of the WTO, nations have gone into a new cooperative phase.

The impact of globalization in Asia really began at the end of the Cold War Regime in the beginning of the nineties. Since then, the expanding economic activities and rapid diffusion of information technologies have been diminishing walls between nations. In such a borderless age, individual nations cannot survive in seclusion, but only in the economical and cultural interdependencies on the global scale. The year 1995 was especially important for the engineering profession in Asia. With the WTO born, initiatives were taken to remove the barriers that restricted free trade of not only commodities but also services and the WTO enacted the General Services Agreement on Trade in Services (GATS) in January 1995. GATS stipulates that the accreditation and licensing requirements for engineers are to be open, transparent and nondiscriminatory, and that they system of accreditation should encourage liberalization of the professional engineering trade.[168]

In accordance with this movement, APEC leaders gathered in November 1995 at the Osaka Summit Meeting to adopt a resolution to accelerate mobility of registered engineers within the region. In 1996, APEC Human Resources Development Working Group (WG) of APEC began energetic cooperation among member countries to establish a common regional qualification, called the APEC Engineer. The final agreement on the requirements for APEC Engineer was settled in the Sydney Meeting of the WG in November 1997 and monitoring committees were founded in member countries for the registration of the new regional qualification. As the framework of the APEC Engineer showed promise, the Japanese Government in 1996 started to revise national systems to make them compatible with the APEC or "global" systems. Two major issues arose: 1) the introduction of accreditation systems of engineering education at universities and 2) revision of the "old-fashioned" Professional Engineers Law. The former resulted in the establishment of the Japan Accreditation Board for Engineering (JABEE) in 1999 and the latter by the amendment of the law in 2000.[169] However, Japan as a nation has still not truly broken down many of its barriers to foreign suppliers and contractors. These barriers thwart the international system's promise of full and mutual access to major markets and will continue to hinder the Japanese ability to move forward as leaders in the construction arena.

This borderless world is now recognized throughout the world on all continents. The European Union (EU) on the other side of the Atlantic with the uniting the European Countries, as well as the North American Free Trade Agreement (NAFTA)'s approach to an economic union, initially of Canada, USA and Mexico and hopefully eventually all of the Americas, trying to bring simplified procedures to all nations sharing the Andean mountain range. NAFTA was passed in January 1994 and created the world's largest free trade area. Chapter 12 of NAFTA governs the Cross-Border Trade in Services and specifically governs professional services. NAFTA encourages and provides for trilateral reciprocal licensing of engineers in the United States, Canada and Mexico, prohibiting unnecessary obstacles to cross-border trade of professional services. However, the process of obtaining licensure between the three countries is not fully developed and may be difficult and time consuming with different procedures in each country.[170]

Latin American is the second-fastest growing region of the world after Southeast Asia. Overall trade between Latin American/Caribbean (LAC) region and the United States grew from approximately $44 billion in 1988 to almost $100 billion in 1994. The United States exports to Latin American, mostly of manufactured goods, more than doubled between 1985 and 1993, from $31 billion to $73 billion.[171] LAC nations are no longer the debt-ridded, protectionist regimes so prevalent in the past. They are experiencing sustaining economic growth and generally declining inflation as a direct result of aggressive implementation of macroeconomics reforms, market opening initiatives and restructuring. Development of the Free Trade Area of the Americas (FTAA) was considered at a Miami summit in 1994 with drafting of terms for the agreement in 1998. Once finalized, it will be the largest free trade association in the world and will be greater in scope than NAFTA, GATS or LAC agreements.[172]

APEC hopes to include all countries with a Pacific Ocean coastline. The world is looking towards China and its integration into the free trade community. China is largely a Marxist system that does not fit into a liberal international economic order. China is welcomed into the WTO, but only under conditions of adherence to international standards of behavior and a commitment to permanently and expeditiously dismantle trade and investment barriers to foreign products. African countries constitute a significant source of new growth, especially in the LNG market and shows promise for a major emerging market.

Engineers must continue to recognize the importance of global markets-both developed and emerging-as opportunities to improve the quality of life and provide leadership in these efforts.

While all those ambitious unifying or border-eliminating approaches are creating new layers of bureaucracies and new volumes of regulations, the real leveler of the playing field, the real destroyer of the borders still confining our industries and our nations is a virus that we have introduced. It is an electronic virus that can cross any border that we can establish. It travels through space, is multi-disciplinary, is multi-national, is multi-lingual, is automatic. It is the worldwide web; it is the internet and the extranet. It is computer aided design and drafting (CADD) that is becoming CDD: computer design, 3-D and 4-D modeling and drafting of equipments, of structures, of scheduling just-in-time deliveries, of how and when you rent equipment. It is e-commerce, it is the 24/7 office working 7 days a week, 24 hours a day.

Businesses in developed countries have to learn to live in two worlds at the same time: the world economy with transnational money and its own national state where money is "increasingly the servant of short term political goals."[173] Businesses will have to start thinking strategically and planning in a world economy rather than in their own domestic economy. The shift to the knowledge worker and the steady upgrading of competence of the workforce represents a very large and almost unprecedented increase in the potential of the human strength in developed countries. Engineers, if they are to be on the forefront of this rapid change to a knowledge based society in a global world are going to have to change the methods and the content of what is taught in the engineering curriculum-especially in the post graduate level.

1.3 Long-Term Strategies

That is the new business landscape. But there is more. Just because there are immense needs in all of the developing and underdeveloped countries, needs driven by previously unmet needs and rapidly growing populations, needs alone do not translate into programs and projects for our industry. Those of us who have been active participants in the global engineering and construction industry have learned a long time ago that to succeed in any exciting part of the world you have to develop and adhere to a long-term strategy. You cannot simply parachute into the region – do your thing and then disappear. You have to stay, to become familiar, and to learn. In underdeveloped countries, the economies have always been volatile. Engineers must now not only understand the engineering concepts that are learned in our universities, but also understand the global economic and financial conditions and barriers before embarking on infrastructure projects. The engineer must understand project management and must recognize what risks face each and every project no matter where its location in the world.

This chapter addresses the mission of engineers in globalization; what engineers need to be aware of with respect to 1) potential projects in a global world and the requirements for sustainability in all future constructed projects, 2) the understanding of the risks that should be addressed in engineering and constructing projects around the world and 3) the necessity for Project Management in all aspects of the engineer's professional performance.

2 THE JAPANESE CONSULTING ENGINEER UNDERSTANDING OF GLOBALIZATION

Internationalization of the construction industry in Japan began with the establishment of the GATT in 1947 with the idea to gradually reduce tariffs, recognize free trade around the world. The GATT Government Purchase Agreement was finally concluded in Japan in 1977. However, due to heated debates, it was not until the Uruguay Round started in 1983 that prompted discussions on what the GATT agreement really meant other than commercial goods, and the GATS was finally agreed and came into force in 1995. The final impact to the Japanese construction industry occurred in 1995 when GATT developed the WTO and Japan was forced to open its borders with respect to construction. [174]

The majority of practicing Japanese consulting engineers are members of the JSCE. JSCE, since it formation has contributed in technological advancements from a global standpoint, based on a wide range of activities including international conferences, invitation of overseas engineers and promotion of technical activities with other overseas organizations.[175] In fact, in 1942, JSCE published "Foreigners and Civil Engineering of Japan since Meiji Era". Since JSCE provides a mechanism upon which to educate the Japanese Consulting Engineer, it would seem logical for the purpose of the internationalization of JSCE to include the goal of having Japanese civil engineers become international or have an international outlook.[176] JSCE's International Activities Committee (IAC) has made some achievements in this regard with international related papers being published in English, having an English homepage, holding symposiums for international students, creating international sections of JSCE, signing Agreement of

Cooperation (AOC) agreements with other countries in order to transfer technology and international engineering practice, and recruiting international members. However, despite these efforts, it still does not address the issue of cross-cultural competence which is required of today's Japanese Consulting Engineer to meet the immediate challenge of working outside of Japan and/or with foreign firms as Japan opens its doors in response to the WTO mandate. In addition, the majority of development projects in Asia are Japanese financed. Thus, the projects typically involve Japanese firms. It is necessary for the Japanese Consulting Engineer to have an understanding of not only globalization, but the ability to negotiate and work with local government officials.

In today's international projects, most of the teams are multi-national consortiums. The multi-cultural team provides the best mix in terms of technology, linguistic and cultural capabilities and cost. Multi-national consortiums are also becoming the competitive nature for these large capital projects. With the number of domestic projects within Japan expected to decrease, the international work will account for a larger share of the Japanese market. Thus, the Japanese Consulting Engineer must recognize the importance of language and working with individuals from different cultures and business perspectives. The Japanese Consulting Engineer must be cross-culturally competent or risk alienating their client and/or fellow worker-both which can end in disaster for the project.[177] The ability of the Japanese Consulting Engineer to work effectively in a foreign environment is now more important than ever.

3 SUSTAINABILITY

3.1 Introduction

The world's population is increasing at the rate of 80 to 100 million a year, all of it outside the so-called developed world (Japan, China, Australia, Europe and North America). Where you have people, you have needs. So the needs certainly exist for huge investments in infrastructure and potential civil engineering projects. Another demographic change is the rapid urbanization of our globe. By 2010, the urbanization rate will be 45 percent and there will be 1,000 cities. Urbanization will greatly promote social and economic development, but will also create several social, economic, and environmental problems. All cities face the same challenge: to balance the relationship between development and environmental protection.[178] This will lead to the critical need for all engineers to apply sustainability concepts in all projects designed and built today.

Sustainability is assessed according to the following criteria:[179]

- People's quality of life and sociopolitical stability;
- The scale of nonrenewable resource use, including the extent to which waste recycling or reuse reduces it;
- The scale and nature of renewable resource use, including the extent to which sustainable levels of demand for fresh water are maintained and the settlement's wider ecological footprint is preserved; and
- The scale and nature of non-reusable wastes generated by production and consumption activities, and methods of waste disposal, including the extent to which the wastes impact on human health.

Sustainable development ensures present needs without compromising future ones. It prevents depletion or degradation of resources.

The normal progression of human habitation is from communities to towns to cities. About one half of the world's people now live in urban areas, up from one third in 1960. The needs in urban areas are obvious. In order for humans to live in urban areas, there needs to be basic infrastructure: water, food, shelter, sanitation; and then if you are going to develop the urban area, you need to have power, transportation and communications. However, most of the world's cities suffer from poor housing; lack of piped water, sanitation, and drainage; lack of basic services such as health care; traffic congestion; and air and water pollution. These problems arise primarily because government institutions have failed in managing rapid change.[180] In addition, most developing countries lack the revenue for infrastructure development and technology development. Ultimately the need is to provide the ability to earn a living which is industrial infrastructure.

Improved infrastructure systems within the urban centers and improved infrastructure systems in the peripheral areas are necessary to support the unstoppable urbanization. Where does the engineer fit into all of these basic needs?

The world is divided into three primary sectors: developed countries, developing countries, and underdeveloped countries. The needs in each one are quite different and the engineer must understand what those differences are and how best to address them when planning infrastructure projects. All of this must be overlaid with the concept of sustainability. Sustainability and these infrastructure needs vary depending on the type of country and what the needs are and where the projects are located in the country.

3.2 Developed Countries

Obviously, in the case of a developed country-increasing urbanization is a real issue. For instance, nearly 80% of the population in all three North American countries lives in urban areas despite the vast land available to support the population. Similarly numbers are true in Asia, Europe and Australia. Within all this, in a developed country, sustainability means cleaning up our abuses of the past as we continue to improve the efficient and quality of life in urban areas.

In the developed countries, the engineer will be concentrating on the need to address aging infrastructure, and repair and rehabilitation of an already constructed infrastructure. This aged infrastructure was constructed during times when little consideration was given to sustainable development. Consequently, our major urban areas face problems with air pollution, traffic congestion, obliteration of natural resources such as trees, and contamination of drinking water sources. Thus, with any new constructed projects in a developed country, thought and consideration must be given as to how to resurrect the need for clean air, clean water, and efficient methods for moving people. For instance, scrubbers are being added to power plants and industrial process plants, underground tunnels for subways and people movers are replacing cars and allowing more people to be moved at a faster rate while at the same time reducing the pollutants that emerge in the air from car exhausts. New construction is being built around trees and/or replanting is being done as well as managed forests to assure renewable energy sources. Innovation and new technologies are critical for saving our current urban areas and the quality of life for its inhabitants.

3.3 Developing Countries

Developing countries pose a different need. In a developing country, the need is to continue to improve infrastructure to support rapidly growing urban populations in meeting all the basic needs in an efficient manner without the environmental abuses and non-sustainable abuses in which the developed countries engaged in the past. Basic needs are there, however, more advanced needs in power, transportation and communications are necessary to advance the way in which its populations live and work. Lessons learned from engineering and construction in the urban areas of the past must be reviewed and conscious efforts made not to repeat the mistakes of the past. The ASCE Canon of Ethics for Sustainability is a guide that can be employed in executing any constructed project. For example, power plants are again being constructed around the world to meet the increasing demands of increasing populations. However, consideration must be given as to what is the most appropriate type of power for a given country balanced with the consequences of that decision. For instance, hydro power is not available in all parts of the world. It mostly has been developed in North America. However, other parts of the world still offer an enormous resource for hydro power. Again, however, one must balance the effects of creating dams and what impact that dam may have to populations living in the area to be flooded. The same is true for transportation systems. Advanced intelligent transportations now exist, however, what is the balance with the knowledge of the population that is to operate and maintain the system? Is the current population able to use and maintain employed technologies and does the population have the ability to deal with the required computer and hardware upgrades that must be performed? These questions must be asked by the engineer before embarking on any project in a developing country.

3.4 Underdeveloped Countries

Underdeveloped countries would first appear to be the biggest challenge, however, the infrastructure requirements in an underdeveloped country are quite basic-meet the basic needs of human life: water, food and sanitation. The ability to move the agricultural products to market for food and to have reliable and healthy water and sanitation systems that enable both to support life is first and foremost. Fresh, reliable potable water is a must and simple processes exist that can still be employed today in most remote regions, once a water supply is found. Food is critical and how that food will be processed and transported to the populations needing the food must be addressed. Engineers play an important role in assuring what types of food processing plants are required and what means of transport and road/rail/or water systems will be most efficient in delivering that food to the population. Sanitation is the key to preventing disease amongst the population. Again, however, consideration must be given to the level of sophistication of the sanitation plant and/or process proposed. Advanced waste water treatment plants may appear at first to be a simple solution, however, if the country location is so remote so as to make spare parts delivery difficult, or if the educational level of the population such that maintenance cannot be carried out, then the advanced waste water treatment plant may not be the answer. Maybe a simple gravity-fed sewer system to a lake with genetically grown plants and fish that can feed upon the sewage is the most practical. However, in all these situations, the engineer must be at the forefront to recognize these potential problems and arrive at the most practical solutions.

4 UNDERSTANDING GLOBAL INFRASTRUCTURE RISKS[181]

The crisis in the emerging markets in the 1990s have made it quite evident that the opportunities of globalization do not come without risks-risks arising from volatile capital movements and the risks of social, economic, and environmental degradation created by poverty.[182] Engineers have not typically been seen as understanding the financial aspects of projects. However, in today's global projects, understanding the financing aspect is fundamental tool in being the Leader of the project team. Investment and financing decisions regarding potential projects around the world are often made on limited analysis of the project execution and its future use or operation. Then financial viability is assessed assuming little risk to achieving scope, function, timing, and cost goals based on these limited analyses. Such an approach leads to highly inefficient use of capital. The potential for such inefficiency is increasing. For example, there is still limited recovery from the Asian downturn that began in 1996. That downturn led to regional political crises, instability and financial retrenchment in many geographical areas, especially in Asia and the Western Pacific – easy financing in this geographical area is a thing of the past. Similarly, the cooling and now recovery (albeit in its infancy) of the U.S. economy leads to more thorough potential project Risk review globally before project financing. The War on Terrorism reprioritizes near and medium term project requirements and a shifting of public sector project spending focuses world wide. All business sectors and their capital project needs are forced to adjust to this different commercial reality.

Nonetheless, global needs continue to rise dramatically. Available capital has shrunk with only recent minimal movement to a growth trend. There now is significant competition for available financing reminiscent of the tight markets of the nineteen eighties. Project risk is a necessary focus that is driving global and regional project financing decisions and a concept that must be understood by today's global engineer. Significantly, medium and long term market demand for the products/commodities in the process industries and resource production sectors indeed are shifting from yesterday's models. Unlike conventional wisdom, public project spending will not lead directly and near term to industrial demand. For example, public spending on security is expensive. Public spending for political stability is expensive. Both goals often require infrastructure development and evolution. Such infrastructure does not improve productive efficiency – merely provides a safer and stable environment in which to live and work. In the past, airport capital projects would expand capacity, use efficiency, and transportation timeliness. All are results that translate into immediate business expansion. Conversely, today's plant and transportation infrastructure security will not translate into immediate business benefit, but will provide longer term business environment risk reduction.

In light of the needs of the populations around the world, the engineer must recognize that these projects will be constructed in the midst of various risks. As the leader of the project, the engineer must not only recognize what these risks are, but how to identify, address and provide the framework for solutions to best manage these risks. Risks in global projects, especially in developing and underdeveloped countries are not easily identified or even recognized at first glance.

What is risk in this context? It is not typical catastrophic risk that can be insured. Risk in this context is simply those issues, conditions, actions that cause a project or a participant therein not to meet is goals, e.g., goals of scope, quality, function, delivery time, and cost. Addressing risk and its potential manifestation, its probable impact, its management prospects, now are fundamental to meeting this milieu. The global public financing agencies, private banking and financing corporations, and government and corporate senior management now demand greater risk consideration. Projects do not move from feasibility to a financed or funded project without broader risk evaluation. Capital wasting projects are being eliminated or properly focused to reduce risks prior to spending on often self-fulfilling feasibility studies. Then, the resultant feasibility studies employing risk evaluations are focused and are used to reduce and eliminate risk prior to seeking financing or funding. The financing community or management / Board of Directors approving committees are requiring risk evaluations by those seeking the financing and those internally considering the financing. The goal: improved and practical efficiency in using capital and in executing and operating projects with reduced risk.

Today, complex proprietary risk rating models are part of the solicitation process or the evaluation process required for project financing or funding. These models and the input upon which they operate assure consistency between project evaluations, provide relative comparison with similar or competing capital uses, and tie to the financing or funding uses. Merchant and investment banks, public finance agencies and affiliates, and executive managements are requiring assessments, evaluations and ratings as part of proposals and applications.

Ultimately, good intentions, good planning, worthy ideas do not become projects without funding or financing. Risk must be addressed. To get projects financed or funded, risks must be evaluated and rated in categories of Project Specific Risks and Context Specific Risks. Such Risk Categories focus on both initial project execution and ultimate project operations. These Risk Categories are then modeled to produce ratings that are consistent and comparable. In turn, the ratings underpin decisions on corporate funding decisions versus other uses of its capital. For financed projects, the ratings underpin project financing decisions and the cost thereof to the party seeking it. Generally as an example, the use of capital that meets a government's agenda the most effectively or provides the corporate owner/operator the better return has the higher rating as risks are less. This means a less probable manifestation of risks that erode the goals planned. Capital funding or financing rates are less risky and thus lower.

What are Project Specific Risk categories? Project Specific Risk categories are those that are driven by the specific project form, scope, etc. These categories include[183]: delivery and operational risks, technology risks, financial risks, political/contracting risks, political risks, environmental risks, social and economic risks. Definition of these risks includes:

4.1 Project Specific

- Delivery/Operations. This risk factor involves those issues or concerns associated with engineering, procurement, construction (EPC) execution and operation of the project.
- Technology. This risk factor involves those issues or concerns associated with the technologies involved in the EPC methods and operation technology of the project.
- Financial. This risk factor involves those issues or concerns associated with the financing of the project, including the EPC period and operations or equity financing.
- Procurement-Contractual. This risk factor involves those issues or concerns associated with the contractual and procurement approaches/systems/processes used for both EPC and operation of the project.

4.2 Project Context

- Political. This risk factor involves those issues or concerns associated with the local, regional and national political situation confronting the project.

- Environmental. This risk factor involves those issues or concerns associated with the environmental problems, concerns and activities confronting the project during the EPC execution and the project operation.
- Social. This risk factor involves those issues or concerns associated with the social and cultural impacts of the project to the community and region within which it is to be located.
- Economic. This risk factor involves those issues or concerns associated with the macro economic impact of the project to the community and region within which it is to be located.

In addressing any needs of the population for any engineered/constructed project, risk assessment is a critical function of the engineer.

5 THE NECESSITY FOR PROJECT MANAGEMENT

How do you begin to satisfy the infrastructure needs of the world's population and the risks that may emerge in the constructed projects? The engineer must again address all issues involved with going forward with a project, including financing, risk assessment and Project Management.

With an annual per-capita income level of less than $3800[184] in most developing countries, there are definite limits on how to finance all those needs out of the public purse. But some of those needs can be met by more creative approaches to financing of well-planned and well thought out projects. That will require enlightened political leadership and cooperative financier investors to make it happen. It will require true public-private partnerships, where the principal role of the public sector is to make a project bankable. This can be accomplished through enabling legislation, through permitting, or at times through subsidies or guarantees and other supporting actions. The private sector will then be able to finance, design, build, operate and maintain many of those needed infrastructure systems improvements. We as engineers cannot impose all of our approaches onto developing countries without an understanding that you must create the proper balances. As leaders, engineers must play a larger role in political structure since infrastructure is politically based whether that means that the ultimate employer is government quasi government or the government overseeing the privatization.

Engineers are really the focal the point for both leading the planning and execution of engineering and construction. It is not just engineering and planning, but also the political and private sector. Engineers must become involved at the decision making level, including high government and private sector company positions. In addition, in order to make wise and well reasoned decisions, engineers, as the primary engineering discipline, must be involved in project management when executing a civil engineered project. It is also critical for engineers to recognize that civil engineering involves construction-engineers cannot think that they are just a bunch of engineers and planners, but that we are the discipline that leads construction.

Engineers must recognize the totality of what they do-it is not simply the design and engineering and then the actual construction, but the execution of the entire process. This entire execution process includes the decisions to allow the project to go forward, the analysis of risks that may emerge in their planning and the financing of those projects. Then the engineer must understand the contracting framework in which a project will be executed.

Today's global civil engineering projects are primarily constructed under the parameters of EPC contracts. This means that the party or typically the consortium of parties that are comprise of multinational firms, bond together to design and engineer a project, procure its material and equipment, construction the project and then commission and start up the project. Global mega projects have typically been constructed in the past using what is termed a cost-reimbursable contract, meaning the consortium is paid for every dollar spent in executing the project.

In the mid-1980s, the Business Round Table[185] commissioned its construction sub-committee to evaluate if a premium was being paid to Engineer-Construct (E&C) contractors for capital projects. Then, if such a situation existed, what was the premium? In 1988, the Business Round Table commissioned the prestigious Construction Industry Institute (CII)[186] to identify the cause and recommend alternatives to correct the situation.

CII determined that the primary cause was the cost reimbursable contractual format and recommended a shift to Lump Sum Turnkey (LSTK) contracting in appropriate situations. Appropriate, however, was not adequately defined. Nonetheless, a wholesale shift to LSTK contracting began in the 1990 to 1995 period globally. The owner/employers' project management was not prepared for the shift. Neither was the E&C contractors' project management.

The result was a 180-degree swing in the pendulum through the end of the 1990s. E&C contractors were now faced with no "brand loyalty" and stiff competition. Operations at best could generate mere "super market" margins. Failure of multi-national and regional E&C contractors was increased, reducing the competition sought by the Business Round Table.

For both parties, project management was in chaos. This was not a surprising reaction considering project management was not treated as a profession. One was forced to learn project management skills in an apprentice format. As a "young pup", you were assigned to a project team where you learned through "on the job training". If you had a good master in an appropriate context, you learned good project management, otherwise you did not!

A paradigm shift is now underway to achieve a more balanced business equilibrium between owners/employers and E&C contractors. Attention is directed at what is the "appropriate" context for LSTK contracts or other formats. Innovative Solutions are being considered for large capital projects such as Private Finance Initiatives (PFI), or Build, Operate and Transfer (BOT) in order to generate capital more readily to get these projects off the ground. However, few engineers today understand these new forms of contract, the risks that may arise or the concepts of how they are to be managed.

Engineers often focus on design and engineering concepts and not sufficiently on project management concepts, yet engineers comprise the largest source of project managers. Project management is rapidly becoming a recognized profession, like engineering with it own required professional certification. Project management, like the use of capital, requires focus and efficiency. There is a two-path trend underway to achieve this result. For example, PMI developed and maintains a globally recognized set of standards for project management. With standards, university program accreditation, training and certification examinations can be undertaken. PMI developed the "Project Management Body of Knowledge" or "PMBOK," which describes generally accepted practices with respect to Project Management (there are both printed and interactive versions of the PMBOK: issued by the Project Management Institute Standards Committee: A Guide to the Project Management Body of Knowledge, Project Management Institute, Upper Darby, PA, USA 1996, and PMI Interactive PMBOK, Project Management, Institute, Upper Darby, PA, USA 1998, (now in its third edition and a U.S. ANSI standard as of 2004). The typical bodies of knowledge included as part of the PMBOK are project integration management, scope management, cost management, time management, risk management, procurement management, quality management, communications management and human resource management. The standards cover planning, monitoring, and execution processes.

PMI undertook examination for “Project Management Professionals” (1) beginning in 1984 to provide professional certification. The author was one of the first PMPs, number 12, and the first woman certified by PMI as a PMP. By 1997, there was nearly 8,000 PMPs world wide. Given the trend toward owner-contractor business equilibrium, the need for professional project management development has exploded. As of September 2002, PMI has certified over nearly 50,000 PMPs, and the most rapid increase has been in the Asia-Australia-Pacific region. In 2005, there were nearly 120,000 PMPs worldwide. Additionally, all PMPs must re-certify with professional development and continuing education every 24 months, thus assuring currency in knowledge and its usage.

Disproportionate to and totally party oriented project management is disappearing. Project management is focusing on the project first and party requirements second. Such a trend reinforces and supports the developing commercial equilibrium between the parties. Thus, project management is enjoying the “mega trend” toward efficiency and effectiveness:

- It no longer is merely a trade learned through apprenticeship.
- Professional standards are available and being required.
- Risk management, a key element of the PMBOK is focusing specific project application of these standards (a topic beyond this paper) in a professional manner.
- Projects are executed with lessen risk manifestations for all parties.
- The necessary move to commercial equilibrium between parties is being implemented.

6 THE IMPORTANCE FOR CROSS BORDER MOBILITY OF ENGINEERS TRHOUGH LICENSURE

The quickly globalizing industrial society and industries call for global engineers, and there are many attempts to establish systems for standardization qualification.[187] It is clear that as the engineering profession has become more global, an internationally acceptable licensing procedure for professional engineers is needed. In an effort to recognize the validity of engineering degrees obtained from other countries and to increase the ability of engineers to practice in other countries, the Washington Accord was developed and signed in 1989. The goal of the Washington Accord is the mutual recognition of accreditation systems and professional engineering qualification between the participating countries of the United States, Canada, Australia, Hong Kong, Ireland, New Zealand, South Africa, the United Kingdom and Japan. However, the Washington Accord does not address the international licensing or registration of professional engineers.[188]

The APEC Engineer was initiated by the APEC Economic Leaders and in November 2000, was the first formal commencement date of the APEC Engineer Registers. (See Chapter on Ethics and Professionalism)

As a result of an agreement by the Washington Accord signatories to explore mutual recognition for experienced engineers, representative of the Washington Accord along with representatives of the European Federation of National Engineering Associations (FEANI) met in March 1996 and with the Japanese Consulting Engineers Association in January 1997. Later in 1997, the Accord signatories agreed to establish a forum to be known as the Engineers Mobility Forum (EMF) through which they, as the representatives of the relevant engineering organizations would:[189]

- Develop, monitor, maintain, and promote mutually acceptable standards and criteria for facilitating the cross-border mobility of experienced professional engineers;
- Seek to gain a greater understanding of the existing barriers to mobility and to develop and promote strategies to help governments and licensing authorities manage those barriers in an effective and non-discriminatory manner;
- Encourage the relevant governments and licensing authorities to adopt and implement mutual mobility procedures consistent with the standards and practices recommended by the signatories to such agreements as may be established by and through EMF; and
- Identify, and encourage the implementation of, best practices for the preparation and assessment of engineers intending to practice at the professional level.

7 THE NEED FOR GLOBALIZATION WITHIN ENGINEERING EDUCATION

Given the impact of globalization on the world economy, engineers today are routinely expected to work cross-culturally. Though this has become an established fact, little has changed in the global engineering education system to ensure a broad-based preparation of engineers. Consequently, more and more schools are looking to find workable models for internationalization of engineering education.[190]

It will be essential for Japan to encourage foreign students to enroll in its universities in order to build upon this cross-cultural experience before they graduate. This includes engineering graduate students being required to make a presentation in English at least once in a JSCE seminar before they can graduate. More interchange of Japanese students and Japanese Consulting Engineers should be conducted with other countries to provide more cross-cultural experiences. Encouragement of students from other countries must be done to increase the number of foreign students at the Japanese universities. This is one area that has made the United States so strong in its ability to appreciate cross-cultural and multi-national teams. Over 20% of the university students are from outside the United States.[191] Many universities are starting to incorporate courses in cross-cultural competency. For instance, at RMIT in Australia, a project on studying the effects of internationalism programs was carried out. Starting in the mid-1990s, professional engineering organizations began to recognize the importance of international diversity. ASCE, JSCE and the Philippines Institute of Civil Engineers (PICE) banded together to conduct the first Civil Engineering Conference in the Asian Region (or CECAR) in the Philippines. The author and then President Ramos, a civil engineer, were the co-chairs of the conference. Since that time, other engineering professional societies have joined CECAR and successful conferences have been held in Japan and Korea.

In the United States, ABET has incorporated criteria for a “broad education” necessary to understand the impact of engineering solutions on a global and societal context. A few universities have taken the lead by creating programs to prepare engineers for a global environment such as the Global Engineering Education Exchange (GE3), the Global Innovation for Engineers program at Georgia Tech and the Eurotech program at the University of Connecticut and the Design for International Market Program at Calvin College.[192] The International Engineering Program (IEP) at the University of Rhode Island leads simultaneously to degrees in an engineering discipline (BS) and German, French, or Spanish (BA), preparing young engineers for careers in the global workplace including six month internships with firms in Europe and Latin America.[193] Other universities have opened up distance learning to provide international experience including Union College in the U.S., University of Washington, Texas A&M University and the University of Pittsburgh.[194]

At a workshop on Global Engineering Education held at Arizona State University in Tempe, Arizona on February 26 and 27, 2004, the following statements were made with respect to defining global engineering education:[195]

- Prepare engineers for designing products for global deployment
- Provide engineering graduates with international experience virtually and personally
- Study abroad
- Degree programs
- Internship abroad
- Educating engineers globally
- Ability to communicate over time and distance
- Teach language
- Develop common global perspectives
- What you do/How you do it
- Educating engineers with a global mindset

The workshop concluded that values to industry would include:

- Improve the coverage of global markets (new markets)
- Global engineers which are necessary for managing global engineering
- Global engineering as a necessity for company's competitiveness
- Reduce "in-company" training for global engineering

The expected outcomes for a global engineering education include:

- An understanding that engineering is globally competitive
- Effective cross-cultural collaboration (face to face and distance)
- The ability to anticipate social/economic/political implications
- Pre-eminent at synthesizing heterogeneous input to create markets for engineered products/systems

Distance learning will change the whole scheme of engineering education. Distance learning is one of the most promising developments in international programming for engineers. With the need so great in preparing future engineers for the global workplace, distance education projects can take an important step toward democratizing international education.[196] It will provide a truly interactive learning environment. Distance learning will not only link a teacher and students at a distance, but will bring them closer together. Global engineering education is, in essence the ability to provide an educational environment where students can learn how to collaborate with each other across their national boundaries and across engineering domains.[197]

8 CONCLUSION

Clearly globalization brings many challenges to engineers in all fields. But it also brings the potential for the best in engineering to be shared across borders and cultures.[198] Engineers today need to focus on matters such as international competitiveness; educational requirements and international standards to practice engineering, and transnational issues, as appropriate (e.g. certification with specific attention has been paid to the practice of engineering in border countries, states, provinces and communities) and; uniform systems of units, codes of design, and standards of practice.

However, the engineer as the leader, must also broaden his/her horizon to not only these issues centered more around the design aspect of engineering, but to that of how, where and under what context engineering projects are constructed in today's global environment. Engineers must understand the entire context of how a project is conceived, financed, managed, designed, constructed and operated. The engineer in its mission of globalization must recognize the needs of the population and that the needs are different for developed, developing and underdeveloped countries. In doing so, the engineer must undertake these projects within the mindset of sustainability while keeping a balance with the needs of the population and the survival of our planet. The engineer must take an active role in the political and private sectors so as to maintain its position as the decision maker and the leader of the project.

As that leader, the undertaking of any project must consider the risks associated in going forward with a project and that may emerge during the project. And finally, in order to have a successful project, the engineer must execute the project under the guidelines of good project management. The 21st Century will be the age of education, and engineers will play a much larger role in society than merely producing products. They will be able to cultivate and develop new learning systems where people can share their outcomes across their national borders but still maintain their competitive edge. Engineers can and must create new environments for global learning.[199]In this manner, engineers will emerge as the leaders of the global infrastructure projects and will continue to build the quality of life in this millennium and millenniums to come.

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V. THE IMPORTANCE OF ETHICS AND PROFESSIONALISM

1 INTRODUCTION

The engineer's role and obligation is to hold paramount the public safety, health and welfare. The engineer must be able to demonstrate an understanding of the commitment to practice according to its Society's Canon of Ethics and associated guidelines. When the author was President of ASCE from 2003-2004, she opened all of her speeches with *"I am proud to be a Civil Engineer."* The author is proud that she is a member of the engineering profession. She takes pride in every activity that she does as an engineer. The author proudly wears a steel ring on the little finger of her working hand that was put there by a fellow engineer during my last two weeks of her senior year at Purdue University before she graduated. That was in 1978. The ring (which will be discussed in more detail later in this chapter) is an external symbol for everyone to see that the author is an engineer and she is proud of it. It is also a symbol to the author that she has a moral and ethical obligation to protect the public health, safety and welfare.

By being an engineer, the engineer assumes certain responsibilities that cannot be delegated. The engineer is responsible for his/her actions and is fully accountable to either his/her firm, his/her clients and/or to the public. As an engineer, the engineer is also a professional. As a professional, it is critical to behave in the manner that is expected of members of a professional body. The engineer should also recognize that as a professional, he or she should be licensed as is required of all members of nearly every profession except the engineering profession where multiple exceptions seem to be the rule. The engineer must understand what ethical behavior means and what his/her roles and responsibilities are. Yet, despite the obligation for engineer to have an understanding of ethics and professionalism, the subject of ethics and professionalism is taught at only a few universities around the world and at most ethics is an elective course. One of the author's objectives as a professional is to better the profession and by doing so, not only will her fellow members of the profession be benefited, but so will the public.

The author sits on the Dean's Advisory Committee at Purdue University in the U.S. which serves to provide guidance to the Dean of Engineering in order to enhance the engineering program at the University. At a recent meeting of the Committee, the author was quite surprised to find that some of the basic skills, or as some refer to them as "soft skills" were no longer taught. The author was also surprised to find that only the civil engineering students knew about the Order of the Engineer ceremony (the “ring” ceremony is to be discussed later in this Chapter) and even then, most had not been encouraged to attend. The author was discouraged to find that some professors were not encouraging their students to take the Fundamentals of Engineering (FE) exam and in fact in some cases were frankly told, *“If you are going into industry, you don’t need a license and thus it does not matter anyway and it would just be a waste of time and money.”* For one woman aero-space engineer who did take the FE exam, she was disappointed that there was not a study course offered to assist her in studying for the exam, or professors that offered to assist and thankfully, one of the civil engineering students had volunteered to help students prepare for the exam. In discussions with the students, the Committee discovered that communication was no longer a separate course and that it depended on the school of engineering relative to how much attention was actually paid to communication. None of the students had any courses in ethics and most indicated it may have at most been one of the subjects discussed in one class on one day, but they could not remember what was actually said. None of the students had any real appreciation relative to globalization or the ethical issues that face engineers working around the world. It became obvious to about ten of the practitioners serving on the Committee that there was a critical element missing in the engineering curriculum which centered not only on soft skills, but the basic understanding and motivation for ethics and professionalism.

The Dean of Engineering at Purdue has embarked on a challenging assignment to reform the engineering education curriculum at Purdue with full recognition that if Purdue is going to graduate the top engineers and produce engineers who can survive in society today, many of these skills will somehow need to be incorporated back into the program. While some may be introductory at the bachelor’s level, there is a clear recognition that major reform is required in the Masters and PhD programs to truly reach the National Academy of Engineering-Engineer 2020. She has made great strides towards this goal, but the real challenge will be to get the faculty to agree.

This chapter lays out the importance of ethics and professionalism, its importance to engineers and the need to include this critical subject in the engineering curriculum. The chapter also focuses on those issues which are becoming more controversial and are under debate relative to raising the bar on the engineering profession. These include licensure and global ethics.

2 THE ENGINEERING PROFESSION

When examining engineering ethics and professionalism, it is first important to establish what is meant by a profession. In Japanese, the words representing vocation are “shokugyo” and “shigoto”.[200] In English, these words are respectively translated into “profession” and “occupation.” In a broad sense, a profession is any occupation that provides a means by which to earn a living working with advanced expertise, self regulation and a concerted service to the public good.[201] Another definition has been used that says: *“The occupation which one professes to be skilled in and to follow….A vocation in which professed knowledge of some branch of learning is used in its application to the affairs of others, or in the practice of an art based on it.”*[202] But what differentiates a profession from a job or an occupation? A job is a task for which someone is paid. Then clearly engineering is a job. But it is certainly more than that. An occupation implies employment through which a person earns a living. Then clearly engineering is an occupation. But it is certainly more than that. Is a person who is a member of a profession the same as a professional? A professional can have different meanings depending on the context in which they are used. A professional is often referred to as the difference in paying someone for what they do versus an amateur is who unpaid for what they do - such as athletes. Then surely an engineer is a professional. However, the engineer is clearly more than that. While necessity of education and training is emphasized in the definition of “profession”, an individual cannot always become a professional simply by having a broad education. A professional is an individual with comprehensive abilities namely:[203]

- Leadership and the ability to communicate openly
- Specific characteristics such as being business oriented, taking practical actions based on certain knowledge, and the ability to make decisions and to recognize opportunities for creating added value
- Aptitude to be able to recognize system needs, improve flexibility and speed, accept various ways of thinking, act on matters in advance, and challenge things to the limit.
- Knowledgeable of related fields, execution processes and skill integration.
- Possess good work ethics

The engineering profession came about in society as the number of construction projects increased, larger and larger projects emerged and as a result, so did the number of engineers. The increasing number of engineers resulted in large corporations being formed in which to employ those engineers and the status of engineers changed from individual consultants to corporate employees. As suggested by Layton in his book on the history of American engineers, *The Revolt of the Engineers: Social Responsibility and the American Engineering Profession,* the idea of engineering as a profession emerged as an alterative against the situation that as engineers got to be employees, the social status of engineers was decreasing. It was not an evolutionary path, but rather a path of struggle and negotiation against corporate interests.

ASCE in its Official Register defines a profession as "*The pursuit of a learned art in the spirit of public service*". It goes on to expand that definition:

> *A profession is a calling in which special knowledge and skills are used in a distinctly intellectual plane in the service of mankind, in which the successful expression of creative ability and application of professional knowledge are the primary rewards. There is implied the application of then highest standards of excellence in the educational fields prerequisite to the calling, in the performance of services and in the ethical conduct of its members. Also implied is the conscious recognition of the profession's obligation to society to advance its standards and to prescribe the conduct of its members.*

There are a number of attributes considered to comprise a profession such as the medical, legal, accounting, and engineering profession. These attributes include:

1. Work that requires sophisticated skills, the use of judgment, and the exercise of discretion;
2. Membership in the profession requires extensive formal education, not simply the practical training or apprenticeship;
3. The public allows special societies or organizations that are controlled by its members of the profession to set standards for admission to the profession and to set standards of conduct for their members and to enforce those standards; and
4. Significant public good results from the practice of the profession.[204]

Herbert Hoover, a former President of the United States who was also a mining engineer, noted his own definition on the engineering profession: [205]

> *It is a great profession. There is a fascination of watching a figment of the imagination emerge through the aid of science to a plan on paper. Then it moves to realization in stone or metal or energy. Then it brings jobs and homes to men.*

> *Then it elevates the standards of living and adds to the comforts of life. This is the engineer's high privilege. The great liability of the engineer compared to other professions is that his works are out in the open where all can see them. His acts, step by step, are in hard substance. He cannot bury his mistakes in the grave like doctors. He cannot argue them into thin air or blame the judge like lawyers, He cannot, like the architects, cover his failures with trees and vines. He cannot, like the politician, screen his shortcomings by blaming his opponents and hope that the people will forget. The engineer simply cannot deny that he did it. If his works do not work, he is dammed.*

The engineering profession requires judgment, discretion, confidentiality and the requirement to protect the health, safety and welfare of the public. Engineering requires formal training and experience in order to become a professional engineer. Engineers in all that they do, must keep the public good at the forefront. Every engineer, as part of their professionalism, should at a minimum be a member of his/her respective professional engineering organization. Professional organizations are set up both to better the public good and to work towards improving the image of the profession. Raising the bar on the profession will in turn allow engineers to earn a better wage and to entertain a higher level of living than most non-professionals. The later statement will be discussed more below in respect to professionalism.

If engineers viewed themselves in the same light as their fellow medical, legal and accounting professionals, especially in regard to licensing and increased education, that they could indeed continue to raise the bar and retain higher salaries and leadership positions that they should hold given their expertise and experience. J. Douglas Brown, an economist by profession and a former Dean of the faculty at Princeton University, in 1962 counseled engineers to "*throw aside the last vestiges of the engineering profession's evolution from a craft and take on the full responsibility of a learned profession.*" He felt that the professional engineer, more than anyone else, must act as a moderator and the interpreter between the two worlds of science and the humanities.[206]

3 ETHICS AND PROFESSIONALISM-WHAT DO THEY MEAN?

3.1 The Definition of Ethics

The word ethics has several meanings. Ethics itself is basically an open-ended, reflective and critical intellectual activity. It is essentially problematic and controversial.[207] However, one definition is synonymous with morality. It refers to moral values that are sound. *Thus, engineering ethics consists of the responsibilities and rights that ought to be endorsed by those* *engaged in engineering, and also of desirable ideals and personal commitment on engineering.*[208] But if *ethics is a study of morality, then it is an inquiry into ethics in the first sense and thus engineering ethics is the study of the decisions, policies and values that are morally desirable in engineering practice and research*.[209] Ethical principles can be established only as a result of deliberation and argumentation.

Despite a few variances on what the word "moral" or ethics may mean, there are a few universal values held by engineers that would encompass what one would envision when one speaks of ethics:

- Truth, honesty, trustworthiness
- Respect for human life and welfare, including that of posterity
- Fair play
- Openness
- Competence

These concepts set the basis for engineering ethics and the codes of ethics under which engineers practice.

3.2 The Definition of Professionalism

Professionalism is a mix of privilege and obligation.[210] Professionalism for engineers is not exclusively a matter of esoteric knowledge. Professionalism, because of its stress on social responsibility, offers one way of meeting the need for informed public policy by establishing a legitimate role for private judgment by engineers, protected and encouraged by an organized profession.[211] William Wisely, emeritus Executive Director of the ASCE, commented on professionalism: [212]

> *The obligation to give primacy to the public interest is the very essence of professionalism. Without this commitment, the effort of a group to seek elite status as exponents of a body of specialized knowledge is but a shallow and selfish charade, no matter how sophisticated that body of knowledge may be or how rigorously it may be pursued.*

The Engineer's Council for Professional Development stated that of an Engineering Professional Practitioner[213]:

1. *They must have a service motive, sharing their advances in knowledge, guarding their professional integrity and ideals, and rendering gratuitous public service in addition to that engaged by clients.*
2. *They must recognize their obligations to society and to other practitioners by living up to established and accepted codes of conduct.*
3. *They must assume relations of confidence and accept individual responsibility.*
4. *They should carry their part of professional groups and they should carry their part of the responsibility of advancing the professional knowledge, ideals and practice.*

The engineering profession as defined by Dan Pletta, in his book on *The Engineering Profession* notes the purpose of an engineering profession as:[214]

a) *that will serve the public by using materials and forces of nature for man's comfort and benefit;*
b) *that will provide a corps of professional practitioners eminently competent technically, whose foremost dedication is that of unselfish service to society; and*
c) *that will develop a nucleus of engineers to complement other professional for the industrial, governmental and societal leadership of our technological civilization.*

4 ETHICAL AND MORAL OBLIGATIONS OF ENGINEERS

In the author's capacity as ASCE President, one of her primary goals for the year was to raise the awareness of ethics and professionalism and to remind the members that over the years engineers have *forgotten* what it means to be a professional. While in office, it was surprising to see a few of our members questioning whether we should be raising the bar to our profession; whether we should be aggressively pursuing policies to improve education for engineers or requiring faculty to be licensed or why they should be a member of the Order of the Engineer and wear a stainless steel ring on the little finger of their working hand. As an individual who is proud to be a civil engineer, these questions and push backs simply astounded the author. They say history repeats itself. However, the author must ask the question of whether we as engineers today are merely repeating history or whether we have simply forgotten what it means to be a professional and what is required to advance engineering to the same level of public recognition, respect and leadership positions of our communities, states and national government as has those of other professions such as the legal, medical, accounting and architectural professions.

Paul Harvey, a nationally recognized commentator in the United States, provides his messages with a story and then delivers his point with "the rest of the story". In the monthly *ASCE NEWS* publication sent to all members, the author had a monthly column which addressed various issues of importance to the profession. One of the author's messages in her year as ASCE President was on the subject of professionalism. The following is a portion of an address made by ASCE member at an ASCE local Section meeting who also shared concerns of where engineers were going in the future, with us as individuals and with our profession. At the end, "the rest of the story" will be provided.[215]

> *In what I have to say to-day* [sic] *you will find little that has not been said before, often in an abler way, but I wish to speak of some fundamental points which I believe should be constantly borne in the mind by every engineer who seeks to advance the interests of himself and his profession. Particularly do I desire to speak to the younger members of the Society, who in due time will be called upon to take up the burdens and responsibilities now carried by their seniors, and who must in turn become the leaders of the profession.*
>
> *The future of engineering is bright. Opportunities are expanding. The world is coming to expect and to demand a higher standard of the engineer and of engineering. ….Upon no profession does the world depend so much for its advancement as upon the profession of engineering-… Of all the professions, the profession of engineering, in its broad sense, contributes most to the welfare and advancement of mankind. Even far more important than the medical profession is the profession of the engineer, for while medical men seek to cure disease, the sanitary engineer is constantly at work to prevent it. In every field of activity, the work is coming more and more to depend and rely upon engineers….But to meet these demands engineers themselves must grow and become broader….*
>
> *The successful engineer of to-day* [sic] *and of to-morrow* [sic] *cannot be like the engineer of yesterday, who too often would "retire into the technical recesses of his professional work and content himself with being the servant of other men." On the contrary, if he would stand high in his profession, the engineer of to-day[sic] should be…., aggressive, alert, in touch with public questions outside his own narrow field, and a leader-not a follower-….. It is upon the development of these qualities in engineers themselves that the whole future success of the profession depends…*
>
> *What are the qualities …..for success in the profession of engineering? The ideal engineer must be a scientific man and at the same time a business man…..A recent President of the American Society of Civil Engineers has said: "We do not consider imagination, ordinarily, as an important quality in the engineer, yet I think no engineer ever rises to the eminence in his profession without it"….*[216]
> *The engineer of the past has too generally been considered a mere builder, and he has not as a rule been given the position to which his responsibilities and his achievements legitimately entitle him; but the engineer of the future should aim to take a position in society and business as a cultivated and highly trained man, on a level with men in any of the other professions.*

There is one quality of highest importance to the success of the young engineer, which cannot be taught in schools and which he must gain for himself, and that is the ability to properly meet and mingle with his fellow-men. ….He should be a manager, ….It should not be considered unprofessional for an engineer to be a capitalist, and when he takes his proper place as a promoter and organizer and shared in the profits of engineering enterprises, he will not no longer be taunted with the saying that 'and engineering is only good to spend other people's money'. It is by acquiring individual strength that the engineer can give strength to the profession. It is well known that engineers of admitted proficiency often have to work under the direction of men who are unfitted by education and experience to direct engineering work. This is because the engineer is a workman while the other party belongs to the class of 'managers'. …..This is no plea for titles, since no title is more honorable than that of engineer, but it is a plain statement of present conditions. …..

The feeling is general among us that the public does not sufficiently appreciate the value of the work of engineers, and does not give the engineering profession the recognition to which it is due. ….The otherwise intelligent public has little or no conception of the importance and magnitude of the office side of engineering work…..To the engineer the lack of appreciation by the public is frequently painfully apparent, particularly when measured in terms of dollars and cents; but are we not ourselves largely responsible for this situation? The general public can learn of the qualities of engineers and the work that they do only from stories written by the reporters of local newspapers, and in the public press today…..

The chief reason for this, I believe, lies with the engineers themselves. They are far too content to keep in the background. They are accustomed to doing things and not to writing or talking about them. They seldom take an interest in the questions of the day, local, state and national, and rarely do they participate, as they should, in public affairs. The architects are ahead of the engineers in that through their professional societies they apply themselves to problems affecting the public welfare, particularly to city planning, and to many public questions concerning the development and improvement of our cities, especially along artistic lines; but how must greater is the opportunity for collective work along similar lines by engineering organizations!

Practically everything of a communal nature that appertains to the comfort, convenience, luxury, and necessity of the dweller in the city-all in fact, that makes possible the existence of cities-is the work of the engineer. Is it not the duty of the engineer, even more than of the architect, to study these questions in their broad sense, and to take an active part in promoting the welfare of the community as a whole? The engineer of ability, experience and success in his profession should be considered as large a factor in the life of his city as the lawyer, merchant, banker or physician.

In another way, I regret to say, are engineers frequently responsible for the low estimate which the public places upon the value of engineering services. Chief engineers of corporations and public boards all too often make the mistake of hiring engineering assistants at the lowest possible wage, under the false impression that by such rigid economy they are enhancing their own value in the *minds of their employers…..Such practices do grave injury to the whole profession and cheapen it in the estimation of the public.*

It is time that this Society, which is a strong one, should make itself felt to a much greater degree on public enterprises, in the forming of public opinion, and in the various phases of our government. In this and in other ways I believe that the Society can do much to advance the standing of the engineering profession and the welfare of its members….

One's first thought is that this is an ASCE member who shared similar views as the author did as the ASCE President and made a speech based upon the points that the author made in her inaugural speech in Nashville, Tennessee in November, 2003. However, this address was made by Frederic H. Fay, President of the Boston Society of Civil Engineers at its annual meeting on March 18, 1914. And now you have the rest of the story. Have we forgotten?[217]

As a demonstration of an engineers' recognition of their ethical and moral obligations, the Order of the Engineer Organization conducts a formal ceremony that allows engineers to listen about engineering error that cost the lives of the public and to appreciate their roles and responsibilities to the public. The Order of the Engineer has its roots in Canada in the early 1900s when a steel bridge collapsed taking the lives of 75 workmen due to a design error. The engineers in Canada were so moved, that they collectively had a "Calling of the Engineer" which was a ritual where they remembered that tragic day and took an oath to protect the public in an effort to reduce future situations like the steel bridge failure. The ceremony took on so much support that today you will not find a Canadian engineer that does not proudly wear the steel ring. Even the Canadian public knows about the steel ring and gives respect to all engineers they see wearing the ring. The Order of the Engineer was finally instituted in the United States in 1976. The ceremony requires the engineer to accept an oath that is based on ethics and professionalism. At the conclusion of the ceremony, a steel ring is placed on the little finger of the working hand as a symbol for the engineer and the public to visually see that that person is an engineer and has accepted its ethical and moral obligations and responsibility to the public. The Creed states[218]:

I AM AN ENGINEER,
IN MY PROFESSION I TAKE DEEP PRIDE.

TO IT I OWE SOLEMN OBLIGATIONS.

SINCE THE STONE AGE,
HUMAN PROGRESS HAS BEEN SPURRED

BY THE ENGINEERING GENIUS.

ENGINEERS HAVE MADE USABLE,
NATURE'S VAST RESOURCES OF MATERIAL AND ENERGY
FOR HUMANITY'S BENEFIT.

ENGINEERS HAVE VITALIZED
AND TURNED TO PRACTICAL USE,
THE PRINCIPLES OF SCIENCE
AND THE MEANS OF TECHNOLOGY.

WERE IT NOT FOR THIS HERITAGE OF ACCUMULATED EXPERIENCE,
MY EFFORTS WOULD BE FEEBLE.

AS AN ENGINEER,
I PLEDGE TO PRACTICE INTEGRITY AND FAIR DEALING,
TOLERANCE AND RESPECT,
AND TO UPHOLD DEVOTION
TO THE STANDARDS AND THE DIGNITY OF MY PROFESSION,
CONSCIOUS ALWAYS
THAT MY SKILL CARRIES WITH IT
THE OBLIGATION TO SERVE HUMANITY
BY MAKING THE BEST USE OF EARTH'S PRECIOUS WEALTH.

AS AN ENGINEER,
I SHALL PARTICIPATE IN NONE BUT HONEST ENTERPRISES.

WHEN NEEDED,
MY SKILL AND KNOWLEDGE
SHALL BE GIVEN WITHOUT RESERVATION
FOR THE PUBLIC GOOD.

IN THE PERFORMANCE OF DUTY
AND IN FIDELITY TO MY PROFESSION,
I SHALL GIVE THE UTMOST.

Engineering is a great profession. How much stronger would it be if engineers banded together and demonstrated their pride to the public in such ways as obtaining licenses and wearing symbolic rings of the Order of the Engineer? We as engineers must improve the image of our profession if we are truly ever going to be considered equal to the other professions such as medicine, law and accounting.

5 HOW ARE ETHICS MEASURED IN SOCIETY-CODE OF ETHICS

5.1 What Constitutes Codes of Ethics?

A Code of Ethics provides a framework for ethical judgment for a professional.[219] The codes express the rights, duties, and obligations of the members of the profession. It defines the roles and responsibilities of professionals. However, no set of code of ethics is all encompassing and can cover all possible situations that could arise. It is merely a framework and serves as a starting point for ethical decision making.

Codes of ethics are important for at least two reasons. First, there is the compilation of the thoughts of engineers about their ethical or professional responsibilities. As such, the codes help the public to understand how engineers see themselves and to find out what the members of the profession as a whole have learned over the years. Second, the codes are mechanisms for controlling the behavior of engineers and assisting them to behave is socially responsible ways.[220]

Just as important as to what a code of ethics is, is what a code of ethics is not. It is not: a procedure for ethical behavior; a substitute for sound judgment; a legal document from which one can be arrested if not followed; a tool for the creation of new moral or ethical principles. Rather, a code of ethics spells out the ways in which moral and ethical principles apply to professional practice and guides the engineer to apply moral principles to the unique situation encountered in professional practice.[221]

The primary purpose of a code of ethics is to motivate those to conform to the principles set out in the code. Thus, codes of ethics should be designed to inspire, encourage, and support ethical practitioners, rather than a basis for proceedings against wrongdoers.[222] Codes of ethics play at least eight essential roles[223]:

1. Serving and protecting the public;
2. providing guidance;
3. offering inspiration;
4. establishing shared standards;
5. supporting responsible professionals;
6. contributing to education;

7. determining wrongdoing; and
8. strengthening a profession's image.

Professional ethics dates back as far as the Hippocratic Oath, presumed to date back to 2000 B.C. in Egypt. The Greek medical writings making up the Hippocratic Collection were formulated in about 400 B.C. The present form of the Hippocratic Collection originated around 300 A.D. The first "professional organization" in the United States to adopt a code of ethics was the lawyers with the adoption of the Canons of Professional Ethics by the American Bar Association in 1908. The lawyers were followed by the Architects and the American Institute of Architects (AIA) which adopted its Code of Principles of Professional Practice and the Canons of Ethics in 1909. The doctors followed next with the American Medical Association, founded in 1847, who adopted their Principles of Medical Ethics in 1912. The first code of ethics adopted in the United States by an American engineering society was that of the American Institute of Electrical Engineers (IEEE), which was adopted in 1912. This was followed closely by ASCE and the American Society of Mechanical Engineers (ASME), in 1914.[224] This code served as a model for other engineering societies. However, in the early codes, there was little mention of an engineer's responsibility to the general public. It was not until 1947 that a major reformulation of the codes of engineering ethics was made by various societies using the new Canons of Ethics for Engineers of the Engineer's Council for Professional Development (ECPD) which showed a concern for the public. However, it was not until 1974 that the ECPD canons were revised to where they now read: *"Engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duties*."[225]

Engineering ethics were evaluated in Japan in the 1990s with Codes of Ethics enacted by most of the engineering societies and associations.[226] In 1928, JSCE established "The Summary of the Principles and Implementation for Civil Engineers." The following guiding principles were highlighted in the document:[227]

- Contribution to the development of the nation and advancement of welfare of all people
- Advancement and improvement of technologies
- To sustain a sincere attitude and to respect virtue and honor

The code further noted that civil engineers must proactively serve society in light of national and various social needs.

In 1936, JSCE set up the Research Committee on Reciprocal Codes for Civil Engineers with the following objectives: (1) to decide on the duties of civil engineers, (2) to enhance the position of civil engineers, and (3) to promote the dignity of civil engineers. The three objectives were incorporated into a doctrine and a code of ethics which was suited for the conditions prevailing in the industry at the time were established in May 1938.[228] The Asian Engineers as defined by the academies of China, Japan and Korea, developed a code of ethics which mirror much of the same canons included in the engineering societies in both the UK and the United States. The Code of Ethics as adopted by the Asian Engineers in November 2004 includes the following canons:[229]

1. *Accept responsibility in making engineering decisions consistent with the safety, health and welfare of the public, and disclose all relevant information concerning public safety, health, welfare, and sustainable global development in carrying out irreversible civil engineering work of long-term and large-scale in nature.*
2. *Act as faithful agents or trustees in business or professional matters for each employer or client, provided that such actions conform to other parts of this guideline.*
3. *Disclose all known or potential conflicts of interest that could influence or appear to influence their judgment or the quality of their services.*
4. *Be honest and trustworthy in stating claims or estimates based on available data.*
5. *Perform work in compliance with applicable laws, ordinances, rules and regulations, contracts, and other standards.*
6. *Honor property rights including copyright and patent and give proper credit for intellectual property.*
7. *Seek, accept and offer honest professional criticism, properly credit others for their contributions and never claim credit for work not done.*
8. *Given due effort to the need to achieve sustainable development and conserve and restore the productive capacity of the earth.*
9. *Promote mutual understanding and solitarily among Asian engineers and contribute to the amicable relationships among Asian countries.*

A review of the various codes of ethics in the U.S., the UK, Japan and China, show a commonality between values as shown in **Table V-1**

TABLE V-1 COMPARISON OF WORLD ENGINEERING SOCIETIES CODES OF ETHICS									
VALUE	**ASCE (US)**	**ABET (US)**	**IEEE (US)**	**ICE (UK)**	**FIDIC (EU)**	**CEAI (INDIA)**	**JSCE**	**JACE**	**JAME**
Integrity, honor, dignity	√	√			√	√	√	√	
Honesty	√	√	√	√		√	√	√	√
Safety, health, welfare	√	√	√	√	√	√	√	√	√
Competence	√	√	√		√	√	√	√	
Conflicts of interest	√	√	√		√	√			
Reputation	√	√	√		√	√	√	√	√
Honest criticism	√		√	√	√	√	√		
Professional development	√	√	√	√	√	√	√	√	√
Quality assurance				√	√				
Disclosure	√		√	√		√	√		√
Confidentiality	√			√		√		√	√
Fairness	√		√		√	√	√		√
Privacy				√					
Bribery			√	√	√		√	√	

TABLE V-1 COMPARISON OF WORLD ENGINEERING SOCIETIES CODES OF ETHICS									
VALUE	**ASCE (US)**	**ABET (US)**	**IEEE (US)**	**ICE (UK)**	**FIDIC (EU)**	**CEAI (INDIA)**	**JSCE**	**JACE**	**JAME**
Avoiding injury to others	√		√	√	√				
Compliance				√			√		
Intellectual property				√					√
Heritage							√		
Assisting colleagues	√	√	√					√	
Sustainability	√			√	√	√	√		

What can be determined from the comparison in **Table V-1** is that there is a common value amongst engineering societies around the world to hold in the forefront the public health, safety and welfare; to be honest, and to encourage professional development. These are all key elements not only to the profession, but to society and how society views codes of ethics. The only differences are with respect to the wording of the codes. In Asian codes, especially in Japan, the wording used is “shall not” versus “should” in western countries. This is the result of a fundamental difference in attitudes towards ethics-a contrast between the hushido spirit as given in the hagahure in Japan and the Christian Golden Rule.[230]

5.2 How Codes of Ethics Are Viewed by Society

Engineering is considered one of society’s activities that has the highest of ethical standards. Personal opinion polls have been conducted to obtain public feelings toward various professional groups. In such polls, engineering has rated near the top in public esteem and judgment of ethical standards.[231] The impact of an engineer’s work on society is dramatic.

Modern engineering technology is a pervasive, complex system whose cultural, social, political, and intellectual elements are manifest in virtually every aspect of our lives. Thus, engineers need to act conscientiously regarding the health, safety and welfare of the public in performance of their professional work.[232]

A written code of ethics declares before the public the high standards which are professed and provides the public with an understanding of what to expect in their relations with members of the profession.

With codes of ethics in place from every professional engineering society, the public then "takes for granted" that the infrastructure for which the public relies will not fail. The public also puts their trust into engineers and believes that engineers will be truthful and honest. As quoted from Richard P. Feynman: [233]

> *The first principle is that you must not fool yourself-and you are the easiest person to fool…By honest, I don't mean that you only tell what's true. But you also make clear the entire situation. You make clear all the information that is required for somebody else who is intelligent to make up their mind.*

The standard of truthfulness in engineering is very high, much higher than in everyday life. It imposes an absolute prohibition on deception. Within the National Society of Professional Engineers in the United States (NSPE), there is specifically a canon that calls for honesty. Per Canon 3[234]: *"Issue public statements only in an objective and truthful manner.*" Canon 5 of the NSPE Code of Ethics requires its members to *"Avoid deceptive acts."* Thus, taken together, the interpretation is that engineers must be objective and truthful and must not engage in deception. ASME and ASCE have the same canon:[235]

> *Being honest and impartial, and serving with fidelity the public, their employers and clients…*

And the chemical engineers also have similar cannon in its code of ethics which notes:[236]

> *Issue statements or present information only in an objective and truthful manner*

The public has come to expect competence, trustworthiness, and expeditious action: the unethical actions of a few can arouse public indignation which may condemn and punish a profession at large.[237]

However, engineering failures around the world have in some instances “shattered” the public’s image of the engineer. It is the collapse of the Quebec bridge in the early 1900s that brought about the Calling of the Engineer (Canadian version of the Order of the Engineer), when the collapse killed 75 people. Accidents such as the Tay Bridge collapse in the UK in 1879 killing 74 people who were on the train when it crossed the bridge and collapsed in the storm that gave way to public anger. The reason for the collapse had been the result of inadequate cross bracing and insufficient allowance for wind pressure.[238] George Sinclair, in the IEEE transactions in 1980 commented on the decline of professionalism:[239]

> *…definite decline in professionalism is not hard to document… the BART episode in San Francisco, the Three Mile Island accident, the DC-10 (crashes)… the collapsed buildings have all involved some degree of engineering incompetence… Pressure on engineering societies to curb…incompetence…and enforce… codes of ethics….is increasing…the perceived ethical problems arise from more than professional incompetence….a new design of engineering education is produce….true professionals is required. The first task is to develop a philosophy of engineering as a profession.*

Recent events such as the Challenger explosion, the Ford Pinto automobile crash and its fiery tragic ending, the Chernobyl nuclear accident in Russia, and the Monju nuclear reactor in Japan have created “doubt” in the public’s mind about the engineering image. The Monju nuclear plant was regarded as one of the most important projects to solve energy problems for resource-poor Japan. In December 1995, there was a natrium leakage accident. On January 27, 2003, the Kanazawa Branch of the Nagoya High Court ruled on the invalidity of the government’s approval due to human mistakes and the lack of awareness in the safety review of Monju.[240] The Engineer’s Academy of Japan (EAJ) felt a sense of crisis over this accident as engineers are being questioned about their social responsibility and ethics. The largest fear of EAJ is that this accident may arouse the public’s distrust in science and technology. Engineers must then begin to reflect upon themselves and commit themselves for recovery and make efforts to restore the public’s trust.

One potential problem in Japan is that the definitions of “engineer” and “engineering” are different from the definitions in Europe and the United States and thus there is a “gap” in what is expected of ethical practice in Japan. The confusion seems to be attributable to the translation of the word “engineering” into the Japanese word “Kogaku”, whose direct translation into English is “engineering Science”.[241] It will be necessary to make a distinction between definitions for international collaborations. Further, since the distinction between a technician and an engineer and the work boundary between them is ambiguous and engineers may need to take responsibility for engineering ethics in connection with acts of technicians or technical support workers. Unless these boundaries are clarified in Japan, it may be difficult to meet the expectations of engineering ethics from the public.

6 GLOBAL ETHICS

One initially thinks that ethical thinking is different in certain parts of the world as there are different foundations for the ethical systems. We might also think this way given different cultural differences in the way business is conducted in countries like Japan, China, India, Saudi Arabia or Africa. However, while there may be business differences, which will be discussed in more detail below relative to what engineers need to do in order to change the business global practices in some countries, the ethical thinking has developed similarity around the world and is not dependent on Western culture or religious traditions. Ethical standards are similar world wide.[242] For example, ethical principles of Hindus and Buddhists are similar to other religions around the world. In fact, Islam, Christianity and Judaism all developed in the Middle East. Personal ethics are not governed by geography but rather deep inside principles of what are right for the fellow human being.

One way of looking at what “global ethics” might be is to consider what has been termed “culture-transcending norms” (CT).[243] Engineers may face dilemmas when traveling from their home country to the host country in where they will be working relative to what should be considered as “ethical practice”. While no two nations are exact in what the citizens of that country consider as “values” or “morals”, or even “ethical practice”, values can be ascertained through the review of various religions as noted above, philosophers, and international documents such as the United Nations’ Universal Declaration of Human Rights. Charles Harris, Jr., Michael Pritchard, and Michael Rabins, in their recent book (third edition) *“Engineering Ethics-Concepts and Case Studies,”* have developed what they call the universal or near-universal values CT norms to assist engineers who are in the global working environment:

- Avoid exploitation,
- Avoid paternalism,
- Avoid bribery and gift giving or receiving excessive gifts,

- Refrain from violating human rights,
- Promote the welfare of the host country,
- Respect the cultural norms and laws of the host country,
- Protect the health and safety of host-country citizens,
- Protect the host-country environment, and
- Promote a society's legitimate background institutions.

As the world becomes more global and engineers work around the world and/or with others around the world through the Internet, it is crucial that global ethics be developed to guide engineers working in either the design and/or the construction arena that will guide engineers to a mutually accepted Code of Ethics. By moving forward towards a common goal to reduce corruption and to reduce unethical practices, the world economy will improve as the monies that are wasted in these efforts can be put back into global projects in the ideas of sustainability and to improve the quality of life for everyone.

6.1 Global Ethics in the Construction Industry

Global ethics of the 21st Century expand much further than the traditional ethics that have bound engineers together as discussed previously. Global ethics today are still evolving and center on issues of corruption and bribery, engineering practice, and the environment. The current status of each of these issues is discussed below.

6.1.1 Corruption and Bribery

Starting in 1994, member companies of the World Economic Program developed global ethics for practicing in the construction industry entitled: "*The Partnering Against Corruption - Principles for Countering Bribery"* ("PACI Principles"). The principles were broadened to allow for multi-industry support from member companies and non-member companies of the World Economic Forum. The goal is for widespread adoption which will raise standards across industries and contribute to the goals of good governance and economic development.

Companies that adopt these PACI Principles will be committing to two fundamental actions – adoption of a "zero tolerance" policy on bribery and development of a practical and effective program of internal systems and controls for implementing that policy. In practical terms, this will mean either implementing anti-bribery practices based on these PACI Principles or, for companies with established programs, using the PACI Principles to benchmark existing practice.[244]

U.S. multinational corporations have been weighing the pros and cons of subscribing to business-wide voluntary codes of conduct for three decades. Research has indicated that no time during this period has there been a successful attempt by government or private litigants to bind signatory companies to such voluntary codes, as opposed to existing law that might be reflected in the codes. The aim of these PACI Principles is to provide a framework for good business practices and risk management strategies for countering Bribery. They are intended to assist enterprises to:

- Eliminate bribery;
- Demonstrate their commitment to countering bribery; and
- Make a positive contribution to improving business standards of integrity, transparency and accountability wherever they operate.

The PACI Principles build on general industry anti-bribery principles developed in 2002 by Transparency International (TI) and a coalition of private sector interests, non-governmental organizations and trade unions. The primary United States law governing corruption in international business is the Foreign Corrupt Practices Act (FCPA). The FCPA is a federal criminal statute and, as such, private parties cannot increase or decrease its scope or effect through adoption of private voluntary guidelines such as those embodied in the PACI Principles. The PACI Principles articulate guidelines for program implementation that address Board and CEO oversight responsibilities (highlighted by Sarbanes Oxley in the United States), relationships with agents and other business partners, training and human relations components of the Program, and other specific aspects of compliance.

In 2004, ASCE formed the Task Committee on Global Principles for Professional Conduct comprised of engineers around the world and from other sister engineering societies to study the issue of global ethics, and in particular the problem with corruption and bribery as it affects the engineering profession. At the ASCE Annual Convention in October 2004, the Task Committee held a workshop on the subject in an effort to gather information relative to the subject on corruption and bribery. The findings of the workshop included:

- The contractor group of the World Economic Forum (discussed above) is actively promulgating its anti-corruption pledge, zero tolerance for bribery, and its industry-specific guidelines and practices.
- The World Bank has a Director of Institutional Integrity with a $10 million annual budget and a staff that is will soon approach 50 persons. The World Bank has a hotline receiving anonymous calls reporting corruption on World Bank projects. Bidders on World Bank-financed projects now must have anti-corruption programs. A statement certifying that they will not engage in bribery or other fraudulent practices must now go into the bidding documents. The Bank's "integrity clause" states: *"We hereby certify that we have taken steps to ensure that no person acting for us or on our behalf will engage in bribery."*
- FIDIC (the International Federation of Consulting Engineers) has a 30,000-firm organizations program celled BIMS (Business Integrity Management System). FIDIC describes corruption as "abuse of entrusted power for private gain." BIMS has been designed as an organized way of instilling, training and tracking integrity in business practices, needed to be fostered in every-day business operations.
- Transparency International (TI)--USA maintains a "bribe-payers index" which annually ranks 146 countries according to how corrupt they are in business practices. TI has found that corruption continues to be a cost of doing business despite the fact that 35 countries now have anti-bribery laws. TI has worked with many private firms and agencies around the world to produce a document entitled "Business Principles for Countering Bribery" which it calls "an essential tool for business."

The ASCE Task Committee has also received and reviewed the Codes of Ethics submitted to the Committee by its sister engineering societies around the world with who ASCE has an Agreement of Cooperation (AOC) as well as other societies indicates that most do not tackle the specific problems of corrupt business practices. Out of over 60 organizations, only two had any specific clauses that currently address the issue of corrupt business practices: The Institution of Civil Engineers (ICE) of the UK and the American Institute of Architects (AIA).

ICE has drafted a new set of guidelines including a statement on corruption in construction. Specifically, it states as a breach of rules: *"Having any form of involvement, whether direct or indirect, and whether for the benefit of the member, the member's employer, or a third party, in bribery, fraud, deception and corruption. Members should be especially rigorous when operating* *in countries where the offering and accepting of inducements and favors, or the inflation and falsification of claims, is endemic."*

AIA's 2004 Code of Ethics and Professional Conduct states in its Rules: *"Members shall neither offer nor make any payment or gift to a public official with the intent of influencing the official's judgment in connection with an existing or prospective project...Members serving in a public capacity shall not accept payments or gifts which are intended to influence their judgment."*

With benefit of all the above information from the Workshop, from review of information received from the ASCE AOCs and other organization documents, and from personal discussions of corruption problems with society leaders around the world, the Task Committee has developed a draft of Principals for Professional Conduct for consideration of the global Engineering and Construction community:

PRINCIPLES FOR PROFESSIONAL CONDUCT - A DRAFT

Individual engineers can become fighters against the crime and corruption that plague the engineering and construction industry worldwide by:

- *Assuring that they are not personally involved in any activity that will permit the abuse of power for private gain.*
- *Recognizing that money intended for projects for the benefit of mankind is going into pockets of dishonest individuals worldwide.*
- *Understanding that corruption occurs in both public and private sectors, in both procurement and execution of projects, and among both employers and employees.*
- *Refusing to condone or ignore corruption, bribery or extortion or payments for favors wherever they are found.*
- *Urging adoption of enforceable guidelines to professional practice in ethical codes of engineering societies where they may not now exist.*
- *Enforcing anti-corruption guidelines by reporting infractions by members or non-members of the engineering profession.*

PROPOSED GUIDELINES FOR THE ASCE CODE OF ETHICS

The Code of Ethics that has served ASCE since 1914 has been amended through the years and as recently as 1996. The Committee proposes that additional Guidelines be added to the Code to recognize and confront the serious problem of corruption in the engineering and construction industry. If individual members of ASCE - and cooperating societies around the world - were to adopt and enforce stringent guidelines, the high cost of corruption could be significantly reduced.

The ASCE Code says in its Fundamental Principles that –
"Engineers uphold and advance the integrity, honor and dignity of the engineering profession by…being honest and impartial and serving with fidelity the public, their employers and clients."

Fundamental Canon 6 says:
"Engineers shall act in such a manner as to as to uphold and advance the honor, integrity and dignity of the engineering profession."

The sole Guideline to Practice under Canon 6 says:
"Engineers shall not knowingly…engage in business or professional practices of a fraudulent, dishonest or unethical nature."

In place of that Guideline the Task Committee proposes the following series of Guidelines to address corruption issues:[245]

- *Engineers should be aware of the vast sums of money being lost globally to bribery and corruption.*
- *Engineers shall be scrupulously honest in their control and spending of money intended for the projects on which they work.*
- *Engineers shall adopt a zero-tolerance for any bribery, fraud, deception and corruption in any design or construction work on which they are engaged and not turn a blind eye.*
- *Engineers should be especially concerned about corruption in countries where projects have depended on payment of inducements or gratuities for their execution and should undertake special due diligence.*
- *Engineers should adopt the practice of certifying in contract documents that there will be zero tolerance of bribery, extortion or other fraud during the execution of the project.*
- *Engineers must strive for complete transparency in the engagement of agents, reporting purpose, name and address, gratuities and commissions paid.*
- *Engineers shall avoid or disclose any conflict of interest that could influence decisions in procurement or execution of work.*
- *Engineers shall be duty bound by the ASCE Constitution to report any observed violations of the Society's Code of Ethics.*
- *Engineers should encourage and use hotlines and other approaches -- designed to offer anonymity and reach highest authority in companies and public agencies -- for reporting corrupt behavior or practices.*

6.1.2 Global Engineering Practice Ethics

The term "conflict of interest" is widely used in commercial and legal transactions, and is acknowledged in the codes of ethics of professional bodies, including engineering associations, to identify behavior that may be unacceptable.

However, despite international use of the term, there is a great deal of confusion and serious problems, both real and perceived, that have materialized because there is no universally accepted definition of conflict of interest. The problem is amplified by the globalization of the consulting engineering industry leading to confusion, with different interpretations of what constitutes conflict in different countries and even within countries.

There have been a number of major ethical breaches involving different industries in various countries. These have been of such a magnitude that domestic as well as international regulators are taking action that can have a profound effect. FIDIC has expressed its concern that international actions may be applied across the board to all industries, with suppliers of consulting engineering services being drawn in and maybe forced to comply with a series of actions ill suited to the efficient conduct of their business.

As a result, several international organizations have begun to take action relative to the conflict of interest issue. The following describes the actions that these international organizations are taking:

- **FIDIC**

  FIDIC is strongly committed to the avoidance of conflict of interest in the consulting engineering industry, and to the concept that clear, transparent and internationally accepted principles should be applied. FIDIC's policy on conflict of interest requires that consultants provide professional, objective and impartial advice, and at all times hold the client's interests paramount, without any consideration for future work and strictly avoiding conflicts with other assignments or their own corporate interests. FIDIC has developed a draft policy that can serve as FIDIC's definition of conflict of interest is as follows[246]:

  > *A consultant conflict of interest (COI) is a situation in which a consultant provides biased professional advice to a client in order to obtain from that*

client an undue benefit for himself, herself or an affiliate and in so doing, places the consultant in a position where its own interests could prevail over the interests of the client.

Consultants shall not be selected for any assignment that would a) be in conflict with their prior or current obligations to other clients, or b) may place them in a position of not being able to carry out the assignment in the best interest of the client. Without limitation on the generality of this rule, consultants shall not be engaged under the circumstances set out below:

a. <u>Conflict between consulting activities and procurement of goods, works or services</u>

A firm that has been engaged by a borrower to provide goods, works or services for a project and any of its affiliates, shall be disqualified from providing consulting services related to those goods, works or services, unless the potential conflict arising from this situation has been identified and resolved in a manner acceptable to the client throughout the selection process and the execution of the contract.

Conversely, a firm engaged to provide consulting services for the preparation or implementation of a project, and any of its affiliates, shall be disqualified from subsequently providing goods or works or services resulting from or directly related to the firm's earlier consulting services, unless the potential conflict arising from this situation has been identified and resolved in a manner acceptable to the client throughout the selection process and the execution of the contract.

b. <u>Conflict among consulting assignments</u>

Consultants, including their personnel and sub-consultants, or any of their affiliates shall not be engaged for any assignment that, by its nature, may be in conflict with another assignment of the consultants unless the potential conflict arising from this situation has been identified and resolved in a manner acceptable to the client throughout the procurement and execution phases of the project.

As an example, consultants engaged to prepare engineering design for an infrastructure project shall not be engaged to prepare an independent environmental assessment for the same project, and consultants assisting a client in the privatization of public assets shall not purchase, nor advise purchasers of such assets. Similarly, consultants hired to prepare terms of reference for an assignment shall not be engaged for the assignment in question.

c. <u>Relationship with the client's staff</u>

Consultants, including their personnel and sub-consultants, that have a business or family relationship with a member of the client's staff or of the project implementing agency's staff may not be awarded a contract, *unless the conflict stemming from this relationship has been resolved in a manner acceptable to the client throughout the procurement process and the execution of the contract.*

- **EFCA**

  The European Federation of Engineering Consultancy Associations (EFCA) has been involved in negotiations with the European Commission on the conflict of interest issue with respect to the procurement of consulting services. To date, the Commission is maintaining a very strict interpretation of conflict of interest contrary to the position of the consulting engineering industry.

  EFCA believes that cases of conflict of interest should be restricted to very well defined circumstances, such as:

  - ➜ conflict between consulting activities and the procurement of goods or works;
  - ➜ certain conflicts within consulting assignments, for example the preparation of terms of reference and participation in the resulting tenders;
  - ➜ the execution of a project or study execution and the evaluation of the same project or study;
  - ➜ the design of a project and the study of its impact on the environment;
  - ➜ advice given to both government and buyer in, for example, privatization;
  - ➜ a conflict arising from family or other personal relationships.

  EFCA further states that the fact that a consultant has participated in a previous phase of a project, other than the preparation of the terms of reference, is not per se a conflict of interest as long as all preliminary investigation documents are made available to all participants to ensure fair and transparent procurement.[247]

- **The World Bank**

  The World Bank has also issued its *Consulting Services Manual.* Chapter four of this document, entitled "Conflict of Interest", sets out clearly the categories of conflict, giving examples of each and proposing actions to mitigate conflict of interest in the various cases. The document provides excellent guidance for both borrower and consultants. The focus of this Policy Statement is Section 1.9 of the *Guidelines: selection and employment of consultants by World Bank Borrowers*.[248]

A good definition of the concept of conflict of interest is found in the opening paragraph of Chapter Four of the World Bank's *Consulting Services Manual:*[249]

> *A consultant conflict of interest (COI) is a situation in which a consultant provides biased professional advice to a Borrower in order to obtain from that Borrower an undue benefit for himself, herself or affiliates. Although COI is an easily understood concept, to identify it and address its consequences, that is, the potential or actual prejudice to the Borrower's interests, requires in practice particular attention and expertise. COI is a concern when the consultant is in a situation in which its own or its affiliates' interests could prevail over the interest of the client.*

- **UNESCO**

The United Nations Educational, Scientific, and Cultural Organization (UNESCO)/ICSU World Conference on Science (1999 WCS) called for an ethical code of conduct for scientists formulated as a Hippocratic Oath. The final document "Science Agenda – A framework for action" states:[250]

- ➔ Ethics and responsibility in science should be an integral part of the education and training of all scientists;
- ➔ Young scientists should be appropriately encouraged to respect and adhere to the basic ethical principles and responsibilities of science;

The Report of the Secretary-General Policy Working Group on the UN and Terrorism in 2002 recommended: [251]

> *Relevant UN offices should be tasked with producing proposals to reinforce ethical norms, and the creation of codes of conduct for scientists, through international and national scientific societies and institutions that teach sciences or engineering skills related to weapons technologies, should be encouraged*
>
> *Such codes of conduct would aim to prevent the involvement of defense scientists or technical experts in terrorist activities and restrict public access to knowledge and expertise on the development, production, stockpiling and use of weapons of mass destruction or related technologies.*

At the Inter-Agency meeting of the Working Group, the following General Recommendations were made:

- ➜ Encouraging ethical codes of conduct for scientists and engineers
- ➜ Promoting ethics of science education and awareness
- ➜ COMEST could play a decisive role in fostering dialogue on education and ethics of science
- ➜ Involvement of COMEST together with ICSU in the field of the responsibility of scientists

- **<u>OECD</u>**

  The Organization for Economic Cooperation and Development (OECD) has had an initiative since the late 1990's dealing with the Principles for managing ethics in the public service. While this work is not directly applicable to the case of consulting engineering, there is common ground on several of the principles, and with the general objective of improving morality in public service. The OECD work is instructive for consulting engineering industry concerns as evidenced by the following approved principles:

  - ➜ Ethical standards should be clear and reflected in the legal framework (Principles 1 and 2).
  - ➜ The decision-making process should be transparent and open to scrutiny (Principle 6).
  - ➜ There should be clear guidelines for interaction between the public and private sectors (Principle 7).
  - ➜ Adequate accountability mechanisms should be in place (Principle 11).
  - ➜ Appropriate procedures and sanctions should exist to deal with misconduct (Principle 12).[252]

- **<u>RIL</u>**

  The Finnish Institution (RIL) has taken a major effort in focusing on the issues of corruption and bribery to the extent that TI has ranked Finland as the least corrupted country in the world. The factors that the Finnish believe have assisted them in fighting against corruption and bribery in Finland include[253]:

  - ➜ Anti-corruption legislation is clear and it's control is open and public
  - ➜ Limits of hospitality are commonly accepted
  - ➜ Salaries of civil servants are in line with private sector
  - ➜ Public administration is transparent

- ➜ Government is transferring its operative power to private enterprises to meet the citizens with more customer oriented manner (e.g. vehicle inspection, electrical inspections, quality control of building materials, preparation of building codes).

The construction industry in Finland has also been reformative. For example, the following actions are currently going on:

- ➜ Private enterprises, especially design and planning companies, have issued their own codes of conduct or are on the way to structuring their own codes of conduct
- ➜ The road and transport clients, consultants and contractors have built an industry wide code of ethics together with professional associations like RIL. According to those codes corruption is prohibited and should be actively resisted by all organizations and individuals within the industry. The codes encourage industry to develop competitiveness through research and development (R&D), life long learning and innovations – not by bribing.
- ➜ The European Council of Civil Engineers (ECCE) has developed a general code of ethics for civil engineers in Europe, which is approved and implemented in Finland by RIL.

6.2 Environmental Ethics

One of the most important political issues of the late 20th Century has been environmental protection and the rise of the environmental movement.[254] In the past, it is true that engineers may not have acted as responsibly as they should have concerning the environment, but were simply reflecting the views that were predominant in society. Engineers are part to blame for the creation of technology that has led to damage of the environment but have now become the "saviors" and responsible for finding solutions to what at the time seemed like improving the quality of life-it was just unfortunately not balanced with the quality of life for mother earth and the realization that if her life suffers, evidentially so will ours.

As concern over the environment has increased, so has the ethics of the professional engineering organizations. Engineers are well suited to make contributions to the area of the environment. They can encourage and guide corporations into the direction of greater concern for the environment and thus the need for sustainability in the decision making on all projects. Engineers within their own engineering professions have seen the awareness heighten with respect to the environment such that many professional engineering organizations have now included responsibility for the environment and/or sustainability within their code of ethics. The first step was taken by ASCE in 1977 when ASCE introduced into its code of ethics that engineers should be committed to improving the environment to enhance the quality of life. While the word should only suggest that engineers take note and consideration of this fact, it was still a major achievement in that the engineering profession was becoming aware of the critical importance to protect the planet and the environment that is critical to sustaining the quality of life. As more research took place and more global conferences were held, the issue was heightened again to the point where in 1997, ASCE changed its fundamental canon from a recommendation "should" to a mandatory "shall": [255]

> *Engineers shall hold paramount the safety, health and welfare of the public and shall strive to comply with the principles of sustainable development in the performance of their professional duties.*

The term sustainable development was introduced in the 1970s but became more popular in the 1980s and 1990s in conjunction with the 1987 publication *Our Common Future*, developed by the United Nations in its World Commission on the Environment and Development. [256]

> *Sustainable development is a process of change in which the exploitation of resources, the direction of investment, the orientation of technical development and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations…Sustainable development...meets the needs of the present without compromising the ability of future generations to meet their own needs..*

Engineering organizations around the globe have formed a global coalition committed to the long-term actions in support of sustainable development. This partnership entitled The World Engineering Partnership for Sustainable Development (WEPSD), formed in 1992 through a combined effort of global organizations including the World Federation of Engineering Organizations (WFEO), (representing about 10 million engineers in 80 countries), FIDIC, and the International Union of Technical Associations, and adopted the following vision: [257]

> *Engineers will translate the dreams of humanity, traditional knowledge, and the concepts of science into action through the creative application of technology to achieve sustainable development. The ethics, education, and practices of the engineering profession will shape a sustainable future for all generations. To achieve this vision, the leadership of the world engineering community will join together in an integrated partnership to actively engage with all disciplines and decision makers to provide advice, leadership, and facilitation for our shared and sustainable world.*

In consideration of how an engineer should approach the ethical thought process in making decisions regarding the environment, Hank Hatch, former head of the U.S. Corps of Engineers and 2004-2005 Chair of the AAES International Activities Commission, developed nine design concepts for building the framework for sustainable engineering:[258]

1. Engineers must be educated about the significance of sustainability
2. Engineers must adopt a notion of “ecosystems” thinking
3. Engineers must emphasize the aggregate consequences of what they recommend
4. Engineers must acquire environmental economic tools to integrate the environment and social conditions into market economics
5. Engineers must search for sustainable alternatives
6. Engineers must develop and apply technology to serve sustainability
7. Engineers must listen to those that they serve
8. Engineers must cultivate a multidisciplinary team approach
9. Engineers must continually educate those that they serve.

Sustainability has reached the world stage. In a 1998 visioning document, FIDIC stated that “increasingly, sustainability will be the primary measure of project success.” Believing sustainability to be a huge future market opportunity, and further believing that engineers are the key to getting it done, FIDIC has been a major player to establish a strong position on sustainability. In September 2005, FIDIC will be hosting is annual conference in Beijing, China with its theme to be “Sustainable Engineering-Global Leadership.” While engineers around the globe understand what sustainability is, it will take leadership to implement and provide specific direction. The FIDCI 2005 conference will focus on a “how to” action plan for the world’s consulting engineers to assume such a leadership position.[259]

Engineers must strive to educate all elements of society and promote universal adoption of a sustainable development ethic, particularly among private and public sector decision makers - the developers; the investors; and local, regional, national and international governing bodies.

7 HOW DOES AN ENGINEER ACHIEVE PROFESSIONALISM?

7.1 The Importance of the Professional Engineering Organization

Moral leadership is paramount within the professional engineering societies. Professional engineering organizations strive to unify the profession and to speak on behalf of the profession on issues that affect the public. Professional societies provide a forum for communicating, organizing, and mobilizing change within and by large groups.

Some of the things which professional societies do for an individual and which the individual can do for the society include:

1. Professional societies develop, preserve, and disseminate professional knowledge. The Professional society publications and technical papers presented at conferences are a primary source for the knowledge required to keep up with the advances in engineering.
2. The meetings of the professional society affords a less formal contact with one's peers and executives than is likely to be found in one's daily work environment.
3. Engineering societies add in the formation of engineering curricula with their close involvement with accreditation associations such as ABET in the United States and JABEE in Japan.
4. Student chapters of professional engineering societies afford beginnings in universities of guidance and motivation towards careers in the engineering profession.
5. Professional societies through group action are able to exert a powerful force to protect both the public and members of the profession and to serve as a voice to policy makers.
6. Every engineer has a debt to pay for the knowledge given to him or her by his predecessors-to do the same for those who follow. Engineers, a part of professionalism and as part of the ethical and moral obligations to contribute to their profession and to improve the profession through their volunteer efforts.

In Japan, there are 2.4 million engineers. Among them, 600,000 belong to one or more professional engineering societies. Each engineering society has two major functions: academic and professional. For example, JSME is to promote the advancement of mechanical engineering science on the basis of quality judgment by peer review. Another objective of JSME is to help mechanical engineers maintain and develop their expertise as professionals. Other engineering societies in Japan, such as JSCE, have similar mission and goals with respect to its members.

Engineering societies no matter where in the world can also assist greatly in the continuing professional development (CPD) of engineers, and especially with respect to requirements for CPD credit to maintain licenses and certifications.

7.2 Business and the Professional

Beginning in 2001, a wave of corporate scandals shook the United States and Americans' confidence in corporations. In that year, one of the largest energy companies in the world became the largest bankruptcy in American history with approximately $600 billion in shareholder value lost. It was not a year later that another giant international firm, WorldCom beat the Enron record. The service providers to these firms, and Arthur Anderson in particular, one of the largest accounting and auditing firms in the United States at that time and who had checked the books of Enron, (and was the largest employer of engineers at that time in the United States), was charged with complicity and was forced to dissolve. Compliance is about assuring that individual comply with professional standards and avoid wrongdoing. Procedures are needed in all companies to deter employees from fraud, theft, bribery, incompetence and other immoralities that exist today.[260] As a result of the actions that individuals took that bankrupted and dissolved some of the largest companies in the world, new laws and regulations were created in order to govern business practices. The most expansive of these laws was Sarbanes Oxley that goes to the heart of those overseeing the finances and business practices of a corporation-the company Directors. Engineers as they become officers and Directors of corporations need to have training in these areas and to recognize that the very codes of ethics on which they have abided in the engineering profession hold true to a large extent in running a business.

Personal and business ethics to some extent are not one in the same. Personal ethics deals with how we treat one another in day-to-day situations while business ethics involves choices at an organizational level and problems may seem quite different.[261] The engineer also must recognize that there may be a difference between the strict interpretation of the law and ethics. Somewhat that is illegal might not be unethical. This might have to do with a particular material that can be specified in a design. While it may be illegal to specify a particular product in one state or country, which does not mean that it is unethical. Further, just because something is legal does not make it ethical. For instance, in some countries, it may not be illegal to let certain emissions into the air, however, if the levels are so toxic that an engineer would know the harm that would be caused to the population, it would be unethical to so design a plant to allow the emissions, even though it is legal.

It is paramount that engineers take notice of the business landscape and how it is changing. It will be critical for the engineer to understand the consequences of business decisions and be able to withstand political and business pressures which are not in the best interest of the public welfare.

7.3 Professional Licensure

Licensure is mandatory in Canada to the extent that you cannot even refer to yourself as an engineer without having a license. Almost all engineers in both the United Kingdom and Australia are licensed and Australia is moving towards having all engineers licensed. Other countries, such as Mexico and Japan are beginning to also recognize the importance of licensure. In April 2001, the revised "Professional Engineers Law" went into effect in Japan. The revised law defines new procedures to obtain and maintain a Japanese professional certification called "Professional Engineer". The enforcement of the new law will have a large influence on the public's perception of the engineering profession. The responsibility to the public is stressed in the new law and Japan is hopeful that it will allow the public to regain its confidence in engineering and engineering achievements. Since the requirements and procedures are globally recognized, it will also allow Japanese engineers to apply more easily for other certificates such as the APEC Engineer and the International Engineer.[262]In 1995 at the APEC leaders' meeting in Osaka, Japan, there was an agreement to facilitate the mobility of qualified engineers among the member economies. The initial operation of authorized APEC Engineers Register by the eight founding members commenced on November 1, 2000 and was based on the *APEC Engineer Manual: The Identification of Substantial Equivalence."*[263] While countries around the world are noting the importance of licensure, engineering in the United States remains one of the few professions that do not require licensure in order to use the term "engineer" after one's name.

However, licensure is a proper way to provide public protection and to develop unity within the engineering profession. Professional engineering registration is also the strongest source for enforcing ethics since licensure takes on a legal perspective and not a voluntary perspective, one can be held legally accountable for their actions. In the United States, all states have a code of ethics that must be adhered to by all licensed professional engineers. Licensing laws are predicated on the assumption that the restrictions they impose upon the practice of the practitioner involved are necessary to protect the public health safety and welfare. Laws and codes thus, serve an identical purpose. Laws require evidence of competence for licensure. Do too professional societies, but not all enforce effectively. It is really inconceivable why licensure is yet to be mandatory in the United States or at a minimum for those engineers that are responsible for the infrastructure on which the public relies. Industries that design airplanes, for instance, are exempt from licensure as "the company takes on the responsibility." Yet, where does that leave the professional, who personally should be just as concerned about his or her actions as having a direct impact on the public. Engineers especially, are ethically and morally bound to protect the health safety and welfare of the public. Engineering is more than simply the stamping of a design drawing. It is about research, planning, design, construction and maintenance of today's infrastructure around the world. Engineers improve the quality of life and the world could not live without us. Yet, the majority of the public does not even know what an engineer is or does.

Major leadership positions that would benefit by the knowledge and talents of engineers such as Congressmen, Secretary of Transportations and even City Engineers are primarily held by non-engineers. Engineers have not held themselves to the same high standards as has the medical, legal, architectural and accounting professions. If we are truly going to raise the bar on our profession, a key element to this task is the requirement for engineers to be licensed. Engineering licensure recognizes competency and enhances the stature of civil engineering in the view of the public. Yet, the subject of mandatory licensure has been a controversial subject for years.

Even more controversial and often thought of as "taboo" is the requirement for engineering faculty to be licensed. Often I hear the defense: *"But I am only involved in research,"* or *"I have no practical experience,"* or even worse, *I do not design or stamp drawings and thus a P.E. License is worthless to me and not required to do what I do."* While a good majority of our faculty does see the value in being licensed, there are others who have indicated that they refuse to change their view on this issue. This lack of vision reminds the author of an anonymous quote: "*It might be just as offensive to be around a man who never changes his mind as one who never changed his clothes."*

Would you want to be operated on by a surgeon not licensed to practice medicine or to be operated on by someone taught by someone who was not licensed to practice medicine? Would you want to be represented in court by someone not licensed to practice law or to have been taught by someone not licensed to practice law? Would you want your taxes prepared by an accountant that was not licensed as a CPA? Then why is it we allow individuals to practice engineering without being licensed? Every engineering faculty member practices engineering every day and teaches students to practice engineering. It seems tragic that our profession has not considered engineering instruction to be important enough to require licensure.

Our engineering faculty is a valuable asset to the engineering profession and serves a very important function than just teaching and research: they serve as role models to our students who in turn will be the future engineering leaders of tomorrow. If our engineering faculty does not take pride in our profession and do not take part in professional activities and become licensed, then what do you think our students will do once they graduate? Our profession as a whole would be bettered if we as engineers were licensed. It would be in the best interest of the profession if graduates were actively encouraged by their professors to become licensed professional engineers. A first step in accomplishing this would be to find a mechanism whereby a larger percentage of our engineering faculty was licensed.

In the author's opinion, it is a myth that faculty members who have been awarded a doctoral degree in engineering do not possess sufficient experience in engineering work, as they have either done so prior to obtaining the doctoral degrees or in the teaching of advanced engineering courses, have no doubt exceeded the minimum technical requirements to become licensed. If an engineering faculty member cannot pass a professional engineering examination which merely confirms that an individual is competent in the area of their respective field of engineering, what does that say about the quality of our education? If the public really knew that our engineering faculty was not required to be licensed, what confidence do you think would be bestowed on the research that is conducted at our universities? As noted earlier, the practice of engineering is more than the stamping of a drawing; it is rather an affirmation in our profession and a pride in what we do. It is a basic premise required to be called a profession.[264]

A licensed professional engineer has an obligation and legal requirement to take “responsible charge”. This is another reason that licensing is so important and critical to the engineering profession. If engineers are to protect the public health, safety and welfare, and there is not a mandatory requirement for someone to take “responsible charge” as exists today in many corporations and in government positions, then how do engineers confirm to the public that the public is truly in their best interest? Responsibility begins with obligations. Responsibilities are obligations that are mandatory actions. Being responsible also means being accountable. Wrongdoing has both voluntary and negligent actions. When engineers voluntarily take an action with full knowledge of what he or she is doing, then that is a flagrant disregard of known risks or recklessness. In contrast, if an engineer unintentionally fails to exercise a standard of care which would be expected for the services rendered, that is deemed to be negligence. An engineer might not have known what it was doing-but it should have.

7.3.1 Engineering Licensure in Japan

The revised “Professional Engineers Act” was enacted in April 2000 and went into affect in April 2001. The Act was necessary as the Japanese engineer lacked global equivalence and was isolated from the rest of the world such as the PE in the United States and the CEng of the UK and Australia, allowing these individuals to practice on a global scale. The Japanese revised Act defines new procedures to obtain and maintain the professional qualification renamed “Professional Engineer”. The procedure consists of a primary examination, training and practice, a secondary examination and certification of PE and CPD. Graduates of an accredited engineering program are exempt for the primary examination, since the fundamental competence is assured by the program itself.[265] This is a difference from the U.S. model which still requires all students to take the Fundamental Exam as the first step toward the PE license. The Japanese certification system will assist greatly in expanding the opportunities for Japanese engineers to obtain such certifications as APEC Engineer and the International Engineer being discussed by the Engineer Mobility Forum.

7.3.2 Licensure conclusion

A professional engineering license just adds one more step in the engineer’s thought process-a reminder that having demonstrated competence through testing, the license now requires the engineer to exercise a standard of care and to accept a mandatory responsible charge for the work performed with the intent to protect the public health safety and welfare. For instance, all APEC Engineers must agree to be:[266]

- Bound by the codes of professional conduct established and enforced by their home jurisdiction and by any other jurisdiction within which they practice; and be
- Held individually accountable for their actions, both through requirements imposed by the licensing or registering body in the jurisdiction in which they work and through legal processes.

There are several reasons why engineers should become licensed:[267]

1. Support of the engineering license laws enhances the statute of the profession.
2. Licensure gives one an importance and status as a professional in one's community, and not the status of a mere employee.
3. One may at any time receive an offer of employment that requires the engineer to be licensed.
4. More companies are using an engineering license as an impartial means of judging the competency of its employees. Salaries and advancements are often based on licenses held.
5. Later in life part-time consultancy may necessitate the credentials of a license, especially if an individual is going to testify as an expert witness based on his/her experience and expertise.

The author encourages engineering students to question their professors as to whether they are licensed and if not, why not. The author further challenges all engineers to take an active role in pursuing excellence and raising the bar to the engineering profession. This will necessitate members encouraging other members to be licensed, employers requiring engineers to be licensed, and universities to stand up to the plate and require licensure as a step for tenure and as a measurement of university excellence.

8 THE IMPORTANCE OF THE INCLUSION OF ETHICS AND PROFESSIONALISM IN ENGINEERING EDUCATION

One of the key tenets of ABET is:

Engineers shall hold paramount the safety, health and welfare of the public is performance of their professional duties.

ABET adopted new criteria in 2001 that requires all engineering colleges in the United States to demonstrate how they are teaching ethics and professionalism to their students and to assess the effectiveness of that teaching.[268] Yet, despite ABET having this requirement as part of its standards of engineering education, engineering students are still not yet taught about what it means to be a professional and the moral and ethical obligations that it puts upon them to serve the public. Engineering students are not necessarily taught about the importance of their respective professional organization and the importance to give back to and promote their respective profession, knowing that by doing so, the profession will be bettered and the welfare of the public will be protected. Engineering students are not necessarily encouraged or presented with the reasons for licensure and that as a profession; engineers should be required to be licensed just as any respected profession such as the legal, medical and accounting professions. Engineers are not taught lessons learned from engineering failures that occurred and why and the often serious implications such as bodily harm and death-and thus failing to achieve the very reason for their being: to protect the public health, safety and welfare.

If engineering students are not presented with ethics and professionalism as a subject just as critically important as their technical courses, then upon what basis does the student judge that it is a requirement to be an engineer? How does a student take seriously that professional organization membership, licensure and taking the oath as Order of the Engineer are critical steps to in fact becoming a professional. We teach engineering students the technical nature of what they do, but we do not teach them the implications of what can happen should they not apply the applications of sound judgment based on consideration of what could happen if anything goes wrong. As a result, the increases in engineering failures increase, public confidence is lost, and engineers again lose the ability to gain the leadership positions that they should be holding.

The study of engineering ethics strengthens one’s ability to reason clearly about moral questions. Ethical problems encountered in engineering practice are not simply the question of what is right or what is wrong that could be answered by the lay person, but are very complex and typically involve conflicting ethical principles. One source of ethical issues encountered in the course of engineering practice is the lack of knowledge.[269] However, the lack of knowledge is not foreign to the practice of engineering. By its very nature, engineering is about the creation of new ideas and new technologies and new products. Thus, in some respects, the engineer's job is about managing the unknown. However, as engineering schools today seldom teach anything about management, there is a double dilemma in that the engineer of today neither fully understands the consequences of the decision he/she makes, nor understands how to manage the very unknowns that he or she is faced. While an engineer cannot be fully sure that the final design will not harm anyone, the engineer must use all available information and sound moral and ethical judgment when coming to the final decision and must be confident that it is in the best interest of the public. The engineer must also be able to weigh what is ethical and what is not and when an engineer based on his or her reasonable judgment does not believe that something is in the best interest of the public, there needs to be procedure where the engineer can voice those concerns and do so in a way that is not going to be criticized or ignored.

While one might say that only seven lives were lost, the Challenger disaster was an engineering failure that received world-wide attention and put the US space program on hold for years. It was a "life or death" situation. It was an engineering failure that cost lives. However, what most people do not know is that the engineers who had designed that little "O" ring did not believe it would perform under certain temperatures. In fact, they recommended against the Challenger going up due to low temperatures that day. However, political pressure won out and the Vice President of that company was asked to go back and "reason" with the engineers to get them to change their mind. All but one engineer reluctantly agreed to sign the release to allow the Challenger to go up. One engineer refused to sign. Now, what was that engineer to do? If engineering students are not taught ethics in school, how can they reason these types of real-life situations? How can engineering students learn if they are not provided with the mistakes and failures of the past and asked to comment on them?

Other major failures that resulted from engineering mistakes and/or misjudgments such as the Challenger include the Ford Pinto car that exploded and killed the occupants due to the position of the gas tank (a less costly design and thus a cheaper car); the Chernobyl nuclear disaster in Russia which due to the lack of a containment (again, less costly solution), cost many lives in several countries and severe illness that will be life lasting; the nuclear disasters in Japan which lost the confidence of the Japanese people in engineers; the infamous Titanic that killed hundreds of people - not only due to a design issue, but due to a decision not to carry the needed number of life boats. Multiple examples could be noted, yet why don't our universities around the world take advantage of these real life stories to teach students why they must take their responsibilities so seriously?

It is critically important that this concept not only be discussed in the engineering curriculum, but be a full class devoted to reviewing actual cases, actual situations, hypothetical problems and issues and have the opportunity to fully debate these issues among their peers so as to fully prepare them for reality and what they will face when they enter the workforce.

Engineering students should be instructed that engineering problems seldom have a correct answer that will be reached by everyone in the class. However, the problem solving methodology is not so dissimilar to the thought process to solve engineering design problems. There will always be multiple ways to design something that result in the same final product use, but derive a different approach. For example, there are multiple sports arenas all around the world. They all provide the same function, but their design is typically quite different. While there will be no one correct answer, there will be a range of solutions, some of them clearly wrong.[270] However, the thought process to arrive at the solution is the same for both engineering ethical problems and engineering design problems. It is this very thought process that must be considered within the engineering curriculum.

Courses in ethics are beginning to appear in some universities. For instance, there is an on-line course entitled “Ethical Issues in Engineering E131/STS 115” that is taught by Case Western Reserve University in the United States.[271] The course is specially designed to study the ethical issues in engineering practice today. The purpose of the course is threefold: (1) to expose students to ethical issues of the sorts that engineers sometimes face in professional practice, (2) to help students think more clearly and deeply about such issues and (3) to explore resources, strategies, and options for grappling with such conflicts.

Other courses are beginning to appear relative to professionalism and professional practice. One such course entitled “Civil Engineering Practice”, was developed and is being taught at Rowan University in the United States.[272] This course is intended to introduce students in their senior year to some of the professional practice issues that they will encounter in the real world. The subjects while broad include topics such as specification preparation, cost estimation, client and societal relations, marketing, ethics, regulatory agencies, law, organizational and human behavior, team effectiveness and job safety. Emerging issues in the engineering practice are also presented when they arise. The topics fall into four primary categories:

- Business Practices and Project development
- Professionalism and Professional Development
- Current Engineering Trends
- Community and Societal Impacts

Seminars are also being developed and taught in the United States on Ethics and Professionalism. One such seminar is conducted by ASCE entitled “Ethics and Professionalism for engineers.”[273] It provides continuing education credit required for maintaining licensure in the United States. The stated objectives of the seminar include:

- Understanding the historical basis of ethical requirements
- Knowing the major themes of ethics
- Developing and expanding the engineer’s source of information to sustain a commitment to ethical professional conduct
- Knowing the hazards that typically result in ethical temptations and failures
- Sustaining the engineer’s commitment to a sound set of behavior, ethics and career

Engineering ethics is the study or moral decisions that must be made by engineers in the course of engineering practice. It is critical for engineering students to study ethics so as to make the most informed decision during their careers. Engineering ethic problems will have several solutions, with some being better than others. [274]

9 CONCLUSION

Just having a degree in engineering is not enough. What most people have yet to realize is that being an engineer is a life or death position. Any error or mistake on a drawing or the failure to review a change or a shop drawing can potentially have fatal consequences. How can a person instruct and teach others about how to design without having been examined in the not only the fundamentals of engineering, but whether the design concepts and decisions made are sound? If not examined, there is a probability that any faults in the teaching process will be passed down to students who may go on to be practitioners. One of the most meaningful activities that the author participated in while she was a senior at Purdue University was the “Order of the Engineer.” The steel ring the author wears on the little finger of her working hand reminds her every day that everything she does as a licensed professional engineer has a life or death consequence. It makes the author think before she acts; it makes her realize the importance of our profession and what it means to be a civil engineer. It is more than a job.

The profession calls for high standards as it should. We have an ethical responsibility to the population of this world to act responsibly in everything we do, whether it is designing, constructing, or making managerial decisions. So what are the steps required to enhance our profession? We can proceed with several steps right now.

The steps, in the author’s opinion view that should be taken by every engineer include first becoming a member of their respective professional engineering society, which can be done as a student and retaining that membership throughout a person’s lifetime as part of his/her professionalism. “The Order of the Engineer” ceremony should be a program that is world-wide and mandatory for every senior college civil engineering student to remind us of our role as engineers. The FE exam is a prerequisite to assure one understands the basic concepts why we went to engineering school. The professional engineering license examination is a necessary requirement to ensure that we can safely design and teach others how to design. Continuing education should be required to maintain a professional engineering license and to better ourselves as first managers and then leaders of the engineered project. We must move as a coalition to ensure that we maintain our stronghold in leadership and decision-making positions, whether that is in City or State government, a particular project, or within our own universities or corporations. We must endure a long battle, but it is our civic duty and obligation as part of our ethical and professional responsibilities. [275]

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VI. DIVERSITY AND ITS CRITICAL IMPORTANCE TO THE ENGINEERING WORKFORCE[276]

1 INTRODUCTION

The general public depends on the media for most of its science-related information, but clearly much is being lost in translation when so few people are familiar with what engineers are or do. I feel one of the primary reasons the public has little knowledge of the engineer is that engineers have not kept up with the changing demographics of today's workforce.

The result of non-diverse and non-communicative engineers is as noted by William Wulf, President of the U.S. National Academy of Engineering (NAE): *"To the extent that engineering is a pale male profession, which it largely is, it is impoverished."*

However, the deliberate development of skills in creativity and innovation in engineering is no longer taught at our universities or portrayed to the public in a manner that responds to the public's needs. The need to deliver capable engineering graduates to the workforce, reflective of the image of today's workforce and furnished with the broad range of abilities demanded by today's workplace is a forgotten practice and for which the profession has suffered greatly. This, in turn has resulted in a negative impact to the competitive nature of our economy. Further, an increasing global marketplace is increasing the need for the understanding of diversity. Even in the United States, the population itself is by definition "diverse". This year, the U.S Census Bureau projects that one in three Americans will either be African American, Hispanic American or Asian Pacific American. Together these three groups are increasing seven times faster than the population as a whole.[277] U.S. Corporations are beginning to recognize that its management, including senior management, must represent its customer base in order to win their loyalty. The same should be true for the engineering workforce, in order to gain the loyalty of our customer workforce-or the public. As noted by a senior manager at the internationally based accounting firm Deloitte, *"Unless you influence the leadership appointment process, we find white males will, generally speaking, pick a white male, or a U.S. Partner looking for an appointment in the US will generally pick another U.S. Partner. Every time we create a team, we step back and evaluate that team based on its diversity. It could be diversity from color, from sex, from background, but it's rare that we form a team that is not diverse."*[278]

Why does the author think that engineers are not reflective of today's current workforce or that they are being quickly being left behind? The reasons are threefold:

- Engineers are not trained in the necessary skills required to work with today's public and workforce including skills in:
  - ➜ Communication
  - ➜ Public Policy
  - ➜ Social Behavior
- The population workforce today is diversified and is filled with women, underrepresented groups and the physically challenged. Yet, the engineering workforce of today still consists primarily of white Caucasian males.
- Engineers have become comfortable with the status quo and are reluctant to be creative and innovate.

Because of the increasing complexity and scale of systems-based engineering problems, there is a growing need to pursue collaborations with multidisciplinary teams of experts from across multiple fields. Essential attributes for these teams includes excellence in communications, an ability to communicate using technology, and an understanding of the complexities associated with a global market and social context. In addition, the need to be flexible and receptive to change with mutual respect is essential.[279] Consulting engineers should be able to lead teams as well as participate as a member of a team. This requires an understanding of team formation and evolution, personality profiles, team dynamics, collaboration among diverse disciplines, problem solving, and time management and being able to foster and integrate diversity of perspectives, knowledge and experiences.[280]

2 ENGINEERS ARE NOT TRAINED IN THE NECESSARY SKILLS REQUIRED TO WORK IN TODAY'S WORKFORCE

Engineers, in general have a negative image when it comes to social skills such as communication, public policy, leadership and management. In a recent conversation the author had with a manager of the Environmental Protection Agency (EPA), when asked if she thought the EPA could be improved if the head of the EPA was also an engineer, the author received an emphatic, "*Absolutely not!! Engineers are too narrowly focused only on technical matters and certainly do not know anything about management*." While a little taken back, the author was not surprised. This educated person's view is the same view shared by many individuals in the United States. As the Dean of Science at the University of British Columbia, Canada said: "*The current image …is smart… skinny, thick glasses, pale, no life, no people skills….is completely inaccurate and discourages many young people, including the vast majority of young women.*"[281]

So, what is required to change this image, to better equip the engineers of today to be the leaders of tomorrow? In the author's opinion, we must change the image of the engineer as seen by the public, we must educate our engineers in non-technical skills that allow them to better communicate and manage and we must involve ourselves in public policy.

The "image" process must begin at a very young age and continue throughout a child's term in K-12. An engineering career should be portrayed just as any other profession that is highly regarded such as doctors, lawyers, accountants and architects. Engineers need to be in the schools assisting with teachers in describing what engineering is, why it is fun, and why it is a career that helps the public and the planet and improves the quality of life for all. Engineering needs to be better portrayed in the media - we need to get the same coverage as other professions, not only in the news, but in television programs, in movies, in the kind of day-to-day life demonstrating that engineering is a career path that young kids can and want to strive for.

However, we as engineers must be the ones who make this change. In order to do so, we need the non-technical skills that have been long removed from the engineering curriculum-written and oral communication skills, financial skills, people skills, leadership skills, public policy skills, and management skills. Engineers need to understand the global context and business skills if we are to be competitive. We need to assure that we have life long learning and keep pace with the changing environment and demographics around us. If we do not change, we will become a commodity at best, bid for on the open market at supermarket prices. We must look for the opportunities to innovate rather than simply finding ways to improve productivity.

To accomplish this goal, we must change the way we educate engineers today and we must involve ourselves in the public policy process so as to engage other decision makers regarding the value of legislation which impacts upon the quality of life. Simply receiving a Bachelor's degree in a technological discipline is not enough. Engineers must go beyond and obtain the requisite education required to become, as defined by Joe Bordogna, Past Deputy Director at the National Science Foundation (NSF), a "holistic" engineer: [282]

> *An Engineer must be able to work across many different disciplines and fields- and make the connections that will lead to deeper insights, more creative solutions, and getting things done….The 21st Century Engineer must have the capacity to:*
> - *Design-to meet safety, reliability, environmental, cost, operational, and maintenance objectives;*
> - *Realize products;*
> - *Create, operate, and sustain complex systems;*
> - *Understand and participate in the process of research; and*
> - *Gain the intellectual skills needed for lifelong learning.*

In a knowledge-based economy, education is paramount to one's nation's future. Engineering education is an investment in our nation's capacity to perform.

3 TODAY'S DIVERSIFIED WORKFORCE AND THINKING OUT OF THE BOX

Education is just one problem of the today's engineer. Concurrently to providing the necessary skills in the engineer's tool box, as discussed above, we must change the "image" of the engineer. We must be more like the public that we serve-we must be diverse. The problem of engineers not representing the face of the workforce of today, however, is not just appearing on the horizon. The problem has been around for quite a while. Vannevar Bush, in his 1945 work entitled: *"Science: The Endless Frontier",* discusses his correspondence with United States' President's Roosevelt and Harry Truman, which suggested: *"First, we must have plenty of men and women trained in science."* Vannevar Bush also said: *"…The frontier if science…is keeping with the American tradition-one which has made the United States great… [and] that new frontiers shall be made accessible for development for ALL American citizens."* The key was "all" Americans. This statement transcends across the world for all citizens no matter in what nation they reside.

As the world becomes "global" with the infusion of the internet and the capability to communicate around the world in live time, 24/7, the problem of a non-diverse profession becomes heightened. The problem has become so significant that in October 1998, U.S. President Clinton established a Presidential Commission on the Advancement of Women and Minorities in Science, Engineering, and Technological Development (CAWMSET). The mandate of the Commission was to "*research and recommend ways to improve the recruitment,* *retention, and representation of women, underrepresented minorities…and persons with disabilities in science, engineering, and technology (SET) education and employment."*[283]

As noted in the preamble to the CAWMSET report: [284]

> *Today's US economy depends more than even on the talents of skilled, high tech workers. To sustain America's preeminence we must take drastic steps to change the way we develop our workforce. An increasingly large proportion of the workforce consists of women, underrepresented minorities, and persons with disabilities-groups not well represented in science, engineering and technology (SET). Unless the SET labor market becomes more representative of the general U.S. Workforce, the nation may likely face severe shortages in SET workers, such as those already seen in many computer-related occupations." ….If on the other hand, the United States continues failing to prepare citizens from all population groups for participation in the new, technology-driven economy, our nation will risk losing its economic and intellectual preeminence. It is time to move beyond a mere description of the problem toward implementation of a national agenda that will take us where we must go, so that our nation can thrive now, and in the years to come. It is also time to establish clear lines of responsibility and to define effective accountability mechanisms.*

While the report was issued in September 2000, the term of the Commission has expired and four years later, no action has been taken on the Commission's recommendations.

However, Vannevar Bush's theme and the recommendations of the Presidential Commission remain in the minds of many of us today who are stepping up to the plate to effectuate change. As Joe Bordogna, echoed in his address before the Awards for the Integration of Research and Education in the 21st Century:

> *The nation's economic viability, capacity for security, and overall quality of life depend on a general workforce that is scientifically and technologically literate and a science and engineering professional workforce that is world class at all levels. …The softening of the nation's capacity to perform is exacerbated by slow progress in attracting and advancing underrepresented minorities, women, and persons with disabilities to careers in science and engineering. We must address these issues with both passion and strategic investment. It is unrealistic to imagine that the United States can persist in sustaining its freedom without long-term dedication to resolving this workforce conundrum. The US has neglected proactive recruitment of our domestic talent ….We also know that wanting to broaden the participation of underrepresented minorities and women in science and engineering is just not enough. We must learn to take full advantage of our rich human resources, and there must be strategies and a plan for action that creates a path for making this happen. Engineers must possess integrative*

capabilities and insights into global diversity in order to perform and succeed in an increasingly complex and international work environment.

While the demographics of today's workforce have changed to reflect the diversity of the population and despite Bush's vision in 1945, the engineering workforce of today bears no resemblance of the public for which it serves. For example, in the 1990s the Hispanic population in the United States grew by 60%. Most of this growth was only in four states, though the Hispanic population stretches across the US and represents the major demographic and cultural change in many areas of the nation. By the third generation, Hispanics have achieved the same education and economic levels as non-Hispanic whites.[285] The Asian American population in the United States grew by 63% in the 1990s and is the fastest growing segment of the population. The African American and Native American populations are also outpacing the Caucasian population in the U.S. There is no clear majority of any ethnic population in California and 50 of the largest cities in the U.S.[286] Americans with a disability of some level account for 20 percent of the population, with half of those having a severe disability.[287]

While women and minorities together make up 60% of the total workforce in the U.S., African Americans and ethnic minorities constitute only 23% of the science and engineering labor force. Women comprise 46% of the total labor force in the U.S., but only 23% of the Science and Engineering workforce.[288] According to the U.S. Census Bureau from 1995-2000, in 1983, only 5.8% of the engineers in the United States were women. Almost two decades later, in 1999, the percentage of women in the engineering in the U.S. universities had risen to just over 19%, however, women engineers in the U.S. workforce has only increased to only 10.6%.[289] However, at a National Academy of Engineering Summit meeting in May 2005 held in Washington, DC, an alarming decrease has occurred relative to women engineering students. In 2004, the enrollment of women in engineering at U.S. Universities was only 16.3%. Women engineers in the workforce have risen to only 11%.

In the UK, women make up 52% of the population.[290] UK engineering products and services approximate 40% of all UK exports and the engineering industry employs 1.8 million highly skilled employees, yet women make up only 4% of the total number of employed graduate engineers.[291]

While statistics were not easily gathered for the overall women in engineering generally in Japan, the statistics relative to women in civil engineering per data from JSCE showed a low percentage of women in engineering. Of the 39,842 members of JSCE, 1,025 are women, or 2.5%. Of the Regular members, there are 30,761 which only 520 are women. Of Student Membership, there are 5,473 members of which 502 are women. Of Fellow Membership, there are 2,268 fellows of which only 3 are women.

On the positive side, female membership in JSCE is growing. In 1999, there were only 33 new women members that year. In 2000 there were 75 new members. In 2003, there were 254 new women members and 204 new women student members. Of the breakdown of industry, the following shows the percentage of women versus male members:

Industry	Women	Men
Private	19%	12.1%
Consulting	30%	23.7%
Construction	12%	25.9%
Public Companies	3%	3.2%
Educational	15%	10.9%
Government	4%	5.3%
Self Employed	5%	3.5%

It was noted that in the legal, accounting and medical fields, there was more networking among women and that this appears to be one reason these fields have also had a more rapid increase in the number of women entering the fields as one of the networking tasks is to show role models and the contribution women make to these fields.

All of the demographics described above will have a significant impact on the way managers must approach topics in their respective businesses and many of the corporate policies on how we do business will need to be revised. The demographics will lead to greater workforce diversity. The United States had always achieved pre-eminence in science and engineering partly because it was able to recruit and educate the best talent from around the world. However, several factors question whether the United States will remain the pre-eminent country in science and engineering, let alone whether there is even enough supply of engineering professionals that are needed to maintain the country’s long-established global leadership.[292]

Anita Borg, President and Founder of the Institute for Women and Technology, of Xerox Corporation indicated in the 2000 Presidential Commission report: *"We cannot define the future by a narrow slice of the population. We must all be represented. We must all benefit."* Research has demonstrated that a diverse workforce creates a competitive advantage through greater creativity and innovation; increased organizational flexibility thanks to higher levels of divergent thinking; and better decision making based on multiple perspectives as well as a critical analysis of alternatives.[293] A mixture of genders, ethnic backgrounds, and ages in senior management teams-consistently correlated with superior corporate performance in such areas as annual sales, growth revenues, market share, shareholder value, net operating profit, worker productivity, and total assets.[294] The Chair of the 2000 Presidential Commission, Constance Morella noted: "*Until our scientific and technological workplace reflects our diversity, we are not working to our potential as a nation."*[295] Baroness Susan Greenfield, Professor of Pharmacology at Oxford University in the UK noted:[296]

> *We are now beyond the token woman scientist or engineer: it is far more important that we have a balanced workforce in SET, to maximize the effectiveness of the SET marketplace. The essential first step is to attract women as the norm, rather than the exception.*

4 WOMEN IN ENGINEERING

4.1 The Career Woman Engineer

With respect to women, many ask why more young girls are not attracted to the field of engineering and why so many leave the profession even though they are educated and trained just as their male counterparts. Little research has been done to answer this question. However, it is the suspicion amongst many women engineer professionals that the answers lie in similar answers to those of young women who leave the engineering profession. Catalyst, an organization that conducts studies on women in a variety of fields, indicated in a 1999 report the following regarding why women chose to leave the engineering profession:[297]

- Female graduate students in the sciences remain uninformed about potential careers in business.
- Academia is viewed by many as unwelcoming to women scientists.
- Absence of female role models

- Isolation
- Risk-averse supervisors and stereotypes
- Differences in style
- Exclusion from informal networks
- Lack of mentoring
- Lack of line or general management experience
- Work/life balance

The situation in Japan is not much different from that in the United States. In a Civil Engineering Round Table meeting hosted by JSCE in June 2004, the following was noted as to why more women are not in the engineering profession:

- Difficulty in balancing work and family
- Male consciousness
- Work environment
- Social driven behavior
- Lack of role models

The factors leading to the low percentage of Japanese women in leadership were attributed to the following factors:

- Priority given to the male worker
- Balance of work and family
- Work environment
- Insufficient role models

Many of these reasons converge around the reoccurring theme of “image.” Image has been demonstrated to have a profound affect on young women. According to Linda Fedligan, a professor at the University of Alberta, Canada: “Many *of the newest generations of women primatologists talk about the positive effects on them as children of seeing National Geographic coverage of Jane Goodall and Diane Fossey.”* The lack of role models in the engineering industry has contributed to the flat growth of women engineers in the profession.

While it is a task at hand to get more younger individuals interested in engineering as a career, it is hard enough to keep girls in particular interested in math and science so as to retain them in the technical fields when they enter high school. However, it is even more difficult to attract young girls to the area of engineering when they are in high school. Thus, as a consequence, there are a disproportionately low number of women in engineering studies at the universities as compared to other professions such as medical, legal, and accounting. Further more, statistics show that an even larger number of women do not stay in engineering once they have received their degree. As a consequence, women advance at a snail's pace to the senior ranks and leadership positions in industry, business, academia, and government careers. And, of course, society as a whole suffers the setbacks of a diminished science and engineering workforce, fewer high-level leaders and innovators, and a citizenry that is far less literate than it ought to be at a time when technological innovation is the force carrying society forward.

It is a fact that engineered products and services are improved with women team members. We need more women in the engineering workplace. The benefits to the public by having a diverse engineering workforce are enormous. In order to compete in a global market, companies will need to diversify their engineers in order to compete. To compete, one must take advantage of life experiences that bears directly on good engineering design. In that way, engineers need to be innovators and change the way we think, the way we act and the way we are comprised. Engineers are viewed as quintessential problem solvers. Give an engineer some parameters, a few constraints and a target to shoot for and away he or she goes, never to see the light of day again until the problem is "solved." However, solved has a different meaning depending on who is viewing the solution. Engineers tend to only see the solution from their perspective. Thus, if that perspective does not include a diverse base from which the problem was analyzed, the solution will naturally be missing key elements. Take for example the Ford Windstar Mini-van - a success story of all time. Why? Because for years, women who chose to stay home while their children were being raised, complained that the "mini-van" when engineered just did not meet the requirements of Moms and children. It was not merely because it was a man or woman, but because the men designed the mini-van did not have the direct experience or exposure to what tasks were done in a given day with this type of vehicle. The solution was for Ford Motor Company to comprise a team of engineers, led by a woman engineer and other women engineers on the team, who had this experience and who had been in the role of the "Mom." The result was a mini-van that met the long-requested needs of the users. By having a diverse team and a team which included women, the final product was a better solution to the problem at hand.

Diversity is important to mobilize resources. Project teams become stronger and more competitive. Research also shows that diversity has a positive impact on the bottom line and, not surprisingly, increasing numbers of companies are devoting considerable financial resources to developing and leveraging diversity.[298] Catalyst's 2004 findings also demonstrate that women are critical to a company's success. Key findings include: [299]

> *The group of companies with the highest representation of women on their top management teams experienced better financial performance than the group of companies with the lowest women's representation. This finding holds for both financial measures analyzed: Return on Equity (ROE), which is 35.1 percent higher, and the Total Return to Shareholders (TRS), which is 34.0 percent higher.*
>
> *Financial Performance was also analyzed by industry, and in each of the five industries analysis, the group of companies with the highest women's representation on their top management teams, experienced a higher ROE than the group of companies with the lowest women's representation.*
>
> *In four out of the five industries analyzed, the group of companies with the highest representation on their top management teams experienced a higher TRS than the group of companies with the lowest women's representation.*

4.2 Young Girls: How Does the Engineering Profession Attract Them?

Today, young people—especially girls—require role models and mentors to give them the hands-on guidance and encouragement that will help them consider an engineering career. Do you remember having a role model who inspired you to become an engineer? Perhaps a childhood hero, a teacher, or a parent was an engineer. Did you have a mentor during the early phase of your career? Do you have a daughter, or granddaughter or know of someone with a daughter who you would love to see become an engineer? If you do, then you understand the need for role models.

According to a study conducted in 2002 by the Educational Development Center, which is headquartered in Boston, Massachusetts in the United States, programs for girls that combine hands-on activities with role models lead to increased self-confidence and greater interest in engineering, science, and technology courses and careers. Moreover, these programs constitute a vital step in educating all students about the benefits of a diverse engineering workforce.

Author Pat McNees illustrates the crucial need for new methods to reach girls in her book *New Formulas for America's Workforce: Girls in Science and Engineering.*[300] McNees points out that girls need more than basic classroom exercises to become fully engaged in a course of study or career that, with its imposing edifice of mathematics, may appear unduly abstract. Hands-on learning is a proven tool for improving learning on the part of *all* students and is indispensable in giving girls self-confidence and stimulating their interest in science and engineering. Supplemental programs that combine hands-on activities with exposure to female role models are necessary to attract young women to engineering and sustain their interest.

To sustain our nation's scientific, engineering, and technical workforce, we must reach out to those who are not yet a part of it—namely, young women. While women make up 46% of the workforce in the U.S., they hold just 12% of Science, Technology, Engineering, and Math (STEM) jobs. This lack of diversity means valuable perspectives and experiences are missing in the United State's pursuit of advancements in science and engineering.[301]

Why aren't girls enrolling in college engineering degree programs and going on to pursue engineering careers in larger numbers? According to a study conducted in 2000, the problem is not one of ability. Contrary to long-held perceptions, many girls express high interest in math and science and perform as well as or better than their male peers in these subjects. Researchers Huang, Taddese, and Walter found that girls are taking high school science and math courses at approximately the same rate as boys: 94% of girls and 91% of boys take biology, 64% of girls and 57% of boys take chemistry, 26% of girls and 32% of boys take physics, and 64% of girls and 60% of boys take algebra II. [302]

Yet, few girls choose to pursue an education and subsequent career in engineering. There is much speculation as to why girls are not choosing engineering. Explanations often include that high school girls:

- do not see many women in engineering and thus few role models exist, [303]
- are not aware of what a career in engineering entails, and
- See engineering as a place for geeks and nerds[304].
- Perceive engineering to be a man's profession
- Do not see engineering as a good working environment where they can make a good salary and have flexibility.

These explanations were confirmed by a May 2005 Final Report entitled "Extraordinary Women Engineers" funded by the U.S. National Science Foundation which researched and evaluated why girls age 14-17 were not choosing engineering.[305]

Japanese research has shown that the reason girls are not interested in engineering is as follows:[306]

- Hard, dangerous and dirty work environment
- Long hours
- Minority and thus no common interests amongst co-workers
- Women felt that they were not treated equally and had restricted working times and locations of where they were allowed to work and received differential treatment.

High school girls are not alone in their limited understanding of the nature and benefits of an engineering education and career. It is our premise that the problem is one of perception. Girls and the people who influence them—teachers, guidance counselors, parents, peers, and the media—do not understand what a career in engineering looks like. The 2005 NSF Extraordinary Women Engineers Final Report noted that science and math teachers and school counselors agreed with the girls. People have a vague sense of engineering as in "I'm not worried about global water supply; engineers will fix that problem." But does the general public understand what's involved in engineering? Do they have an accurate picture of what an engineer's day looks like? Our personal interactions regularly bring us in contact with doctors, teachers, lawyers, and firefighters. In addition, the media presents us with multiple and varied images of these professions through television programs, commercials, newspaper columns, and more. But where is engineering in all of this?

A Harris Interactive Poll of American adults conducted in 2003 found that most would be extremely pleased if their children pursued a career in engineering, yet just one-third of those same adults considered themselves well-informed about engineers and engineering. All too often the very people parents and students rely on to share the opportunities and realities about careers such as engineering—teachers and guidance counselors—are also woefully uninformed.

In 2002, for the first time in history, the top elected leaders of four of the five oldest U.S. engineering societies were women—a feat unmatched previously by even the legal and medical professions. Women were also at the helm, as president, president-elect, or past president, of an additional seven engineering organizations. While this unique accomplishment clearly demonstrated that women have shattered the glass ceiling of professional achievement within the engineering profession, it also called into stark contrast statistics regarding the low number of young women entering the profession.

These women leaders and their male peers recognize the importance of diversity to the future of the engineering profession. Through participation in summits coordinated by AAES and hosted by the National Academy of Engineering (NAE), their respective organizations joined with several other engineering organizations to sign pledges supporting diversity within the engineering profession. As a result, a committee on diversity was established within AAES to serve as the coordinating body for engineering societies and other related organizations to conduct collaborative programs focused on increasing representation by women and other underrepresented groups.

The benefits of collaborative projects to advancing engineering outreach were formally recognized in a March 2002 report from the NAE, the *Public Understanding of Engineering Inventory.* Commissioned in 2001, the U.S. NAE undertook the project "to help the engineering community maximize its resources to deliver a comprehensive, coordinated, and sustained message."[307] The report cited among the most effective engineering outreach programs National Engineers Week, an outreach project coordinated by a coalition of engineering societies with support from major engineering corporations. Among the report's chief recommendations was that the engineering community focus its outreach efforts on the pre-college audience.

To respond to the NAE's report recommendation and to counter the misperceptions of high school girls and the people who influence them, WGBH-who is the producer of NOVA, Building Big and Zoom into Engineering, AAES, and a coalition of over 80 engineering and related associations have formed a partnership to develop and implement the EXTRAORDINARY WOMEN IN ENGINEERING initiative. Comprised of a national outreach campaign, television broadcast, and companion Web site, EXTRAORDINARY WOMEN IN ENGINEERING will:

- Mobilize the 8 million engineers around the United States in actively reaching out to educators and girls to encourage participation in engineering education and careers;

- Provide compelling role models of women actively engaged in fulfilling engineering careers;
- Help high school science, math, and technology teachers and guidance and career counselors to better understand the nature of engineering, the academic background needed by students pursuing engineering, and the career paths available in engineering; and
- Equip high school teachers and counselors to share this information with students, especially girls.

Through hands-on activities and exposure to role models, the program will, it is hoped, give girls an interest in engineering, science, and technology while helping them gain the confidence necessary to consider careers in these areas. The starting point of the project is the project's flagship publication, the book *Women Engineers: Extraordinary Stories of How They Changed Our World*, scheduled for release in February 2006 in conjunction with Engineer's Week, hosted in 2006 by the Society of Women Engineers (SWE) and will be supplemented with educational materials, a television documentary, and national outreach programs during 2006-2007. The Coalition is working with WGBH Boston to produce products for this project that are of the highest caliber.

This program will celebrate the achievements of women in engineering, the goal being to inspire young women to pursue engineering careers. As an added benefit, those who make this choice will themselves be able to serve as role models later in life. At the heart of the program is the sharing of information. U.S Past President Woodrow Wilson summed it up very well: *"I not only use all the brains that I have, but all the brains I can borrow."*

5 NEXT STEPS FORWARD

Engineers must recognize that they must engage in some radical rethinking about education and about their public image. We need to focus on how engineers can think and work in a world where complexity and change are not an occasional event, but in a time where a world is continuously being changed by new technologies and a world that now operates 24-7, globally linked by the push of a button. We must rethink how we educate, in K-12, our universities and life long learning and work together in coalitions-working together as engineering societies, working together as schools and engineering organizations, working together as universities and engineering organizations and working with other countries as well as together with our government agencies.

JSCE women members believe that the steps that must be taken to increase both the number of women in engineering as well encouraging women to enter the profession include:

- Improve the work environment
- Change the male consciousness
- Males need to be more equal in child care responsibilities
- Promote women civil engineering role models
- Change the current stereotypes in Society
- Encourage open discussion and create awareness of gender difference issues
- Gather statistics (very few no matter what country you are in) and monitor progress.

We as engineers and engineering organizations must learn to share information-especially when it concerns on how to better and improve our own needs. Joe Bordogna, Past Deputy Director of NSF summed up the problem very simply:

> *First, it is not about the total number of engineers …the nation may or may not need. …we seem to be stymied and distracted from our diversity goals by questions about trends and statistics….It is about the need to include a larger proportion of women, underrepresented minorities and persons with disabilities in the scientific workforce….Broadening participation is about fully developing our domestic talent. …Although we are doing better than we did thirty years ago, we have not yet seriously tapped our nation's competitive "ace-in the hole"-domestic women, underrepresented minorities and persons with disabilities. Now we are playing catch up in a very competitive world….It is about educating scientists and engineers with a competitive edge. To be on the frontier of discovery and in the vanguard of innovation requires new capabilities and skills that are qualitatively different than production-line educations that turns students into commodities bought on the global marketplace…. It is about providing students with additional capabilities that will enable them to work across boundaries, to handle ambiguity, to integrate, to innovate, to communicate and to cooperate….The differences in race, ethnicity, and gender that abound in our society area a positive force to engender this creativity and dynamism. Broadening participation is about working together. We will realize our goals sooner if we all work together in harmony.*

So, what do we as engineers need to do? I believe the steps are straightforward:

- We must change the "face" of engineers today to reflect the "face" of the public.

- We must change how we communicate to the public about what engineering is and what engineers do - improving the quality of life for the public.
- We must determine why more students are not choosing to pursue engineering programs. We must strive to ensure that our young students of today have the skills needed to thrive in the competitive global marketplace driven by innovation and rapid technology changes.
- We must determine why young girls, in particular, do not choose engineering as their career choice, even though they have decided to pursue a technology based career option.
- We must determine what attracts and retains young women to stay in the engineering profession since the numbers demonstrate a sharp decline in the engineering workforce once they have graduated.
- We need to provide role models and tell our stories of success. Role models, mentors and leaders are critical for the future generations of engineers. They not only inspire, but they can support others wanting to continue and advance in their careers.
- We must better prepare our K-12 teachers and higher education faculty to inspire and challenge their students.

Diversity and women in engineering is a matter of national importance and of national urgency no matter in what nation one resides. We as engineering societies, have an opportunity to work together as partners, together as one voice to better our profession and to capture the intellectual capital that is standing at our doorstep. We can stand up and we can make this happen. Let's take the challenge of the U.S. National Science Foundation-let's follow through on what the great leaders of our great countries have been saying for years-let's make a difference. Be proud that you are an engineer and be proud of the accomplishments not just that we have made, but what is to come given the diverse work force we have today and can use of the engineers of tomorrow. If we do not encourage individuals from all diverse groups to enter into the complex and dynamic field of engineering, we will then lose the opportunity to maximize the potential of intellectual capital. Let's learn from the past and let's not as philosopher George Santayana once said: "*Those who cannot remember the past are doomed to repeat it."*

[276] This chapter is based on the paper by P. Galloway, "Innovation – Engineering a Better Engineer for Today's Work Force," *ASCE Journal, Leadership and Management in Engineering*, Volume 4, Issue 4, pages 127-132, October 2004

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VII. COMMUNICATION

1 INTRODUCTION

In order to appreciate both the importance of communication education and the rationale for its inclusion in the engineering education curriculum, it is necessary first to understand what is meant by communication. "*'Communication' is a rich tangle of intellectual and cultural strands that encodes our time's confrontations with itself. To understand communication is to understand much more. An apparent answer to the painful divisions between self and other, private and public, and inner thought and outer word, the notion illustrates our strange lives at this point in history.*" (Peters, "Speaking into the Air: A history of the idea of communication," 1999). According to Kolb, there are two major differences in the way we learn. The first is how we perceive, and the second is how we process experience and information. As will be discussed below, in perceiving, some individuals sense and feel the situation where others think through the situation. Both perception and processing take place simultaneously when we are faced with new information.[308] Thus, when communicating, it is critically important to understand and appreciate the audience and/or individual to whom the communication is being made.

In 1995, a summer conference of the National Communications Association (NCA) and the Association for Communication Administration (ACA) produced a definition of communication education: "The field of communication focuses on how people use messages to generate meanings within and across various contexts, cultures, channels, and media. The field promotes the effective and ethical practice of human communication."[309] (NCA, 2003, ACA 1995 Definition of Communication).

Effective communication includes listening, observing, reading, speaking, and writing and requires an understanding of the fundamentals of interacting effectively with technical and non-technical or lay individuals and audiences of a variety of settings.[310] Some years ago, Sir James Barrie remarked that "*The Man of Science appears to be the only man who has something to say just now-and the only man who does not know how to say it*."[311] Limited written and verbal skills can severely hinder professional growth in engineering. A study done in the early 1980s of over 2000 executives in the United States concluded that communication was the most significant factor influencing promotions. Another survey of California businesses done during the same period indicated that effective communication skills were among the most significant factors in moving individuals to top management and that 80% of American businessmen place writing ability above all others on a list of business skills.[312]

The world of an engineer intersects with law, business, politics, ethics and all areas of our global world. To prepare consulting engineers for leadership roles in engineering, business and society, Engineers must develop communication skills that will assist in a broad range of areas such as legislation and the political process, pushing new products through patenting and marketing and persuading management to try new audiences as well as explaining the complex and engineering issues to non-technical audiences.[313]

2 THE COMMUNICATION ISSUE

Engineers have been perceived for years as being “shy”, “introverted”, “geeky”, and speaking only in “technical” terminology which no layman can understand. The perception of the lack of being able to communicate effectively is summarized in this engineering “joke” which the author tells at the beginning of every speech involving communication:

> *How can you tell the difference between an introverted engineer and an extroverted engineer? The introverted engineer looks at his shoes while he talks to you, the extroverted engineer looks at your shoes when he talks to you.*

Engineers have “failed” in communication, primarily by the way in which they have been educated. Most engineering education has focused on the individual-individual research, individual problem solving and solitude to do so. Team work and team efforts have not been widely used-and at most in a senior design class at the bachelor’s level. However, the ways of the past are not the ways of the future. Everyone now communicates - around the world, twenty-four hours a day-seven days a week; from my mother in Lexington, KY to my ten-year old granddaughter in New Jersey. Both oral and written communication surrounds everyone today-from television to the computer to advertisements in magazines, newspapers and alongside the road and in train stations. Because there is so much communication around us, individuals tend to only absorb that communication which creates “value” to them as an individual. Thus, communication must be simple and easy to understand and quickly delivered. These concepts are far from being understood by engineers-whether they be students or working engineers.

One of the most common abuses of language among engineers is Merrill’s second principle-the use of verbose, vague, and pompous language. Engineers tend to write and talk in “code” using acronyms, abbreviations, and technical terms that only those attending four years in engineering school would have the foggiest idea of what the words meant. The public has been reluctant to put engineers in leadership positions for the very fact that non-engineers simply cannot understand them. Technical "jargon" is overused by engineers. However, jargon does not necessarily mean the use of acronyms, obscure technical terms, or ill-construed noun forms. It can also be associated with pretentious word selections such as ""utilize" instead of "use", or "at the current time" instead of simply "now". For some reason, engineers read what other professions such as the legal profession write in their briefs and legal documents and then try to "adopt" these terms and use of words in an effort to "appear" more palatable to the public. While there may be good intentions, engineers simply have not had the necessary training in order to effectively communicate with the public. In order for consulting engineers to remain a profession in the 21st Century, they will need to be versatile with mathematics, graphics, the world-wide web, and other communication tools.[314]

3 THE BRAIN AND HOW IT WORKS[315]

Engineers have always been known to be individuals that think only with their "left side" of the brain. The reason is because the left side of the brain is the algorithm thinking part of the brain: step by step procedures for routine items, logic items and cognitive. The right side of the brain is the side that is artistic, intuitive, and creative and deals with uncertainty. Effective communication is more easily performed by those individuals who tend to use the right side of their brain in what they do. However, engineering education has developed the left half of the brain, courses which provide right or wrong answers-close ended problems that deal with logic. In today's changing, global-based, knowledge based society-where society plays a paramount role in all that engineers do, it is now necessary for engineering education to develop BOTH sides of the engineer's brain within the engineering education.

Part of understanding the difference in the left and right sides of our brains is to understand how information is processed by the brain receiving the information. Seeing the world isn't the same as knowing what you see. In 1637, Rene Descartes was the first man to discover that man captures the image of the outside world. One important consideration when discussing communication is "perception" since all that we communicate to others is received with each individual's own "perception" of what he or she has heard or read. In this respect, it is important to recognize how the brain thinks regarding "perception".

Impulses are sent to the brain which are sensations. Sensations are not the same as perceptions. The brain subjects what the eyes sense. An incoming sensation is combined with what the brain knows about the world. This is then a perception. The brain retains size constantly which allows the brain to perceive distances correctly. The brain also fuses two dimensional images into three dimensional.

If the information is not conveyed with the understanding of the audience or individual receiving the information, no matter how accurate the “facts”, the result can be dramatically different than what the sender intended. This is due to perceptions of the receiver of the information. Perceptions can go wrong. The brain organizes sensations into perceptions that it expects. Sometimes the reality is different than the perception-this is called illusion. Several of the illusions created have no depth but since the brain expects depth, the pictures appear difference than they really are. Illusions are limited to abnormal conditions. Pilots must learn about distances of runways, even though they may perceive two different lengths. Painters must learn how to make paintings look three dimensional through linear perspectives, and haze, which makes objects look further way. When enough photos are passed in front of a light fast enough, they appear to move and become continuous image. This is a movie. The brain is unable to keep up with the movement of the slides.

Most visual perception is learned after birth and is learned human behavior. Perception of a word is a mental picture, but it is incomplete. For example, a person can’t hear radio waves or see ultra-violet rays. In sight, the brain interrupts what you see. It does this for the other senses as well. The brain adds into the mental model of the world. Perception is not reality, but a product of the brain. This is one reason engineers have such difficulty with understanding why the “public” heard something different than was intended-after all-all that was presented were the facts! Perception, however, is affected by motives, age, sex, experiences, etc. Some people are more sensitive than others.

All senses have thresholds. An action threshold is a point that becomes so persistent; it drives a person to action. One such perception is subliminal. Related to subliminal perception is discrimination without awareness. This has to do with tension. It is reacting to perceptions which should be conscious, but the person’s attention is somewhere else. When a person learns something new, there is a heavy concentration on that action. But, once it becomes learned, the motions become automatic and discrimination without awareness takes place. A good example of this is driving a car.

Thus, communication is not simply conveying a message, but understanding *how* that message is conveyed and to *whom* the message is being conveyed. Recognizing that the brain of the receiver of your message may in fact change the intention of your specific message is critical in the understanding of how to communicate-both in written and oral form.

4 THE ART OF COMMUNICATION

Communicating has many dimensions:[316]

- Written and oral, listening, and speaking
- Internal (within the organization and/or project) and external (the client, the media, the public)
- Formal (reports) and informal (memos, e-mail, ad hoc conversations)
- Vertical (up and down the organization) and horizontal (with peers)

Information can be gathered in a number of ways-whether it is through the internet, the world-wide web, databases, or project management software. Information can be distributed in a number of ways, whether it is through meetings, electronic communications, written reports or papers and/or through conferences or public presentations. Information can be conveyed to a number of different stakeholders. The art of communicating is to determine the communication dimension and to design the form of communication that will be the most effective.

Relative to the communication dimension of written, oral and listening, the most overlooked area is “listening”. Everyone is so busy and eager to get out what they want to convey, the person communicating may fail to recognize whether the person to whom they are communicating is even interested in what they have to say-or how the message should be conveyed. This is often the case with engineers in their communication with non-engineers. With respect to listening, ten “laws” of communication were developed by H. Mackay in 1994.[317]

1. *It’s not what our message does to the listener, but what the listener does with our message that determines our success as communicators.*
2. *Listeners generally interpret messages in ways that make them feel comfortable and secure.*

3. *When people's attitudes are attacked head-on, they are likely to defend those attitudes and, in the process, to reinforce them.*
4. *People pay most attention to messages which are relevant to their own circumstances and points of view.*
5. *People who are insecure in relationships are unlikely to be good listeners.*
6. *People are more likely to listen to us if we also listen to them.*
7. *People are more likely to change in response to a combination of new experience and communication, rather than in response to communication alone.*
8. *People are more likely to support a change which affects them if they are consulted before a change is made.*
9. *The message in what is said will be interpreted in the light of how, when, where, and by whom it is said,*
10. *Lack of self-knowledge and an unwillingness to resolve our own internal conflicts makes it harder for us to communicate with other people.*

These principles can be applied to any individual and/or situation and should be reviewed before entering into a meeting and/or making a presentation.

Communication principles are paramount to several industries and corporations. Policies and procedures of companies typically contain provisions relative to how information will be communicated both inside and outside the organization and up and down within the organization. Often these policies are conveyed as "communication principles". For example, the U.S. Army Corps of Engineers has developed a communication guide with the following communication principles:[318]

- *Listen to all constituencies both inside and outside USACE regarding issues of importance to them, respecting their viewpoint.*
- *Communicate early, clearly, completely, honestly, accurately, and often with all constituencies on issues or importance.*
- *Incorporate communication activities as an integral part of project management business process.*
- *Be accessible to all constituencies and respond promptly without censorship or misinformation.*
- *Proactively inform the public and other constituencies of the Corps vital role in areas where we have special expertise.*
- *Do what we say we will do.*

These communication principles as well as the prior ten communication "laws" serve as a good foundation for communications in general and provide the basics of what is needed in today's knowledge based society.

Finally, the form of communication must also be well thought out before being delivered. For instance, messages to the public and/or to a client may take on a more formal approach with messages delivered in reports and/or papers and/or presentations. Consistency within how the formal delivery is made is critical so as to assure that the receiver retains the information in the same manner whenever the messages are being delivered which allows more retention of information since the "formatting" is processed and learned, allowing for the brain to absorb additional information more effectively.

Informal communication takes on different forms with the need for accuracy the same, but the detail probably lessened, assuming that internally, the receivers have more knowledge on the subject than those external to the organization. The most common form of informal communication today is the e-mail system. E-mail tends to be overused, however, as a "lazy" means of responding or communicating without having to take the time to communicate directly, either by phone or in person. As a result, this form of communication can potentially isolate individuals and create animosity which could be avoided by traditional methods of communicating such as the telephone. For example, an Engineer A is in his office is desperately trying to finish a deadline for a client. Engineer B has a piece of analysis that is to be incorporated into the final product and has been sent to Engineer A, however, Engineer A does not fully understand one of the conclusions within the analysis. Engineer A's office is only two doors down the hall of Engineer B. Instead of getting up from the desk to speak to Engineer B in order to better understand the analysis, Engineer A sends Engineer B an e-mail. Engineer B responds via e-mail only further confusing the matter. This goes on until e-mail "screaming" occurs, now upsetting both Engineer A and Engineer B, resulting in loss time in completing the final product, and will probably not result in the final product desired by the client. Common sense is a communication dimension that is also forgotten in today's informal sense of communicating. Engineers must stop and "think" as they are so trained to do, to again determine the best method of communicating given the situation and the person(s) to whom communication is being transmitted.

5 PROJECT COMMUNICATIONS MANAGEMENT

Project communication principles are somewhat different than general communication principles in that they are more centered towards a particular project that has specific goals and objectives and a start and finish. In addition, the communication involves information that is learned and conveyed on a project to the project stakeholders. The PMI PMBOK defines project communications management as: [319]

> *…the Knowledge Area that employs the processes required to ensure timely and appropriate generation, collection, distribution, storage, retrieval, and ultimate disposition of project information. The Project Communications Management processes provide the critical links among people and information that are necessary for successful communications.*

The Project Communications Management Process consists of the following four tasks:

- Communications Planning-determining the information and communications needs of the project stakeholders
  - ➔ Who needs what information
  - ➔ When the information will be needed
  - ➔ How the information will be provided
  - ➔ Who will provide the information
- Information Distribution-making the needed information available to project stakeholders in a timely manner
- Performance Reporting-collecting and distributing performance information
  - ➔ Work performance information
  - ➔ Performance measurement
  - ➔ Forecasted completion
  - ➔ Quality control measurements
  - ➔ Project management plan
  - ➔ Approved change requests
  - ➔ Deliverables
- Managing Stakeholders-managing communications to satisfy the requirements of and resolve issues with project stakeholders
  - ➔ Communications Management Plan
  - ➔ Communication Methods
  - ➔ Issue logs and resolution
  - ➔ Approved Change Requests
  - ➔ Approved Corrective Actions

Each of these tasks is critical to successful project outcomes.

Operating in today's global environment makes accurate communication even more critical. Communications between a project site, headquarters which controls and supports it and the suppliers of the other countries are not easily done directly and there are obstacles to effective communication, with the primary obstacle being geographical distances and time differences which exacerbate the communication problem.[320] Thus, the most common use of communication becomes the written word typically in e-mails. As discussed above, e-mail communication has become a predominantly used form of communication and unfortunately one of the most ill-used form of communication. Human emotion tends to enter into e-mail communication as well as much too abbreviated words and sentences, thus making the receiver of the e-mail left with wondering whether the communicator had a bad day or is left to send back additional e-mails requesting clarification of the message that has been sent.

Another factor in global communication is the reliability of the communication. For example, in international construction projects, it becomes necessary to communicate with not only your own organization, but with others working for the owners, consultants, contractors, government authorities, etc. The exactness of the communications with these individuals varies significantly depending on the degree of understanding of the common languages spoken. This is especially true for countries, such as Japan, where English is not widely taught domestically, thus making their abilities insufficient to speak up to others from other countries and thus left to unfavorable situations.[321]

Thus, engineers need to develop an effective Communications Plan for the specific project along with a flow chart of information to stakeholders in the project along with the type of information to be conveyed to the stakeholders, how and at what time intervals.

6 ENGINEERING COMMUNCIATION EDUCATION

Engineering schools across the United States have offered communication courses for more than 20 years, yet industry representatives still cry out for engineers who can communicate more effectively. ABET's EC2000 criteria lists communication as one of the key competency for engineers. However, engineering students still fail to recognize the importance, potentially because the subject of communication has been taught outside the engineering curriculum. There has been no relation made with respect to composition, technical writing or public speaking with the engineering work.[322]

In the 1990s, a new approach to engineering communication emerged in the United States. In the paradigm, engineering and communication experts work together to develop a curriculum that blends engineering and communication instruction and leverages the synergies between the two fields. The emergence of collaborative programs reflects changes that are necessary in engineering education reform. For example, Northwestern University switched to the approach of a cross-disciplinary, cross-school collaboration in a major reform of its undergraduate engineering curriculum as part of its “Engineering First” program requiring freshman to take a new course called Engineering Design and Communication (EDC).[323] Instead of writing essays papers and exams, the students write to faculty and clients to communicate the important information about their projects: for example, they write mission statements, report on client meetings, synthesize the results of the research, prepare progress reports, and create slides for power point presentations. Engineering communication combines written, oral, interpersonal, graphical and mathematical communication.

Georgia Tech in the United States offers a course in its Chemical Engineering department, “Chemical Engineering 4600” which offers a new look at the importance of communication and hosts weekly guest speakers that include state senators, graphic communicators, lobbyists, company CEOs, patent attorneys, regulators and others who help determine a product’s success and the importance of the ability to communicate to achieve that goal.[324]

Standards for general education communication courses, established by the Maryland Communication Association (MCA) in the United States and endorsed by the state’s Chief Academic Officers Group, provides a useful set of general education components for consideration. The MCA report recommends that students taking communication courses should be able to demonstrate eight competencies: (1) the communication process, (2) verbal and nonverbal communication, (3) message development and organization, (4) audience and content analysis, (5) expression, (6) listening, (7) analysis and evaluation, and (8) communication ethics (Maryland Communication Association, 1999). The complete MCA document is available online at: http://mhec.stac.usmd.edu/app-spc.html. In addition to nine content-based curricular goals, learning outcomes were recommended as critical: (1) understanding of multiple theoretical perspectives and diverse intellectual underpinnings in communication as reflected in its philosophy and/or history; (2) competency in effective communication with diverse others; (3) competency in presentation, preferably in more than one form; (4) competency in analysis and interpretation of contemporary media; (5) competency in reflective construction and analysis of arguments and discourse intended to influence beliefs, attitudes, values, and practices; (6) competency in systematic inquiry (the process of asking questions and systematically attempting to answer them, and understanding the limitations of the conclusion reached; (7) competency in analysis and practice of ethical communication; (8) competency in human relational interaction; (9) competency in analysis and practice of communication that creates or results from complex social organization. The report in its entirety is located at the following web address:[325]

http://www.hope.edu/academic/communication/ecc/report.html.

As engineering education reforms, communication will be a critical course that is required if engineers are truly going to be leaders and effective in the 21st Century.

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VIII. LEADERSHIP[326]

1 INTRODUCTION

All engineers are or have the potential to be leaders.[327] However, engineers have tended to focus on "detail" and not the big picture and as a result, few engineers have become leaders. Leadership is the ability to influence other people, with or without authority. The ability to influence others is a derivation of interpersonal communication, problem-solving, and conflict management. Interpersonal effectiveness is the capability of an individual to do this competently.[328] A leader must understand goals and have the capacity to plan the steps needed to accomplish them. Leaders must have a clear vision and understanding of what it takes to accomplish the overall objective effectively.[329] Engineering leaders of today will need to understand globalization as well as value chain management. The value chain categorizes the generic value-added activities of an organization. The "primary activities" include: inbound logistics, production, outbound logistics, sales and marketing, maintenance. The "support activities" include: administrative infrastructure management, human resource management, R&D, and procurement. The costs and value drivers are identified for each value activity. The chain culminates in the total value delivered by an organization. The value chain framework has become a powerful tool for strategic planning with the ultimate goal to maximize value creation while minimizing costs. Leaders who can effectively understand and utilize the value chain model while leading others in its direction, will be able to create new business models and stay on the cutting edge of services offered to their clients.[330]

The author has always believed that good leadership brings success and success is dependent upon three key elements: communication, commitment and confidence. While the teaching of leadership principles is divided into many more sub elements, if an engineer learns to master these three key elements, leadership will come naturally, others will follow and success will be had for the activity at hand. Engineers must continually be self-reflective and self-auditing, listening carefully and acquainting themselves with the best practices of others. Leaders must examine personal values and recognize that leadership is an act of personal and professional integrity.[331] In this way, a good leader today will be even a better leader tomorrow and will serve as a role model to younger engineers as they pave their own way to success. As past U.S. Secretary of State, Colin Powell once said: "*There are no secret to success; it is the result of preparation, hard work and learning from failure.*"

Successful leadership is what separates successful projects from failures. Edward Hoffman, director of NASA's Academy of Program and Project Leadership emphasizes the following four key issues:[332]

(1) A will to win: Successful leaders will invest their missions with a passion, enthusiasm, and commitment to succeed that is contagious and critical
(2) Focus on results: Effective leaders make sure their teams understand the requirements and objectives that lead to project success
(3) Adapt to change: Good leaders establish a climate in which team members can respond to uncertainty.
(4) Create an environment of trust: Successful project rely on collaboration which requires all team members-including employees, vendors, consultants and partners to trust one another.

To empower your team, understand the possible barriers to team building and take proactive steps to remove them. Unclear project objectives and roles / responsibilities, poor communication, unclear lines of command, a disorganized team structure, lack of project manager credibility, distance, poor team member involvement and commitment, and inappropriate selection of team members can all undermine the success of a project. [333]

2 LEADERSHIP VERSUS MANAGEMENT

A precise definition of engineering management comes from the Merritt Williamson's Encyclopedia of Management that notes:[334]

> *Engineering management is ….concerned with managing technical work and technical people in a predominantly technical environment….it is the art and science of planning, organizing, allocating resources, directing and controlling activities which have a technical component. It differs from Industrial Engineering... by its greater focus on people problems rather than on systems design…It differs from general management in its requirement that practitioners be competent in some technical field.*

Dan Pletta in his book on *The Engineering Profession* noted that there were principles of engineering management that must be based on a thorough knowledge of the basic science and engineering but also operations research and systems theories to manage ideas. He felt it was critical to motivate and convince one's superiors, peers or subordinates. He noted that these principles included:

(1) Convey a sense of mission
(2) Keep your superiors aware of your plan
(3) Prepare a worse case scenario
(4) Keep things simple and observe early warnings
(5) Seek help quickly
(6) Take reasonable risks and do not become obsessed with failure
(7) Cultivate how to cope
(8) Don't lose touch with co-workers and listen to their opinions
(9) When you must criticize, try small doses at first and do not humiliate in front of their peers
(10) Motivate subordinates by assigning challenging opportunities and praise their achievements
(11) Be fair-strict-but fair
(12) Strive for excellence
(13) Make decisions and accept responsibility
(14) Issue directions that permit acceptance without resentment
(15) Recruit and train capable subordinates to prevent group failures.

Managers can take the objectives and goals set by the leader and assure that they are executed. Most managers, while needing to know project management skills in order to communicate the goals and objectives and assure that they are delivered on time, on budget and to the quality desired, most managers do not have the ability to be "visionary" or to be creative. Managers are often in the detail, which is why engineers make good managers. They are trained to solve problems and can lay out a process by which to go solve those problems. However, thinking about why the problem got there in the first place and developing a vision for the future, is not necessarily brought about in the same manner as the problem solving skills that an engineer learns.

The differences between a leader and a manager as well as the difference in Asian versus Western cultures is demonstrated in the following figure developed by Dr. Shuji Kusayanagi, head of the Civil Engineering department at the Kochi University of Technology in Japan:

When a problem has happened:

1. A leader starts to think how to break through the problem.	1. A manager starts to think why the problem comes out.
2. A leader thinks that he is right and his enemy is wrong.	2. A manager thinks that he must be neutral for finding reality
3. A leader's way of approach is like a father's way in a traditional family	3. A manager's way of approach is like a father's way in a traditional family
4. Western business and management way is based on "competition".	4. Asian business and management way is based on "cooperation"
5. Leadership shall be the main requirement for "competition. "Guilt culture"	5. When you need to think about "cooperation", you need to keep the manager's mind. "Shame Culture"
6. Western countries need to maintain and reinforce "management"	6. Asian countries need to maintain and reinforce "Leadership"

Leading in the private and public arena, which differs from and complements managing, requires broad motivation, direction, and communication knowledge and skills. Attitudes generally accepted as being conducive to leadership include commitment, confidence, curiosity, entrepreneurship, high expectations, honesty, integrity, judgment, persistence, positiveness, and sensitivity. Desirable behaviors of leaders, which can be taught and learned, include earning trust, trusting others, formulation and articulating vision, communication, rational thinking, openness, consistency, commitment to organizational values, and discretion with sensitive information.[335]

Leaders are able to take charge of a situation and find a way forward. Leaders have the sills to set strategy, think laterally, and lead the activity by example, while giving the team the responsibility to carry out its tasks and motivating it through personal enthusiasm and charisma.[336] Successful leaders have a vision and put forth the effort to obtain that vision. You have to start with the end game in mind. If you can clearly see where you are going, then you can make decisions accordingly along the way. The good leader identifies the vision for everyone and instills confidence in them that they can indeed get there. A good leader also learns from their mistakes. One of the best ways to use mistakes is as lessons are learned-record them, learn what could have been done differently and then communicate it to others. There is an old saying that "experience is the best teacher." Leadership failure is one of the top reasons for overall business failure.[337] The root of this problem is the lack of knowledge and understanding about how to lead others. One of the principal reasons for management failure and a great deal of stress within most teams is lack of focus. Lack of focus wreaks havoc on a team and an organization; it reduces team members' trust in their leader and limits a manager's ability to deliver results on a daily basis. "Focus" is defined as "directing energy towards a particular point or purpose." The most critical management decision is to determine what is the most important thing for you and your team-what is the one point where your team should be directing its energy and attention?

While leadership is about vision and setting goals and objectives for the team and having the ability to lead others so that they want to follow, the leadership principles are also somewhat different in Japan than in western countries, primarily as a result of the difference in culture. In Japan, the following principles are recognized as needed for leadership:[338]

(1) *Fundamental principles*
   - a. *Study and retain knowledge*
   - b. *Listen to the opinion of others*
   - c. *Adopt others' opinions on your own responsibility*
   - d. *Have regard for the spirit of harmony*
   - e. *Do not change course or principles*
   - f. *Take responsibility for failure. Honor and reward should be shared with all members.*

(2) *Policies*
   - a. *Contribute to public welfare*
   - b. *Consider the position of subordinates and the weak*
   - c. *Understand the spirit of harmony*
   - d. *Understand that each human is different*

(3) *Action Plans*
   - a. *Make efforts to remember others' names, and address people by name.*
   - b. *Watch how you speak*
   - c. *In order to exchange information with subordinates and teach them, personally go to their working place rather than ordering them to come to your desk.*
   - d. *Ensure that subordinates take pride in their work and ensure that they understand its significance*

e. Ensure your subordinates remember that someone may be troubled when a construction project is implemented. Again, make much of modesty, solicitude, and attentiveness.

(4) A person becomes a leader not by asserting himself, but by being recommended by others after his or her personality is judged by certain criteria. These criteria consist of the kan'I junikai,(twelve colored caps), a set of criteria devised by Prince Shotoku around 1500 year ago and still functioning today.

(5) The following factors influencing society's evaluation of an individual's behavior are generally accepted:

a. Mercy
b. Righteousness
c. Loyalty
d. Filial piety

In the book, *Philosophy of Leadership* (published by Kodansha, Ltd), the following ten elements are required for leadership:

1. Looks-acting as a role model for others
2. Empathy-offering humane responses quickly when needed
3. Acceptance-strict on one's self and tolerant of others
4. Direction-broadcasting one's beliefs
5. Encouragement-supporting others and always seeking improvement
6. Responsibility-Resolute in a crisis situation, always calm
7. Security-Emotionally stable
8. Holism-aware of the details, but grasps the whole
9. Identify-fine leadership spirit knowing that the organization is dependent on the spirit of the leader
10. Power-Chivalrous spirit even when inundated by enemies –courage to say "no".

In the book *A Passion for Excellence* by Tom Peters and Nancy Austin, the seven attributes noted for leadership qualities include:

1. Attention
2. Symbolic behavior
3. Drama
4. Language
5. Stories
6. Vision
7. Love

One does not "manage" people. The task is to lead people. The goal is to make productive the specific strengths and knowledge of each individual. The foundation of management has to be customer value management exists for the sake of the institution's results-it has to start with the intended results and organize the resources of the institution to obtain these results.[339] A business that wishes to grow must lead in innovation and be willing to take risks. The organization must think through what performance means-strategies must be based on new definitions of performance. Global competitiveness must now be a strategic goal of good leadership. One cannot manage change-one can only be ahead of it. We tend to manage according to the reports we receive and see. –Leaders focus on the areas in which the company does better than expected, the areas of unexpected success.

3 INFORMATION NEEDED FOR SUCCESSFUL LEADERSHIP

Leaders depend on information in order to develop, monitor and change key visions, missions, objectives, and goals for the organization. Key information which is required for effective leadership includes:[340]

- Foundation information
- Productivity information
- Competence information
- Resource allocation information

Foundation Information includes:[341]

- Cash flow and liquidity projections
- Financial ratios as applicable

Productivity Information includes;

- Productivity of key resources
- Benchmarking –comparing one's performance wit the best performance in the industry

Competence Information includes:

- Success rests on core competence that meld customer value with the special ability of the producer

- Nonsuccesses should be viewed as the first indication either that the market is changing or that the companies' competencies are weakening
- Carefully track the unexpected successes

Resource Allocation Information includes:

- Success depends on the allocation of scarce resources and performing people
- The most scarce resource is performing people

The four sets of information tell us about the current business. Information is the key resource. Effective leaders should be asking the following key questions: What information do I owe the people with whom I work and on whom I depend so that they can do their work? In what form? In what time frame? What information do I need myself? From whom? In what form and in what time frame? The key to these questions of course is "listening". Listening is a lost art but a critical part to effective communication. Effective leaders deliver results by:[342]

- Developing a common vision;
- Influencing people to give their best
- Motivating and building high-performance teams;
- Breaking down individual and organizational barriers;
- Stimulating and promoting innovation; and
- Creating energy and cultivating enthusiasm.

No two executives organize information in the same way. However, effective leaders eliminate data that does not pertain to the information needed. The purpose of information is not knowledge but the ability to take the right action.

These questions and gathering of information center, of course, on clear and effective communication. Communication is important-in a positive way-in an energetic way-while always thinking on one's feet. In today's global knowledge based economies, most communication is performed across the world not by the traditional telecommunications (although of course the use of the cell phone is alive and well), but through the use of the internet and e-mail. Communication is critical with respect to e-mail today. Short-and simple are the key elements to e-mail communication.

This chapter presents the ideas and recommendations of the author that are based on the author's experiences and challenges that she has faced and/or methods and techniques which the author believes has assisted her in achieving leadership positions. The ideas come from a life time of reading on the topic of leadership and combine ideas of other great leaders, modified to meet what the author has herself deemed to have made her successful. Thus, this particular chapter is written less on current research, but more on the author's own personal experiences with her achievements being the proof that when the methods and techniques presented herein are applied, they work.

4 THE ART OF MASTERING LEADERSHIP SKILLS[343]

As engineers, most, if not all of our engineering education is a technical education; we do not often obtain the necessary skills in order to be in management and in order to be leaders in government and at companies and at universities. It is very important to recognize that in order to become a leader you need to look at yourself and to determine what you need to do to make other people want to be a part of your team. "*True leaders are not those who strive to be first but are those who are the first to strive for and who give all for the success of the team*". It is very important to recognize that great things, great engineering projects, and great corporations are not done by one person. It is not the individual that makes the project great or the company great but a team of people who come together for a common goal.

"*A true leader has the confidence to stand alone, the courage to make tough decisions and the compassion to listen to the needs of others.*" It is very important to understand that just because you have a great idea that does not mean that idea can not be better by listening to others giving you feed back, giving you their impressions, giving you their input as to what you want to achieve. We all have great minds; otherwise we would not have become engineers. Therefore, we must understand that many great minds make the best decision and give the best opportunity. A good leader is one that can take all of good ideas and formulate all plans to execute all those good ideas.

4.1 No Excuses

A very famous American actress named Florence Nightingale once said "*I attribute my success to this: I never gave nor took an excuse.*" Sometimes it is easier to blame someone else or something else as a reason as to why you did not achieve something. In the United States, in school, students who do not turn their homework in on time often say, "*My dog ate my homework."* They give an excuse for simply not doing what they should have done. A good leader knows to take personal responsibility.

4.2 Leadership and Evaluation Checklist

As a leader, you are responsible for everyone on the team. If someone fails on the team, it is not the individual who fails but the team fails and the leader who takes responsibility for the failure is a good leader. As stated at the beginning of this chapter, some engineers are already leaders and may not even know it. In determining whether you have leadership skills, a simple check list has been prepared to look at yourself and to see whether you have the necessary skills to become a leader.

<u>What influence do I have?</u>

The first question that is asked is "What influence do I have?" A leader must have influence meaning you must have something to offer that others want to take a part of and want to follow. So when you ask, "What influence do I have?" The author offers the following suggestions:

- No. 1 "Your job title does not make you a leader". There can be great generals in militaries that fail. They lose war, they lose the battle. Their job title does not give them the right to win the battle. There are companies where you have the president. But if the employees of the company do not respect their president, no one wants to follow the president, and company may not be successful. Just because a person is given a high title, it does not mean that they are necessarily a good leader.

- No. 2 "Do people look to you for guidance and praise?" One mistake that leaders often forget is to recognize publicly when someone does something well and to offer than praise to them in front of their peers. It means quite a bit individually for me to tell you, "You did a good job. Congratulations!" It makes people feel good. But when you criticize someone in public, it makes them feel very bad and very small. And they do not necessarily want to always be with you for the fear that you might criticize them in front of their peers. Therefore, a good leader praises in front of everyone, but individually gives criticism.

- No. 3 “Do people look for your opinion up and down the hierarchy?” Let me explain that. In the university, you have entry-level students, then you become a senior, you become a graduate student, a PHD, a professor. That’s a hierarchy, walking up the ladder. So do people that are just entry-level students and professors of the university, do they come to you to ask your opinion? That is a good leader. When individuals no matter where they are in a company, at university, or even within your own personal friends. When someone asks you your opinion, and they value your opinion, that means that you have influence.

<u>How are my people skills?</u>

The second point on the check list is: “How are my people skills?” This means “How do I work well with other people?” Do people like to work with me, or do people not like to work with me? The following questions should be evaluated:

- No. 1 “Leadership is all about the relationship with people”. If people do not like you, they may not want to follow you, but there is a difference between like and respect. Someone may not like you. But if they respect you, they will still do for you what you request. So relationships are not necessarily about friendship. They are about what others think about you and what you can do to improve what ever that activity is that you are improving. For example, when the author was the President of ASCE, she was confident that there were some people who did not like her. However the author was able to pull together the profession to visit universities to bring the students back into the profession to get young people interested in civil engineering and to join the society to get new members and older people re-interested and becoming active again in the profession. So while they may not agree with saying, “I like you personally,” they had respected the author for the fact that she said “*Everyone in civil engineering needs to come together to improve the profession*.” ASCE was able to bring in 2,500 new members in just twelve months. ASCE was the only professional engineering organization in the United States that increased in membership during the author’s year as President instead of decreasing in membership.

- No. 2 “Do you feel close to the people around you?” That means if you are the leader how will you behave in a company situation? For instance, let’s assume you are the president, and you come in to the office everyday and you go into your office and close the door and sit down. How do you have any idea about what the people, the employees that work for you like? How do you know what they want to do or how they feel about the company? You as a leader must go and meet the employees of your company. You should go around the office each morning and wish the employees "Good morning". You should take an active interest in what they are doing for the company and ask, "What do you think about this project and I would like to know your opinion. It is important to seek employee's opinions. You also need to show that you care about than as people "What do you like to do when you go home at night?" "What hobbies do you have?" "Do you like to be outdoors?" "Do you like to play billiards?" You should ask the people around you what they like to do to form a close relationship with those with whom you work.

- No. 3 "Do you make an effort to really listen to what people tell you?" Some leaders pretend to listen. They will come to sit down at a meeting and shake their heads "Yes", and when the meeting is over, they were really thinking about other things and have no idea what anyone said. A true leader that listens takes notes. You write down the key points of what people say. Not only does it demonstrate that you are listening, but typically we cannot remember things as we get older. Thus, when you write down the notes of what people say, while you may remember it six month from now, two years from now when you remember that meeting, "*Oh! What did someone say? I wish I could remember.*" If you have your book with your notes, you can always go back to what was said.

- No. 4 "Do you know a lot about them as people and not just drones at work?" Again, this means "find out what your employees like to do for fun. What do the employees like to do outside their business life"? It also allows you as the leader to determine whether someone sits on team A or team B or team C. This is because you don't want all of the same people that are just alike on the same team. Why is that? Because everyone does not think alike, and you want differences of opinion because it makes a better project.

<u>Do I have a positive attitude?</u>

The third item on the check list is "Do I have a positive attitude?" I think all of us would agree, when you are with someone who is always complaining, you get tired of listening to that person, because each of us has our own problems. Each of us has enough bad things to worry about without having to worry about the bad things happening to somebody else. However, when you are around someone who is always happy, who is always excited about doing things, you get excited also and you want to do things. So a positive attitude is very important. It's like taking a glass of water and filling it half way and asking someone about the condition of the water in the glass. A pessimist, someone who is always negative, says, "*The glass is half-empty*." The optimist, who is always positive says, "*The glass is half-full*." It is the same glass, but two different impressions depending on your attitude. Thus, questions to ask yourself as to whether you have a positive attitude include:

- No. 1 "Success will always be harder if you are looking at the dark side of things." It is like watching the movie *Star Wars*. Darth Vader is the bad guy in *Star Wars*. He is always black. He has got a black helmet. And he is on the dark side of the life whereas all the good guys are in white because they are positive.

- No. 2 "People want to follow optimists in positive thinking." In the United States we have an expression: "*there is always light at the end of the tunnel.*" A positive thinker will always tell you "*Don't worry. We will make it happen*." A positive thinker can take a team that believes something is impossible and is ready to give up and give them the little bit more of energy to make them accomplish things they never dreamt of. A good example; if you like history is with respect to the arctic explorer named Shackelton. Shackelton took a wooden boat to enter Antarctica back in the late 1800's. The weather became very bad, and the ice literally crushed the ship and the ship sank in the waters of Antarctica. And the winter set in, and the ocean turned to ice. There was no way to go home. But when the boat sank, Shackelton walked on the ice, looked at his men and said, "Men, it's time to go home!" It took him two years to be able to get them home. But he never lost a single life. All 24 men made it back home. It was his positive thinking that kept them alive.

- No. 3 "Do you focus on possibilities instead of obstacles?" Again, good leaders don't think how they cannot do something instead they think of how they are going to do it because nothing is impossible. NOTHING IS IMPOSSIBLE.

- No. 4 "Do you focus on solutions to problems?" When an employee comes to you and says, "*We have a problem*", the first question is "*And what are the solutions*? *Don't bring* *me a problem unless you have thought of a solution to potentially resolve it*." That is what a good leader looks for.

Do I have Self-Discipline?

The next item on the check list is. "*Do I have self-discipline*?" This is very important for a good leader. Thus, in determining whether or not you have self-discipline, the following steps should be evaluated:

- No. 1 "You have to be able to lead yourself before you can lead others." If you cannot even plan your day, how you can plan the day of others'? You also have to be able to complete things. People often start great projects but never finish them because it becomes difficult and becomes hard and they slowly give up. It is disappointing to see students who come so close to graduating and reach a difficult course and give up and never graduate. Discipline is difficult but nothing is impossible. It may take you one more year. That may be disappointing. But the reward for completing the work will be much greater in your entire life time, then one more difficult year.

- No. 2 "Good time management skills show self-discipline." It is increasingly disappointing to see employees wait to the last minute to finish their work. If you wait to the last minute to complete something, first, it will not be as good as it was if you took the time to do it over in the period of time. Why? How can you check it? You must make the time to put it down, wait and pick it back of and read it again to make sure that it is accurate and it is what you want it to say. But more importantly in the real world of working, you as an employee of a company have a project to accomplish for a client. Again not one person accomplishes it but rather the team. If someone on the team waits to the last minute to complete their portion of the work, there is no time left for the team to discuss the work as a whole and there is no time left for the leader, the project manager to review it and to make sure it is the right product to deliver to the client. Therefore, the project may not succeed or may not be what the company likes to show for their reputation.

- No. 3 "Willingness to put the good of your group ahead of your own immediate desires." Assume the situation that you are the Project Manager for project, and have a tight dead line. Also assume that the dead line unfortunately appears over a holiday weekend and it appears when there is a great sporting event happening on Friday night. It is very tempting to say, "*That's OK. I will just look at it on Monday morning. And I will just tell the team members they can't go to the sporting event and they will have to work the weekend. But I'm going to go to the sporting event and enjoy myself*." That would create very negative morale among the employees and you as the leader would not be well respected even though you as the project manager probably do not need to be there on Friday night or even Saturday. When you are there with the team, as a team in completing the assignment, then the rest of the team does not feel so bad for working. The reason that the team will not feel so bad is that the team knows that you have also given up your personal time for the betterment of the team and the company. As a result, you will get better work from those employees on the team.

<u>Do I succeed more than I fail?</u>

There is an old saying; "*You cannot win them all, but good leaders have a pretty high percentage of what they go after"*. What have you accomplished? It is important for people to set personal goals: 1-year goals; 5-year goals; and 10-year goals. It is also important to write the goals down at the same time every year. A good time to do this is on New Year's Day. It starts out the New Year. One can look at what they hoped to accomplish and check off what they did and those that they did not. It also allows one to evaluate why they did not accomplish something. It's a great lesson to learn. It improves you. It motivates you. It also gives you a plan for your life. You may change your goals. You may do something you never anticipated which puts you on a new pass. But it allows you to evaluate, "Why are you here?" "What do you hope to do with your life?" If you don't set goals for yourself, how do you plan what you do tomorrow, next week, next month, or next year? Look at those goals and ask yourself, "Did anyone benefit from what I did?" Society today is not just for you, but as engineers, what we should do which can be a benefit for others. And you should evaluate in your goals what benefit you can provide to others.

<u>Do I solve problems efficiently?</u>

Again, just identifying the problem is not enough. Try to determine what the root cause is of the problem. What does the author mean by the root cause? For example, there is a tree and the tree has a root which goes into the ground. If you look at a problem superficially, it means that you only see the immediate result. It is like looking at a trunk of the tree. But if you want to find out why the problem really happened, you have to go all the way down to the roots to find out why the tree died. Do you ask for others to help you? Discussing issues as a group will result in a much better solution to the problem than just one individual trying to solve the problem.

Do I settle for the status quo?

Status quo means that nothing ever changes. It means that you remain the same on an equal plain and never strive to improve to look at something differently to innovate to be creative. "Successful leaders never stop at what they were doing". Some people achieve one or two things, and try to always tell people, "Look, I achieved that!" But it may work for the first one or two years after you have made those accomplishments. But ten years into the future, what you did ten years ago will become out-dated. It will no longer be applicable. Good leaders challenge themselves to always know what new technology is, what new management processes are, and to always apprise themselves of how the world is constantly changing.

- "Do you identify new challenges?" Those who go after challenges will probably always be successful because they look at a challenge as an opportunity. A challenge means just that-a challenge. It will be difficult to succeed. That is the meaning of challenge. That's why people don't like challenge. Because it usually means conflict, it usually means difficulty, it makes it hard. But good leaders like challenge. They like to demonstrate that nothing is impossible.
- "Do you take risks?" It is like being able to cross a suspension bridge made up of nothing but open roots, and then…trying to get across that bridge in the mountains high up over a running stream. Yes, it was a challenge. And it was risky. Because the bridge swayed and it was scary but I knew I would feel better if I made it to across the bridge. And we did. We all made it. So we pushed ourselves and pushed all of us out of a complex zone to accomplish walking across that bridge and we succeeded.

4.3 The Cornerstone Principles of Leadership

There are four key areas, for good leaders to know about:

- No. 1 "Communication". Good leaders must be able to affectively communicate. Some of the world's biggest problems happen not because there are not good people, intelligent people working on them, but because there was miscommunication or people were afraid to communicate. In the Asian world, and especially in Japan, where the author has worked since 1987, the author's biggest frustration when she is in a meeting is with Japanese professionals. The author knows that they do not understand something she has said, but instead of saying “I do not understand. Can you please explain again?” they sit there and say nothing-only nodding their head yes. They pretend to understand. This behavior will continue to get the Japanese engineer in trouble. Let’s assure that into today’s global economy, you as Japanese professionals when you graduate and go to work in the real world, if you do not understand something that is being said to you, you must ask. You must ask to have something explained to you. There are five key elements to effective communication for a leader:

(1)Building Trust

Trust is very important. I could be a good communicator, and be very well spoken. But if you do not trust me, it does not matter what I say because you would be hesitate to do it, because you do not trust me. Therefore, before I can begin to efficiently communicate with you, I must gain your trust. You must have confidence at me that I will do what I say. You know I used to always complain about my mother sometimes, because my mother would say, “*Do as I say, not as I do*.” meaning that someone does an action yet tells you not to do the action. For example, when I was young, my mother smoked. Luckily, I have never smoked. But my mother told me, “*Do not smoke, it is bad for you*.” But she was smoking. It did not make any sense to me. So in the beginning I lost trust in that part of my mother, saying only that it was bad for me, “Why are you doing it? Isn’t it bad for you, too?” So this is what I mean by building trust. When you as a leader at any situation for you on the border line, whether this is right or that is not right. Do not choose for yourself but choose for the team. Choose what is most fair for other members on your team and not you.

(2)Live up to commitments.

If you tell somebody that you are going to do something by a certain date, you may miss that date once, and it won’t matter. But you continually tell people that something has to be done by a certain date and you continuously miss that date, then people lose confidence in you and they lose trust in you, because you do not live up to what you promised. If you promise something, you must perform your promise.

(3)Sharing Knowledge

Some leaders for whatever reason fail to communicate the big picture to their team. Assume you have five members on your team and five tasks, some people will tell person 1 their task, person 2 their task, person 3 their task, person 4 their task and person 5 their task…. but they never tell everyone "How do those five tasks fit together?" I will guarantee you that the result, while it may be "OK" and may fit the requirement, it won't be as good as it would have been and the team members will not be as motivated to complete their task, because they will have no way to understand why their task is important to the completion of the entire effort. It is extremely important to share knowledge. You must demonstrate how the team you have designed makes a difference to the customer, to the client. You don't just go to the client and say, "We have five people. We will deliver the product in one month. Thank you very much." The client typically would not award you the job. The client wants to know what each of those team members is going to do to contribute to the final product. They want to know the benefit of the money they are paying you. And so you must share the knowledge. And lastly, if you want to make your company be successful, you need to tell your employees what makes your company special.

(4)How does your company operate?

If you do not train the employees in your company about your business or the way you do business, then how can you really evaluate their work? They can only do what they think is right, which in your mind may not be right.

(5)Providing Feedback

Every employee needs to know exactly what is required of them. Explain very specifically what you want and explain to others to do the following: "It needs to be completed by the following days. I need this report by these days and by the way, here is how your task fits in to the list to the picture". When you give an employee a task on 1st of January and it is to be done on the 1st of April, you don't leave that person alone and come back on April 1st and say, “Where is my product?” You should be visiting that employee regularly. “How are you doing?” “Do you have any questions?” “Do you understand what I need?” “Can I review the product to make sure on the right direction?” To give feed back you must be sincere. Sincere means you are very honest at what you are telling them. You must be quick. Don’t wait if they give you something to review. Don’t wait two weeks to tell them whether which is right or wrong. And make sure that you give it often. People feel much better about themselves when they know their manager cares about them what they do.

- No. 2 “Value Principles,”

  Value principles consist of four key elements:

  (1) “Principles of Integrity”

  The author cannot stress how important integrity is in the business world. You must achieve what you do honestly. You must achieve what you do because your team has earned it and they have done it honestly. Trying to find another avenue to do something so that you don’t really have to do the work is not at honest way and of performing an effort, and it does not have integrity.

  (2) “Principles of responsibility”

  When something goes wrong, you don’t blame the person on the team, you may privately have a discussion with that member of the team to talk about what they did, but you as the leader of the team take 100 percent responsibility for what happened externally.

  (3) “Principles of Commitment”

  The author has always had an opinion that great companies are great because the leaders always hire people who are better than they are. When you hire someone who is smarter, who is better, who wants to do things even more than you do, not only will your job be easier, but you will be guaranteed that the result will be good. A good leader does not seek personal glory because a good leader by hiring the right people will get that glory. But the glory will come because everyone knows they hired the right team and the team got to the result, and not as a result of the individual.

(4) “Principles of Vision”

Again, a good leader has a clear vision of where they want to go and what it is that they want to achieve. They are able to communicate that vision so that the team not only understands that vision but expects the vision as well as wants to go forward.

- No. 3 “Synergy Principles,”

  Synergy means holding the team together as a whole.

(1) “Principle of Communication”

When people understand what it is that their manager wants to do, they will follow them much easier, provided they are rewarded for their accomplishment. Leaders often take all the credit for something that others really did. When people on your team do a good job, give them the credit for doing the work. In the United States, especially in law firms, it is not unusual for the associates, lawyers working to build their way up the ladder, to spend hours researching and writing papers for a senior partner to put only their name on that paper with no credit to the person who did all the work. There is an expression called “*Ghost Writer*” which is what they are, they are as the “Ghost”. They wrote it. But in the author’s personal opinion, that is not characteristic of a good leader. Their name could go on it, but they should reference the individual who provided the research and assistance.

(2) “Principle of Conflict Resolution”

A good leader knows how to deal with conflict. Leaders are also not afraid to face conflict. Conflict is not a bad word and in fact when two people are in conflict, you often have a better solution because you have both discussed two ideas or two points of view. Also good leaders will approach conflict as an opportunity. Good leaders are very good negotiators, they know how to take a difficult situation, and to walk through the conflict, so at the end of the negotiation, everyone feels they won. Very few people can do this very effectively. You have to know when to compromise. You have to know when to let the other side have something, because in conflict you can never have everything.

(3) "The Principle of Optimism"

Again, when someone is very positive with what they are doing, they show energy and enthusiasm and they want to do something. Others say, "*Wow! This must be fun. She is like really excited about this. Why? This looks like really boring stuff.*" The author has shown students that civil engineering is exciting. The author points to the great wonders of the world that engineers have built. Japan has one of the seven modern engineering wonders of the world. It is the longest suspension bridge. The other modern engineering wonders of the world, as presented by the U.S. *Discovery* Channel on television (and for which the author was co-host of the one-hour program) include: The Three Gorges Dam in China; Taipei 101 in Taiwan; the Shanghai Mag-Lev high speed line in Shanghai, China; The Falkirk Wheel, in Scotland; the Channel Tunnel in the UK; and the Big Dig project in Boston, U.S. These are all some of the greatest civil engineering projects to have ever been built and they are all being built now. To what an exciting age that we live in and we could bring more people to the profession if we were to only tell our story to the public about how exciting these projects are. Engineers must be more passionate about the great achievements that they have made and to spread the word regarding how great the engineering profession is.

(4) "The Principles of Change Management"

Good leaders know how to deal with change. Engineers hate change. The word is used strongly because the author finds it difficult to have to re-plan and re-adjust and to have to do something differently that they have set out to do. But there is a project built today that goes exactly to a plan. Many changes happen; whether it is political government, whether it is people who quit and leave to go somewhere else, or whether it is something that occurs on a project that is un-foreseen. Change is going to happen. And a good leader knows how to embrace that change and to still make the job go forward.

- No. 4 "Investment Principles"

(1)The Principle of Empowerment

Empowerment means giving you the opportunity to do something. You may not be the leader of the team, but that's OK. You can do it. I trust you. I have a confidence in you. So you can do that. So I empower you to do things. Very important for good leaders to let others on the team achieve and empower them to have those opportunities.

(2) The Principles of Courage

You cannot be afraid of the situations of which you may hate, you have to have the courage to make tough decisions, and you may find yourself in a tough situation. Let's assume you are on a project where you are going to have a very difficult client and you are going to just not want to be in a meeting with that person. You are just not going to want to have to communicate, so people say, "*I will just avoid it. And I will go to someone else.*" But you have to have the courage to stand up for what you believe in and to meet with that client to discuss what it is that he can said to us problems and obstacles and together devise solutions.

(3)The Principles of Examples

You as a good leader must lead by example. Assume you are working on a project with a tight deadline. If you go home at five o'clock and expect the rest of the team to stay until ten o'clock, you don't set a very good example. Most likely, at six o'clock everyone will go home because you have gone home and they will think that you will never know. But a good leader will stay until the last one goes home. They will demonstrate that they are willing to sacrifice their own personal time. Based on the author's own personal experience, no one wants to work until midnight. Further, the last thing they begin to feel guilty about is seeing you there until they leave. So, proactively the team becomes more efficient, the team begins to work faster because they know there are no short-cuts. If they know that you are not going to leave until they have left. They will finish their work without leaving. They will work as a team to get the work completed. Another example is if you want others to obtain higher education by getting a master's degree. If you only have a bachelor's degree, you wouldn't be setting a good example. However, by having obtained a master's degree, and as the author has demonstrated striving to obtain her PhD later in life, sets an example for employees and encourages them to do the same. Not only will it be better for them, it will be better for the company.

(4) The Principle of Preparation

This is probably the biggest challenge for engineers today. Engineers bid for projects and interview with clients. With the search engines of the world-wide web today, it still amazes the author how many engineers still do not know how to search the web and do not do "their homework" before arriving at a client's office. This often makes the difference between winning and losing a job. There are no short-cuts. Good leaders don't believe in short-cuts. The art of success is preparation and hard work.

4.4 Ten Strategies for Leadership Success

Two of the greatest leaders of our past, Shackelton and Patton, the prior an explorer and the latter a military general, had common strategies for leadership. In summarizing their views on leadership, ten strategies can be developed:[344]

- No. 1 "Never lose sight of the ultimate goal and focus energy in short-term objectives". Remember to set and write down your goals. If you always look and review what your goals are, you will be better prepared to achieve and accomplish that goal.

- No. 2 "Set a personal example with visible memorable symbols and behaviors." People will not do something just because you said to do it. If you do not do as you say, people will no want to do it either. When they see you doing something they also want to do and to be like you. Therefore they will work harder, strive harder and even improve their personal self in order to be like you who have set the example.
- No. 3 "Instill optimism and self-confidence, but stay grounded in reality". What does it mean? Of course, you want to be positive and want to be an optimist, but don't say that you are going to achieve something that becomes extremely impossible in the constraints that you have. It has to be realistic. The author uses an old expression for goals: "Goals should be "SMART". What is meant by that? What does "Smart" stand for?

  ➜ "S" is for specific. You must know exactly what it is you want to achieve.

- M is for measurable. You have to have a way to determine whether or not you met the goal.
- A is for achievable. Goals must be achievable; otherwise it really cannot be a goal.
- R is for realistic. Goals must be realistic, and something that is not beyond the capabilities of what someone can do.
- T is for trackable. You have to set goals in such a way that someone can measure them.

- No. 4 “Take care of yourself.” Maintain your stamina and let go of guilt. If you did something that made you feel guilty, it may take you one or two days to get over it. But then get over it move ahead. Be healthy. And if you are not healthy, and don’t have energy yourself, how can you possibly lead the team and individuals?

- No. 5 “Reinforce the team message constantly.” We are one. We live or die together. We are not individuals, we are the team. The team may succeed or fail, but it does so as a team and not as individuals.

- No. 6 “Minimize status differences and insist on courtesy and mutual respect.” You may have a PhD as a member of the team. You may consider yourself to be the smartest in the room. There may be another person on the team, who doesn’t even have a high school graduation. The worst thing you could do is to look down on that person and think that just because they don’t have the same education as you and they cannot contribute to the team. In fact, that person probably sees things from a much different perspective than you; and probably has something to offer that you would never see because they see life much differently.

- No. 7 “Master conflict, deal with anger in small doses, engage dissident and avoid needless power struggles.” The hardest thing that we become frustrated with is to maintain a pleasant personality. It is very easy to get angry. It is to raise your voice and evoke conflict. Sometimes it may be important to do so because sometimes you may have to make a point, and the only way to make it is to get upset and to get angry. But if you get angry all the time, people become hesitant to deal with you. They become afraid that you are going to yell at them. Some clients do not respect people who get angry. You can disagree that getting angry has nothing to do with a disagreement, but how you convey that disagreement is important. You can after have a discussion without yelling or screaming. In today's global marketplace, one of the biggest complaints that is heard from Asian clients is that they don't like the Italians because the Italians are always screaming and yelling. They don't like to be treated in that way. Sometimes you have to learn how to deal with different cultures. But good leaders know how to deal with anger.

- No. 8 "Find something to celebrate and to laugh about". If you know the team is doing a good job, tell everybody. Have a lunch for everybody. Have dinner. Reward those and celebrate. As a leader, "It is OK to laugh." You will find that if you find something funny the team will be working much more closely together if they know they can relax because you too know how to enjoy humor.

- No. 9 "Be willing to take the big risk." The author's mother often told her, "Opportunity knocks only once." So often you are given a choice and have to make a very quick decision. So often people become afraid that it is too big a risk and they say "No" and they think well. "I'll get that opportunity again next year." They never do. Real leaders know when to say YES and to take that risk and to make it work.

- No. 10 "Never give up. And there is always another move". Life is like a big chess game. You may become very frustrated, especially when the player on the other side has some better move than you. But you have to think. You have to think there is always another way to move. But you have to look at how you can re-shape, re-do, change the way you have been thinking to see that other alternative. Always remember that if you really want to do something, it is always possible. It may take a lot of time, a lot of effort and may require a lot more money in some cases. You have to make a decision whether it is worthy or not. But if something is really worth it, never give up because there is always another move.

4.5 Guideline for Advancement

The following steps are recommendation that the author has always followed and recommendations for engineers to succeed as leaders:

- No. 1 "Do more than it is always required to you". Individuals who demonstrate that they can do more than what someone asked will always be chosen to do the job again.

- No. 2 “Nine-to- fivers really rise above middle management”. What is meant by this phrase? If you go to work at nine o’clock and go home at five o’clock and you never work over time even when the situation at the time requires it, seldom will ever be a leader.
- No. 3 “Success is an attitude”. If you know you are going to win, you probably will. If you think you are going to fail, you probably will.
- No. 4 “Leadership is often a matter of balancing time against available resources. Opportunities are easily lost and are waiting for perfect conditions. Life will never offer you a perfect condition”. So, you have to ask yourself what it is you may sacrifice, what it is you may have to give up in order to accomplish something or who else you may have to bringing to assist you to meet goal.
- No. 5 “Surround yourself with knowledge and judgment, people you trust and make good use of them”. If you hire people and you don’t trust what they do, and you do their work, why do you them? If you have to continuously review every single thing that someone does in your company, then you have done yourself a disservice, and have made your life even more difficult. You will be the one that works 24 hours a day. You must have trust in the people you hired. And if you do not have trust in them, then you should replace them, because you’ll always be in a suffering condition.
- No. 6 “Public Praise, Private Criticism”. When someone does something well, tell everyone. When someone does something wrong, tell them individually. But don’t tell everyone and their peers around them.

5 ENGINEERING LEADERSHIP EDUCATION

All learned professions of the future will have to broaden their public purpose to include societal leadership, for only they can provide the knowledge needed to change or establish national technological policies. All engineering societies will have to work together for all societal goals involving complex interrelationships. Not one engineer “knows it all.”

Leadership skills promote and support practices which foster teamwork and integrity in professional and personal development, and aid in the understanding of vision, culture, and ethics in the corporate and public worlds. Leadership education provides models and methods for problem-solving, and enables engineers to test personal limits, and to explore cultures, management, team development, and ethical decision-making. Through interactive course work, engineers can be exposed to specific leadership theories, and can learn motivation techniques and tools to succeed in a diverse organizational culture. As the corporate world responds to increasing globalization, engineers must be ready to navigate with their colleagues and peers as well as their customers who are from diverse cultures and environment and literally may be a world away.[345]

The converging forces of increased system complexity and the social impact of technology—combined with a need for increased leadership by engineers---create opportunities for new directions in engineering education. The most successful engineers must possess superb professional skills as engineers, including a keen understanding of social, regulatory, environmental, cultural, and other factors. What is needed in engineering education is a holistic view of these systems and all the issues associated with them. These integrative leaders will be professionals who consider the technological components as part of a larger engineering system and utilize different approaches than those based on the traditional engineering education. Universities will need to produce engineering leaders who are:[346]

- Skilled intellectually at dealing with the many crucial technological dimensions of society;
- Have the practical results orientation that is characteristic of engineering professionals;
- Have the courage based on early experience to take on the most difficult system problems; and
- Have the leadership skills to bring others forward as they themselves move along.

6 CONCLUSION

Communication, commitment and confidence – these are the three key ingredients to successful leadership. In order to be a more effective leader, there are five steps that will enhance effectiveness:[347]

(1) Embrace an open-minded and flexible approach-leaders listen well and get to know their employees, what motivates them as different individuals and personalities

(2) Support the team-Leaders make themselves available to answer questions and "spend time in the trenches" so as to understand the nuances of the project and offer practical and emotional support for the employees.

(3) Provide training and mentoring-spend time coaching the bright prospects who can boost team performance

(4) Communicate-communicate the goals and assure that the team fully understands the goals and objectives to be accomplished

(5) Acknowledge the results and celebrate success-offer thanks and praise when it is deserved and recognize significant achievements whether it is with a "reward" or even a free lunch.

Peter DeLisle in an IEEE-USA featured article in May 2000 summed up the essence of leadership in the following poem:

On Leadership

Leadership is an invisible strand
As mysterious as it is powerful, it pulls and it bonds.
It is a catalyst that creates unity out of disorder.
Yet it defies definition. No combination
Of talents can guarantee it. No process or training
Can create it where the spark does not exist.

The qualities of leadership are universal:
They are found in the poor and the rich, the humble
And the proud, the common man, and the brilliant
Thinker; they are qualities that suggest paradox
Rather than pattern. But wherever they are found
Leadership makes things happen.

The most precious and intangible quality
Of leadership is trust—the confidence that the one
Who leads will act in the best interest of those
Who follow—the assurance that she/he will serve the group
Without sacrificing the rights of the individual.

Leadership's imperative is a "sense of rightness"—
knowing when to advance and when to pause, when
To criticize and when to praise, how to encourage others
To excel. From the leader's reserves of energy
And optimism, his followers draw strength. In her

Determination and self-confidence, they find inspiration.

In its highest sense, leadership is integrity.
This command by conscience assert itself more
By commitment and example than by directive. Integrity
Recognized external obligations, but needs
The quiet voice within, rather than the clamor without.

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[326] Parts of this chapter are based on published papers by P. Galloway: "Leadership: Women's Role in Engineering", *A Civil Engineered World*, a publication of ASCE's International Affairs Department, Volume 13, Issue 1, March 2000, Kochi University of Technology, Maeda Special Lecture Series, February 2005
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IX. THE ENGINEER'S ROLE IN PUBLIC POLICY

1 INTRODUCTION

The role of the engineer goes beyond the realm of knowledge and technology. Engineering impacts the health and vitality of a nation as no other profession does. The business competitiveness, health, and standard of living of a nation are intimately connected to engineering. As technology becomes increasingly engrained into every facet of our lives, the convergence between engineering and public policy will also increase. This will require that engineers develop a stronger sense of how technology and public policy interact.[348] The public is playing a much more active role in both private and public projects alike through more open planning processes, environmental regulations, and elevated community expectations that place greater responsibility of those executing project developments.[349] The public understanding of engineering is a critical and growing concern for engineering research, engineering education, and the progress of engineering innovation.

While engineers have indirectly pursued connections to public policy through lobbying organizations and their own professional engineering societies, the engagement of engineers in public policy issues has been haphazard at best. It is both the responsibility of the engineers and importance to the image of the profession that engineers make a better connection with public policy in the future.[350] The Engineer of the 21st Century will need to assume leadership positions from which they can serve as a positive influence in the making of public policy and in the administration of government and industry.[351] Essential public policy and administration fundamentals include the political process, public policy, laws and regulations, funding mechanisms, public education and involvement, government-business interaction, and the public service responsibility of professionals.[352]

2 THE ISSUE

Why is it that: our neighbors don't know what an engineer is; only four of the United States Congressmen are engineers; only 30% of the United States' Secretary of Transportations are engineers; and that there are major U.S cities and other cities around the world with City Engineers who are not engineers, yet hold the title? When you ask someone what an engineer is you will usually be given a description of a person in dirty overalls who fixes cars or worse yet, the person in the hotel who comes up to fix the television or the plumbing! In reality, this is a common misconception that is totally untrue. Today, the word "engineer" is far too often twisted to explain train delays and dirty construction work. In fact, the job of a toilet cleaner often comes with the title of sanitary engineer!

In 1998 and 2003, the American Association of Engineering Societies (AAES) commissioned a Harris Poll to provide a better understanding of the public's attitudes towards engineering in the United States. The results from this data, published in 2004, as shown in **Table IX-1** below, indicates that engineers have a moderate-to-high level of prestige-though at a lower level that other professions such as scientists, doctors, teachers, ministers and policemen.

TABLE IX-1
EXCERPTS FROM THE HARRIS POLL INDICATING THE LEVEL OF PRESTIGE AMERICANS IMPART TO VARIOUS PROFESSIONS

PROFESSION	VERY GREAT	CONSIDERABLE	SOME	HARDLY KNOW	DON'T KNOW
Doctor	61	27	10	2	1
Scientist	55	30	10	3	1
Teacher	53	26	15	5	1
Minister	46	28	19	7	1
Policeman	41	31	20	7	0
Engineer	34	39	22	4	1
Military Officer	34	36	22	4	1
Architect	26	42	26	4	2
Congressman	25	31	26	17	1
Lawyer	23	30	28	18	1
Athlete	20	28	34	17	0
Entertainer	19	29	36	15	1

TABLE IX-1 EXCERPTS FROM THE HARRIS POLL INDICATING THE LEVEL OF PRESTIGE AMERICANS IMPART TO VARIOUS PROFESSIONS					
PROFESSION	**VERY GREAT**	**CONSIDERABLE**	**SOME**	**HARDLY KNOW**	**DON'T KNOW**
Businessman	18	37	38	6	1
Banker	18	33	39	10	0
Accountant	17	33	39	11	1
Journalist	15	33	37	13	1
Union Leader	16	28	33	22	1
Note: Not all percentages add up to 100 because not all respondents answered every question					

Engineers have had little to say about the strategies that are driving some of the most important initiatives introduced over the past decade-those aimed at maintaining a livable world. Instead, to their credit, public policy experts, economists, lawyers and environmental group leaders have led efforts to identify solutions to myriad problems, even though science and technology are at the center of those solutions. The issues are big and worldwide, and include conserving water, conserving energy used in new buildings and pretty much anything that makes it easier for everyone to grow and prosper while better utilizing resources. Why haven't the engineers most able to innovate and design those solutions been part of the movement from the first days? What are the weaknesses and, eventually, the cost of developing public policies and designing action strategies for reform without the influence of those who are best able to develop innovative solutions based on technology?

To a large extent, engineers are at fault for their lack of influence. Engineers simply haven't, as individual leaders or as parts of national professional groups, stepped up and actively and publicly participated in the movements that are, correctly, calling attention to the need for reforms in how we build as well as how we conserve and better utilize resources. Engineers have ceded the leadership roles in the public forums that will advocate for new policies and seem satisfied to play a secondary role and help to carry out others' ideas. While others design the strategy for reform and determine the routes nations will take, engineers seem content to build the locomotives and put down the rails. The problem of engineers being second- and third-stage implementers rather than first-stage innovators is that there can be a cost -- either in too many dollars being spent on a solution or a solution that cannot deliver on the expectation -- when public policy is designed without adequate recognition for the technical requirements necessary for success.[353]

As noted above, the U.S. Congress of today only has four engineers. While there are only five engineers in the Parliament in the UK in 2005, this is only up three from 1998, when there were only two mechanical engineers in the House of Commons. Engineers were simply reluctant in the 19th century in the UK to have any involvement in politics. UK Engineers has simply acquired a marked antipathy towards any sort of public service unconnected with their professional duties. The tendency unfortunately grew even stronger in the 20th century. A debate in the House of Commons in March 1998 demonstrated the tendency in several ways. There was a motion that was being given consideration for improving engineering performance in British industries, and had been the first such debate since the Finniston Report in December 1980. Virtually all the speakers were impressed with the importance of engineering in the national economy, but were deplored either the reluctance of young people to enter the profession. They criticized British firms for not promoting more engineers to senior managerial positions and regretted that there were so few engineers in the House. One speaker observed that although there were 68 barristers, 30 solicitors, 20 accountants, and 6 doctors in the House in 1988, there were only two engineers.[354]

The word engineer is derived from the Latin word ingeniare. Its actual meaning is to invent or devise. Engineers are creative designers who invent, develop and manage the manufacture of their creations. These creations can be as far ranging as from computers to robots to space vehicles. Engineers are characterized by their search for how and why. Their task is continuous a quest for knowledge and their work revolves around it. Engineers are highly skilled people who invent, design and innovate. They are the people who are advancing humanity into an era of space flight and internet information technology. Who knows what they will do next?[355]

However, the reason that engineers are not known to the public partially lies in the lack of involvement of engineers in the public policy process. Over the years, engineers have simply not recognized the direct link of the public policy process to our ethical and moral role and responsibility “to protect the health, safety and welfare of the public.” There is a misunderstanding and perception that as a non-profit organization our professional engineering societies cannot “lobby” or speak for the profession on the “Hill”. There is a misconception that engineers and members of engineering professional engineering organizations cannot hold office or assist in political campaigns. Engineers have simply taken a back seat to politics and have chosen not to get caught up in the perceived “corrupt” and “political” process-and thus have viewed public policy as a foe.[356] However, as Pericles observed in 430 B.C.:

> *Just because you do not take an interest in politics doesn't mean politics won’t take an interest in you.*

One of the key ingredients of engineering leadership is the understanding of public policy. How many engineers realize that policies prepared by our professional engineering organizations assist legislation and the lawmakers who vote on that legislation? How many of realize that these engineering policies that are prepared by the engineers behind the scenes are actually used by regulators in determining what happens to our infrastructure worldwide? How many engineers recognize that it is these policies upon which codes and standards are developed and promoted for infrastructure projects all around the world? However, public policy is not just a professional engineering organization national program; it goes to the heart of the engineering profession and requires the energies and volunteerism at all levels of government.

Two major barriers holding back engineers in the public policy area include:

1) The lack of understanding of what their professional engineering organization can and cannot do; and

2) The uncomfortable feeling of many of the engineers to stand up and speak out on public policy issues.

In turn, public policy has not been a priority with engineers, resulting in little funding to tackle the one area that affects all of us as engineers, as well as the public-the quality of life. The consequence: engineers hold fewer leadership positions and have a reduced voice with key decision makers on critical engineering issues.

Norman R. Augustine, the Retired CEO of Lockheed Martin and former member of the Presidents' Committee of Advisors on Science and Technology, noted in an Excerpt from "L. A. Engineer", *The Bridge*, in the fall 1994:

Engineers today seem to be the stealth profession, the silent occupation....If we as engineers are unwilling to responsibly speak out on issues within our realm of expertise, who then will?

Mr. Augustine made further comments at an AIAA Summer Meeting, June 16, 1998: [357]

The time has arrived when engineers will have to venture out from the shelter and comfort of the Ivory Tower and enter the arena of boiling controversy, real-world debate, and -- brace yourselves -- politics. It is no longer viable to place our high-tech candle under a bushel, for at best we will find ourselves in darkness and at worst our bushel will go up in flames. …Engineers must become as adept in dealing with societal and political forces as they are with gravitational and electromagnetic forces. We must equip engineers of the future to present their cases in almost every forum imaginable--from town meeting to state legislature, from The New York Times to Sixty Minutes, from the Congress to the Oval Office. If, as in the past, engineers place their trust solely in the primacy of logic and technical skills, they will lose the contest for the public's attention -- and in the end, both the public and the technical communities will be the losers.

3 WHY POLITICS AND PUBLIC POLICY NEED ENGINEERS

In the 1920's, in the United States, the economic focus shifted away from agriculture to manufacturing. This lasted only through the end of World War II when the service industry overtook manufacturing. As the United States moved into the 1990s, the U.S. economy again shifted to its current economic focus on information technology.[358] Traditionally, the politicians had backgrounds in the fields that were most prominent in the current economic environment. Today when issues surmount in the technical and knowledge based economy, one would initially think that the Congress would be primarily comprised of technically-oriented individuals such as engineers. However, such is not the case and the majority of decisions on technically based issues which affect the public health safety and welfare, are made by lawyers and public administrators dominant in the political arena. This lack of required knowledge upon which an engineer needs to make informed decisions is detrimental to any country. If the decision makers do not have the required expertise or background, then the individuals must seek out answers from others, relying on second-hand input. Legislation based on these sources is inefficient at best and may not be in the best interest of the public.

As noted by Dr. Neal S. Lane, Special Assistant to President Clinton for Science and Technology Policy, Director of the Office of Science and Technology Policy and former Director, National Science Foundation: [359]

Scientists and engineers constitute one of the largest, most valuable, yet least heard constituencies in America. ….My message to you today is that if you don't take it as one of your professional responsibilities to inform your fellow citizens about the importance of the science and technology enterprise, then that public support, critical to sustaining it, isn't going to be. …You are needed more than ever to be visible and vocal in your communities. This requires your presence...outside the walls of your laboratories and the gates of your universities to a much greater extent than in the past."…. The ballooning of the budget deficit [in the United States] *in the 1980s along with the economic drain from interest on the federal debt have energized the electorate to demand greater accountability of all government investment, including science and technology….. Engineers and scientists need to carry the message of value, application, contribution, and investment to the people whose lives are shaped by science and technology and who pay the bills for our work....We need to do this because nobody else but members of the science and engineering community really understands science and technology, what research is all about, how education--learning--is enriched in a research environment,...the tangible benefits of science, engineering, and technology to people's lives. I'm afraid that if we who do understand these things don't speak up, nobody will. And the American people will be the losers. .*

Other United States key politicians have also spoken out on the need for engineers in public policy. The Honorable Robert S. Walker, Consultant, former U.S. Representative and former Chair of the House Science Committee noted in the *Federation of American Societies for Experimental Biology* newsletter, December 1995:[360]

Scientists [and Engineers] can positively influence the policy process by clearly and publicly enunciating the role and potential of their research so that the lay person, who may not be intimately familiar with basic research objectives, feels comfortable in knowing that his tax money is well-spent. Public seminars, school field-trips, and op-ed pieces can create widespread enthusiasm for science programs.... Furthermore, Congressional members will argue more effectively for continued research funding with their colleagues when they can persuasively defend the programs on both a budgetary and scientific basis, a task directly linked to their interactions with researchers. One of the most effective means of accomplishing this is by inviting representatives to address a gathering of researchers, or by providing hands-on tours of research facilities. Making science real for these members is the true key to legislative success.

Phillip J. Bond, Undersecretary of Commerce for Technology, U.S. Department of Commerce said in his keynote address at the Nanocommerce 2003 convention on December 9, 2003:[361]

Scientists and engineers are in a unique position to contribute to sound policy development, address legitimate concerns, and allay irrational public fear (about nanotechnology). Scientists and engineers alone have the scientific and technical knowledge necessary to sort the wheat from the chaff.

> *In addition, while not historically great communicators, scientists and engineers have unique credibility with the public in speaking to these issues. We need to communicate frequently, clearly and proactively with the public about nanotechnology to ensure Americans have all of the knowledge they need—complete and balanced—to make reasoned judgments on these issues.*

Politicians struggle with an overwhelming number of decisions and need sound, practical advice. If unavailable, decisions are made too often without it.[362]

4 THE REASONS WHY ENGINEERS ARE IDEALLY SUITED FOR PUBLIC POLICY

Engineers by both education and personality analyze problems and find solutions in a rational, systematic way. The entire engineering mindset is to define a problem, identify alternatives, select the best solution, and then implement the most beneficial solution. Engineers are knowledgeable about an array of subjects including business, public health, and technology. They are also people just like the rest of the population. These attributes make engineers ideally suited for them to advocate feasible solutions to problems faced by Society. If engineers were legislating these technological solutions, public welfare would be maximized and the negative impact of technology would be minimized.[363] These opportunities will be missed if engineers continue their traditional non-involvement in politics.

The engineer is entrusted with two key attributes that are critical to public policy and politics:

> (1) The training of critical thinking on solving problems as well as training as to the very activities required to sustain a quality of life for mankind as we know it today; and
>
> (2) The moral and ethical obligations that the engineer vows as part of the engineer's profession to protect the health safety and welfare of the public.

In fact, there were a few engineers over the past that did recognize the importance of engineers being involved in public policy and why politics and engineering must go hand in hand. One such engineer was a Russian engineer, Peter Palchinsky, who in the early 1900s, saw clearly at the beginning of the Soviet industrialization the mistakes that were being made, and tried to rectify them. He insisted in viewing engineering plans within their political, social and economic contexts. He believed that the obstacles to Russia's industrial advancement were not technological, but political, social, legal and educational. He was particularly critical of the engineering education in tsarist Russia. He believed that the Russian engineering curriculum was too heavy in natural science, mathematics, and “descriptive” technology and ignored subjects such as economics and politics. He indicated: *“graduates of Russian engineering schools think every problem is a purely technical one, and they assume that any solution that incorporates the latest science is the best solution. No wonder Russian engineers are unequipped to deal with the competitive world-and that Russian technology cannot compete in the world market even though it is protected by high tariffs.”*[364] Palchinsky’s thoughts of Russian engineers in the early 1900s were not too distant from those in other engineers in the UK, U.S., or Japan in the early 2000s.

4.1 Engineering Definitions

There are multiple definitions that define the engineer and engineering. For example, the term civil engineer refers to an individual who practices *civil engineering*. Originally the term "civil" engineer worked on public works projects and was contrasted with the military engineer, who worked on armaments and defenses. Over time, civil engineering has spun off a variety of fields e.g. architectural engineering, electrical engineering, mechanical engineering, and what is still called civil engineering.[365] An interesting definition could be, "The profession of civil engineering is the art of directing the great sources of the power of nature for the use and convenience of man."

According to Webster’s dictionary, the definition of an engineer is: [366]

> 1. To lay out or construct, as an engineer; to perform the work of an engineer on; as, to engineer a road. --J. Hamilton. [1913 Webster]
> 2. To use contrivance and effort for; to guide the course of; to manage; as, to engineer a bill through Congress. [Colloq.]

Using Wikipedia provides yet another definition of an engineer that notes:

> *An engineer is someone who practices the engineering profession.*

And defines engineering as: [367]

…the application of science to the needs of humanity. This is accomplished through knowledge, mathematics, and practical experience applied to the design of useful objects or processes. Professional practitioners of engineering are called engineers.

Engineers perform services or creative work as consultation, testimony, investigation, evaluation, planning, design and design coordination of engineering works and systems, planning the use of land and water, performing engineering surveys and studies, and the review of construction or other design products for the purpose of monitoring compliance with drawings and specifications. Such work or services may be either public or private, in connection with any utilities, structures, buildings, machines, equipment, processes, work systems, projects, and industrial or consumer products; equipment of a control, communications, computer, mechanical, electrical, hydraulic, pneumatic, or thermal nature. United States laws, which vary by state, govern the licensing of professional engineers. [368] Laws in other countries have similar licensing laws and regulations, including Canada, Australia and Japan.

Engineering is concerned with the design of a solution to a practical problem. A scientist may ask "why?" and proceed to research the answer to the question. By contrast, engineers want to know *how* to solve a problem, and how to implement that solution. In other words, scientists investigate phenomena, whereas engineers create solutions to problems or improve upon existing solutions.[369] As politicians, decisions affecting the public health safety and welfare should also ask not just “why”, but “how” and what constraints may that decision impose.

The crucial and unique task of the engineer is to identify, understand, and integrate the constraints on a design in order to produce a successful result. It is usually not enough to build a technically successful product; it must also meet further requirements. Constraints may include available resources, physical or technical limitations, flexibility for future modifications and additions, and other factors, such as requirements for cost, manufacturability, and serviceability. By understanding the constraints, engineers deduce specifications for the limits within which a viable object or system may be produced and operated.[370] These are the very constraints and considerations that are important when considering public policy.

4.2 Engineering Codes of Ethics and Moral Obligations

Engineers have many moral and ethical obligations that they sign on to whether it be when they join a particular professional engineering organization, whether it be when they obtain a professional engineering license to practice engineering, or whether they sign on via other memberships and/or affiliations, such as their employer and/or The Order of the Engineer. These obligations go to the one of the reasons why engineers are ideally suited to become involved in public policy and even become politicians: the obligation to protect the public health safety and welfare and the agreement not to accept any favors or bribes which could compromise decisions which in turn could affect the public health safety and welfare.

Relative to the practice of engineering, the laws of the U.S. State of Florida for Florida Professional Engineers notes that:[371]

> *The Legislature deems it necessary in the interest of public health and safety to regulate the practice of engineering in this state.*

Engineering values transcend in professional engineering organizations around the world and in all disciplines of engineering. In the Engineers of Australia Code of Ethics, the following sections highlight the obligations with respect to the public: [372]

> *3. Values*
> *……*
> *In enhancing the welfare, health and safety of the community through engineering solutions, engineers remain responsive to the imperative of the community security and social justice. Engineers are pro-active in the quest for achievement.*
>
> *4. National Goals for 2004-2009*
> *…..*
> *To be the primary and trusted adviser to government, industry and the community in matters of engineering, innovation and technology.*
> *…..*
> *To conduct our affairs efficiently, effectively and in the best interests of our members and the community.*
> *To embrace our responsibilities to the profession, employers and the community.*

Within the American Institution of Architects (AIA), Code of Ethics, it is noted:[373]

> *Members shall neither offer nor make any payment or gift to a public official with the intent of influencing the official's judgment in connection with an existing or prospective project...Members serving in a public capacity shall not accept payments or gifts which are intended to influence their judgment.*

Other codes of conduct from engineering professional organizations give other insights as to the obligations of the engineer with respect to public policy. For example, ASCE notes in its Code of Ethics within the Fundamental Principles:[374]

> *Engineers uphold and advance the integrity, honor and dignity of the engineering profession by:*
> 1. *using their knowledge and skill for the enhancement of human welfare and the environment;*
> 2. *being honest and impartial and serving with fidelity the public, their employers and clients;*
> 3. *striving to increase the competence and prestige of the engineering profession; and*
> 4. *supporting the professional and technical societies and their disciplines.*

Within the Fundamental Canons section, two specific canons speak to the public policy aspects:

> 1. *Engineers shall hold paramount the safety, health and welfare of the public and shall strive to comply with the principles of sustainable development in the performance of their professional duties.*
>
> *…*
>
> 2. *Engineers shall issue public statements only in an objective and truthful manner.*

Within the Guidelines to Practice under the Fundamental Canons of Ethics 1 above, four specific guidelines further demonstrate the engineer's obligation to public policy:

> *a.* *Engineers shall recognize that the lives, safety, health and welfare of the general public are dependent upon engineering judgment, decisions, and practices incorporated into structures, machines, products, processes, and devices.*
>
> *….*
>
> *c* *Engineers whose professional judgment is overruled under circumstances where the safety, health and welfare of the public are endangered, or the principles of sustainable development ignored, shall inform their clients or employer of the possible consequences.*
>
> *...*
>
> *f.* *Engineers should be committed to improving the environment by adherence to the principles of sustainable development so as to enhance the quality of life of the general public.*

The American Association of Mechanical Engineers (ASME) requires ethical practice by each of its members and has adopted the following Code of Ethics of Engineers as referenced in the ASME Constitution, Article C2.1.1: [375]

The Fundamental Principles

Engineers uphold and advance the integrity, honor and dignity of the engineering profession by:

I. Using their knowledge and skill for the enhancement of human welfare;
II. Being honest and impartial, and serving with fidelity the public, their employers and clients; and ….

The Fundamental Canons

1. Engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duties.
2. …
3. Engineers shall continue their professional development throughout their careers and shall provide opportunities for the professional and ethical development of those engineers under their supervision.
4. …
……
7. Engineers shall issue public statements only in an objective and truthful manner.

The Order of the Engineer, for instance, is an organization in Canada and the United States that specifically speaks out to ethics and professionalism. The symbol is a steel ring worn on the little finger of the working hand. As noted in the "significance of the ring" discussion during the ceremony, it is noted: [376]

The ring you will receive today is a symbol of the strength and continuity of our profession. The engineer's ring says to all who see it – "There is an engineer, a person with special technical knowledge, and a publicly avowed dedication to his profession and the public it serves…… the significance of the ring is to remind each of us that even minor errors are important and ethically we must do our best to protect the life, health, and safety of the public.

The actual obligation that an engineer vows to accept when becoming a member of the Order of the Engineer, that includes:

When needed, my skill and knowledge shall be given without reservation for the public good.

4.3 The Engineer as Politician

Contrary to stereotypes, many politicians exhibit an extraordinary sense of commitment, dedication, and enthusiasm.[377] Because engineers have an obligation to further the interests of mankind, the role of the politician is a perfect fit. Because of the engineers' ethical standards, engineers will be held to higher standards than the stereotyped politicians and as such will be held in higher regard and will enlist more trust from the public. Engineers often have superior knowledge of current scientific issues as compared to career politicians which can be extremely useful when debating legislation regarding emission guidelines from automobiles, clean water, energy policies, and air pollution mandates. Since the engineer is to protect the public health safety and welfare, this moral obligation, combined with the engineer's ability to think and devise solutions to problems, has major benefits for government positions and political positions since a person in office should also strive to create legislation, public policies, and economic budgets that are to protect the public and environment while at the same time furthering progress.[378] Engineers have a unique opportunity and responsibility to the public to promote issues such as energy, clean water and sustainability and other key global issues especially through political involvement.

There are many examples of engineer/politicians in history; in the U.S. we had presidents including George Washington, Teddy Roosevelt, Herbert Hoover, and Jimmy Carter, all who were engineers. The Russian engineer, Palchinsky, was one of the most well known engineers in Russia in the early 1900s and served as the chairman of the Russian Technology Society and a member of the governing presidium of the All-Russia Association of Engineers.[379] In 1927, through the Supreme Council of the National Economy (VSNKh) was a scientific technical administration that was responsible for the development of policies for guiding industrial research and development. Palchinsky was one of its members. These engineers called for the application of scientific methods not only to Soviet economic development, but also to such fields as industrial psychology and management. According to one of the documents, "the future belongs to managing-engineers and engineering-managers."[380]

5 IN A WORLD WHERE ENGINEERS ARE TRUE POLITICANS: AN EXAMPLE THAT IT CAN WORK

Public policy, globalization and professionalism are all key areas where engineers ought to be in the forefront. So, If you were to have a vision of the perfect state, the perfect city where engineers held the top government positions, where engineers were active in public policy, where partnerships were formed with other cities, other states, other prefectures, other regions, other countries, where designing and building could be accomplished on budget and schedule, where innovation was key and restoration was blended with the new, where private and public investment came together to better the quality of life for the population, where roads and bridges were repaired and expanded to meet the congestion needs and to reduce the commuting time, where would you be? Many would say no where because this scenario would only exist in an engineer's dream. However, this dream is reality and believe it or not, the engineer's city is located in the Dmitrov Region of Russia.

During the author's ASCE Presidential delegation to Russia in 2004, the ASCE delegation met with its Russian counterparts and was taken to a town approximately 70 kilometers outside of Moscow named Dmitrov. Dmitrov is in the Dmitrov District of the Moscow Region and is one of the oldest towns in Russia. It celebrated its 850^{th} birthday in September 2004. The Dmitrov District consists of 2 towns, 4 settlements, and 440 villages. There are 1000 kilometers of roads.

The head of the District, equivalent to a United States State Governor is a professional civil engineer. His name is Valeri V. Gavrilov, and he has held three 5-year terms in this elected position. The Mayor of Dmitrov and his Deputy, who is responsible for the construction policy of the Region, are also civil engineers. The representative of the Moscow Region is also a civil engineer. In fact, past Russian President Yeltzin was also a civil engineer-a fact that many of engineers probably did not know. Engineers are not only well respected in Russia, they are believed to be the most qualified to hold government positions that require the knowledge to move Russia forward. Mr. Gavrilov's comment to the ASCE delegation was "Happy is the man who has the profession of a civil engineers, who can leave behind what he has created with his own hands and can tell his grandchildren that he built this. Happy is the man who has the profession of the civil engineer who will leave his mark on the world long past he has gone for the people to enjoy."

Gavrilov is a man of great vision - a vision to see his District expand for the betterment of the people. Upon the fall of the Soviet regime, Dmitrov was one of the first developments in the Moscow Region. It was recognized early that private investment was required to improve the conditions of the city and to become a true business. While Russia went through hard times from 1990-1998, Dmitrov suffered no losses. Industrial plants remained opened and jobs flourished. More that 4000 workers are still needed in the Region due to rapid expansion. Unemployment is only 1 percent and this percentage represents that portion of the population that just does not want to work. Young people are encouraged to stay and are provided with facilities such as sports facilities, activity clubs, and activities where the families can come together. A new sports complex is being built with another 20 to be constructed in the region. The quest to engage young people in activities has significantly reduced juvenile delinquency and drug use and created a base for the city's work force.

Bureaucracy of the Soviet era restricted how civil engineering projects would be completed. Basic needs were all that was completed with cost being the major factor and quality not considered important. Minimum facilities to meet the basic public needs were all that mattered and only within the confines of what the mother country could afford. Outside assistance was unheard of. As a result, upon fall of the Soviet Union, massive reconstruction was necessary and multiple problems had to be rectified. One of the major problems of housing people in the Soviet era has become one of the biggest new problems of today. Housing was owned and controlled by the government and construction, while swift to house people, was done so at the expense of quality. 50-years later, these buildings must now be demolished with new residential multi-use developments where apartments, duplex side by side and single family homes are constructed with common facilities such as parks, libraries, sports complexes, day care centers and shopping can all be incorporated together, allowing families the ability to walk or drive and have a choice.

He noted that his plans to build an additional 70 new facilities would have never been realized under the Soviet years. Private investments and a capital market have resulted in a new middle class where most families now have cars and now make an income to allow social spending, travel and enjoying life. Gavrilov has long recognized that partnerships with companies and countries results an increased ability to expand the infrastructure and to renovate and innovate.

Innovation has been introduced in many aspects of the city's features. For example, there are fountains throughout the city that have been constructed to "entertain". The fountains go off every two hours-and not only do they flourish with water, but the water "dances" to music-both Russian and pop music from all around the world. Partnerships have been forged with cities and countries around the world for innovative technology and research. Agriculture has become a big business and new joint ventures with multiple countries have been formed to research new technologies in vegetable and potato growing. With Moscow only 70 kilometers away, there is a market of 10.5 million people. The only farm breeding animal research station in Russia is currently being designed and will be built in Dmitrov. San Diego, a city in Southern California of the United States has become a sister city and together will design and build the country's;

largest medical center with research in new medical technologies. Venture Capital money from the United States has also resulted in a new nursing home and senior center for the elderly. The facility is a modern facility with tile and wood and spacey rooms with the comforts of television, refrigerators, large bathrooms and the common areas where the old traditions of Russia are blended with the new. Construction is of very good quality.

Roads and bridges are being repaired and brought up to new international standards. Additional roads are being constructed. Historical buildings are being restored to their original state and Soviet buildings are being demolished to make way for modern housing and new industrial facilities. Companies, including designers and construction firms were brought in from around the world with a surge of construction which started on July 1, 2004 with the goal of completion by the Jubilee. 15th Century cathedrals were restored to their original conditions with frescos restored and artifacts again displayed-all in less than 2 years. Original stone cobblestone walkways cleaned up and restored to provide walkways into the past-yet bring people to the future.

The problems faced by Dmitrov today are not unlike what many of the developed countries are facing today: Maintenance, housing and common services (i.e. water, sewage and power). $70 million Rubbles (29 rubbles/dollar) is being invested for heating, water and sewage. Housing is slowly being transferred from public ownership to private ownership as private investment is made to provide funding for expansion projects. However, with a civil engineer at the helm-plans are underway to continue this Region's development and to make it a word class place for business and tourism alike. Public policy, globalization and professionalism-all in Gavrilov vision-all in a civil engineer's dream-except this one man's dream is reality-one that engineers around the world should strive to repeat. [381]

6 MAKING THE TRANSITION

Engineering focuses on actions, while politics on compromise and negotiation. Can the engineer make a successful transition into the political arena? Engineers while having a succinct laid out thought process in arriving at solutions; tend to have a different thought process than politicians to accomplish their respective goals. The engineer's thought and decision process strives to choose one alternative by identifying an existing problem. The politicians follow a similar process, but select the most beneficial alternative with focus on justification and compromise relative to their constituents' desires. The political process places more emphasis on the stakeholders rather than from an engineering standpoint that may be the optimal solution for the specific technical problem. [382]

This is where the engineer clearly holds the advantage. While a non-engineer may make decisions that may involve compromise, an engineer can ensure that the welfare of the public is not compromised while at the same time assuring that the decisions for the government are made to the best interest of the nation. In addition, not only is government involvement essential to the engineer's responsibility, it is essential to the survival of the engineering profession as a whole. Government is vital in upholding the standards of the profession and improving the integrity of the field. Government has the power and influence to take important projects from the drawing board to reality.[383] Funding is also a key to critical projects that are essential for the well-being of the public. Thus, if the engineer were to take a major role in the regulatory and legislative process, the benefits would not only be to the engineering profession, but to the public to which they serve.

If engineers are to raise the bar on their profession then public policy must be viewed as a friend and not as a foe. Engineers need to be aware of the facts of what their professional engineering organizations can do in the public policy area as well as what you can do as an individual member. While some professional organizations are not able to endorse specific candidates for office, due to government tax status, most do and actively participate in public policy and "lobbying" relative to legislation regarding engineering issues. However, as an individual, an engineer can run for office, participate in political campaigns and make contributions to those individuals that an engineer believes are in the best interest of their nation and engineering issues.

The engineering profession globally must also dispel the perception that engineers cannot participate in public policy or politics just because they are engineers. Engineers often feel it is impossible for them to participate in public policy or hold a political position, indicating "I would not have a chance since it is a political appointment" or "I do not feel comfortable in presenting or writing letters to my congressmen as I do not know enough about the issue at hand". Engineers are often respected and ridiculed for their intense beliefs and interests. Perhaps because of their deep understanding of the interconnectedness of many things, engineers such as United States Past Governor of New Hampshire and President Bush's Past Chief of Staff (1989-1992), John H. Sununu, a mechanical engineer, are often driven into politics to "fix things" for the public good. Sununu delivered a talk at Purdue University in the United States entitled "The Engineer in the Public Policy Arena." In his address he indicated: [384]

> *People don't think of engineers as being actively involved in public policy, but I think there is a great need for people with the quantitative skills and the problem-solving understanding that engineers have to be much more visible, active and involved," Sununu said. "Public policy is getting more and more dependent on technology."…"Nobody ever expects a mechanical engineer to end up as governor or chief of staff to the president of the United States," Sununu said. "I think my background served me well in government, and I try to encourage some of the young engineers who might be listening to be a little bit more interested in taking that route. I understand there is only one real engineer in the U.S. Senate, and it happens to be my son.*

In addition, Richard G. Weingardt, P.E., President, American Consulting Engineers Council (1995) indicated: [385]

> *Engineers cannot afford to sit on the sidelines while others shape our physical environment and public policy. By virtue of our training and experience, we're well qualified to apply innovative problem-solving skills in the public arena. Getting involved in government enables us to take the lead in addressing critical quality-of-life issues facing American communities: crumbling infrastructure, environmental and economic decline, public transportation, hazardous waste, and crime.*

Even if an engineer chooses not to run for political office, one of the key activities that engineers can do is to communicate with their respective lawmakers in their respective countries, no matter whether the engineer wishes to personally become active in the political arena. Professional organizations such as IEEE have developed guidelines to assist engineers in how to communicate with their respective lawmaker:[386]

- *Identify clearly the issue in which you are interested. Be sure to include the House or Senate bill number if addressing specific legislative proposals.*
- *State briefly why you're concerned about the issue. Your personal experience will lend supporting evidence. Explain how you think the issue will affect your business, profession, community, or family.*
- *Explain how your issue or concern affects the Congressman's constituents and how you think those constituents will benefit from your position.*
- *If you want your Congressman to take action on your behalf, clearly (but politely) ask for this action. Don't expect Members of Congress to know exactly how to solve the problem, and don't expect them to read between the lines to discern what you want done.*

- *If you have an idea you'd like to see turned into legislation, suggest this initiative to your Congressman. Volunteer your services as an information resource or researcher on the subject.*
- *If your issue has been discussed in newspapers or magazines, be sure to include copies with your correspondence. If the issue hasn't been included in the news media, it might be useful to attract the interest of the press first.*
- *Restrict yourself to one topic in a letter or other communication. Concentrate your arguments; summarize them and make your recommendations on one page.*
- *Use your own words and avoid technical terms. Also avoid using trite phrases or clichés, which can make your correspondence sound mass-produced. When Members of Congress receive many letters with nearly identical wording, they may discount them as being part of an organized pressure campaign. This method works only when mail is so voluminous that it has to be weighed. Personalized, individual letters often work best.*
- *Communicate at any time, but especially when legislation is being considered by Congressional committees or subcommittees, before it reaches the House or Senate floor. Your communication will mean more when attention is currently focused on the subject matter of your concern.*
- *Find out the committees and subcommittees on which your Congressman or Senators serve. They have more influence over legislation in these jurisdictions.*
- *Present the best arguments in favor of your position and ask for their consideration. You may find it useful to review arguments against your position and show why your position is preferred over others.*
- *Communicate with Members of Congress as a constituent, not as a self-appointed neighborhood, community, or industry spokesperson. However, if you are truly representing a particular group, mention it.*
- *If Senators or Representatives have supported your cause or idea in previous legislation, let them know you appreciate their past leadership on the issue and that such support is applauded by their constituents.*

In addition to engineers being involved, either as politicians or aiding politicians with information vital to making decisions that affect the public health, safety and welfare; engineering education has to revise its curriculum to highlight the importance of public policy within the engineering profession. Engineering education has moved to a purely technical viewpoint versus concentrating on the very elements that are also essential to providing the engineer the necessary tools required to become leaders-both in business and in politics. Engineering education needs to include courses that include discussions on how politics influence the engineering profession. Professors need to integrate contemporary problems, global issues and world politicians into the technical curriculum. This will ensure at a basic level that engineering graduates have a basic grasp of public policy issues and that politics is an acceptable career choice for engineers. Political involvement will allow engineers to directly enhance the public welfare, the environment and the society through their specialized knowledge and skills.

7 ENGINEERS IN PUBLIC POLICY IN JAPAN

While many leading consulting engineers agree that knowledge about public policy and involvement in it are absolutely important for Japanese Consulting Engineers, unfortunately most Japanese Consulting Engineers do not have it nor want to currently do so. Approximately only 10 engineers hold positions at National Levels in Japan. The position of Administrative Vice-Minister or Directors of MLIT have been engineers, however, under Japanese law, if the position of Administrative Vice-Minister is occupied for 1 term of 2 years, the next one will be selected from non-engineers. There are currently only 2-3 engineers in the Upper House. If the number increased, consulting engineers could be viewed as a widely recognized indispensable player in the construction market delivery process and a lobbyist for engineering issues.

It is becoming increasingly important for Japanese Consulting Engineers to have knowledge of public policy, not only for the consultants, but for the entire project team. Most of the public works are for the public good and as noted previously, the role of the engineer is to protect the public health, safety and welfare of the public. As the Public Involvement (PI) process increases for public works projects in Japan, it is essential that the Japanese Consulting Engineer play a vital role in this process. Japanese Consulting Engineers can efficiently and effectively contribute to the study and review of projects from the beginning stages to the final stage and satisfy the public policy makers. The Japanese Consulting Engineer is ideally suited for this role; especially since the consulting engineer can be in an independent position and take a neutral viewpoint which is important in the public policy decision process. There are current movements in the direction to more involve the Japanese Consulting Engineer in the public policy process. For instance, the Engineering and Consulting Firms Association (ECFA) attempted to be involved in the process to decide the new ODA policy. Many consulting firms expressed strong objections against the draft of the Fair Trade Law which increased the fine on “dango” to almost 10 times that if the existing law. However, the current Japanese Consulting Engineer does not possess enough experience to participate in this process nor has the knowledge currently to do so. In order to change, engineering education is going to need to be reformed.[387]

8 CONCLUSION

Policymakers and the public benefit from an understanding and appreciation for the value of the engineer. Thus, engineers have an obligation to participate in public policy and public awareness. To maximize engineers' effectiveness in public policy and public awareness, engineering societies should work together and leverage their resource through close association. The engineering societies globally, on behalf of their members, should be the advocates of the engineering profession's common viewpoints on issues important to their respective nation and the profession. The engineering societies can contribute effectively in shaping public policy and public awareness by providing a forum for team building and liaison, sharing information through collection, analyzing, and disseminating, and coming to a consensus on issues. When taking action the engineering organizations should speak with a unified voice and cooperate in their respective activities and with their resources.[388]

Life will continue without engineering leadership if we let it. However, the results from the current process will most likely not be desirable for engineers or for the public. Key engineering leadership positions will continue to be filled by other professionals, despite their lack of understanding of the engineering issues. If engineers turn their backs to the public policy process, engineers stand to put their own profession in jeopardy. As is true with most areas in our lives that require change, change can only come about from those who are wiling to stand up and be heard. Engineers must take a more active role in the legislative process to ensure that legislation is enacted that is truly in the interest of protecting the public health safety and welfare.

Finally, engineering education must be reformed to provide courses in the engineering curriculum that describe reasons why engineers must be involved in public policy, the benefits to the public, and the process by which engineers can get involved and the different options that involvement may take.

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[372] http://www.wa.engineersaustralia.org.au/about_us/strategic_plan.shtml
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[374] American Society of Civil Engineers, Code of Ethics, adopted September 2, 1914 and amended November 10, 1996.
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[386] http://www.ieeeusa.org/policy/guide/basics.html

[387] Observations were taken from the author's survey of Japanese Consulting Engineers performed in 2004. See **Appendix A** for a list of survey questions.

[388] http://www.csae-scgr.ca/Perspectives/Summer01/English231-04.pdf

X. PROJECT MANAGEMENT[389]

1 INTRODUCTION

Project management is an essential element that must be incorporated into the engineering curriculum. Not a task, activity or project is conceived or executed without objective of schedule, cost and quality. Managing projects also requires knowledge about dealing with people, work scope, organizational options, communication and risk management. However, project management is not a subject that has been incorporated into the engineering curriculum. It has really been up to the individual engineer as to whether or not they pursue project management, either through advance education, individual self training, and/or on-the-job training. Since project management is lacking in the engineering curriculum, and this training has been inconsistent, project management has been viewed differently in different parts of the world. For example, designers and constructors in Japan have traditionally designed and constructed projects in a different manner than that of their counterparts in the United States and Europe. These differences have centered on management and operation methods and have primarily been based upon Asian values, which from a cultural perspective are quite a contrast to the values perceived to be important in the West.

However, the modern image of "Asia" is a blend of cultures and has had Western influence in its making. This is not to say that traditional Japanese values do not have a place in this new "Asia" nor is it to say that there is not common ground between Japan and the United States and Europe in its application of project management.

A book entitled *The Principles of Construction Management*, authored by Masahiko Kunishima and Mikio Shoji was published in Japan in the mid 1990s. Despite perceptions that Japanese have difficulty working outside Japan due to "cultural" differences and that Western companies have similar difficulties working in Japan or Asia, close review of this book and PMI's PMBOK clearly demonstrates that although individuals may have different personalities which may, in turn, strongly influence certain actions taken in the course of a project, the basic philosophies and principles towards project management are very similar. Thus, this chapter summarizes the key principles and requirements for successful projects, resulting in the "harmonization" of Japanese and International project management.

2 CULTURAL PERSPECTIVES

In understanding the dilemma faced by the Japanese Consulting Engineer in his/her effectiveness to compete in a global market, it is important to understand the differences of the Japanese management system with other systems in the international construction market as well as the cultural differences in Japan as compared to the rest of the world, which contribute heavily to whether the Japanese Consulting Engineer can truly be effective or competitive outside of Japan and/or to foreign competition that will enter the Japanese market as demanded by WTO.

The difficulty that faces Japanese Consulting Engineers is with respect to the ability to use management systems and to understand the importance of project management in order to be competitive in a global marketplace. The management systems and structures in the international arena are quite different from those in Japan where a 2-party system (see Chapter II on The Consulting Engineer) is used in the construction industry. This combined with the major cultural differences and the basis of "mutual trust" versus "mutual mistrust" thus creates the major reason why Japanese Consulting Engineers are not competitive and cannot be effective or competitive in the international market place unless there are some immediate changes to how Japan looks at the way it conducts business and immediately changes its engineering education to include the teachings of project management.

The understanding of the concept of "mutual trust" and "mutual mistrust" is critical to the success of the Japanese Consulting Engineer. To be successful in an environment of "mutual mistrust" requires the Japanese Consulting Engineer to be trained in project management and especially a culture of contract management. The 1994, Kunishima and Shoji book on project management, the authors compared the construction management practices inherent in Japan with those found in the United States and Germany.[390] Nielsen, in his doctoral dissertation on the proposed Japanese standard form of construction contract for civil works noted that in the comparison, there was little difference in the manner in which construction technology is used to complete construction projects in the three nations. They suggested that the manner in which the projects were accomplished was quite different. This difference was identified as the management techniques that were employed. The authors attributed the difference to values based on uniquely Asian values for Japan and for the United States and Germany.[391] As noted by Nielsen, this initial book that was published in Japan followed an early 1990 report by the

JSCE President, Kiyoshi Horikawa, in the Volume 29 of the *JSCE Journal* entitled "JSCE Activities in the International Era." Dr. Horikawa said:

> *…international competitiveness is now a serious concern for Japanese enterprises in order to compete fairly with others inside and outside Japan. It is needless to say that the construction system in Japan has evolved to the present style through a long history of custom and tradition in order to accomplish the highly qualified construction of various civil engineering structures. However, the present ways and systems in Japan seem to be a different from those of other countries, particularly in Europe and the U.S.A. That is why Japanese contractors have experienced bitter difficulties caused by the cultural differences between Japan and client countries. Since we have to open various markets including the construction market in the near future, we should adjust ourselves to these new circumstances. Even in such circumstance we should maintain a dauntless attitude, and we should stay pliable in order to adjust ourselves to different views. In order to reach our ideal circumstances, all of the people have to be well grounded in culture and to respect each other. We should thoroughly investigate the way of thinking and the mode of carrying out work in other countries, and then clearly distinguish the differences among us. Based on the above investigations, we should increasingly devote our effort to let the counterparts in negotiation understand our thinking.*

However, since the early 1990s, the Japanese civil works infrastructure construction market has severely contracted and it is not expected to ever grow again to it former size.

As stated in Kunishima and Shoji's book on *The Principles of Construction Management*, construction management can reasonably be understood to be classified into three steps:

> *The first step is the choice of fundamental technologies regarding analytical techniques for analyzing productivity and efficiency in terms of time and cost; the second one is the choice of practical procedures, in which rules for smoothly and safely directing or leading actual work, such as design and construction, organizations, and management techniques, become important; the third one is deciding how to judge whether the process of construction project implementation is fair and just, contributes to the public welfare, and provides the client and investors with interest and benefits based on social systems, common sense, ethics, and other criteria.*

Although the three steps are addressed in three separate volumes, with the first step only addressed in the book quoted, the steps identified in the Japanese framework for project management do not differ from those steps taken in American project management.

However, as summarized in this text, the causes of differences in construction management between the United States and Japan can be summarized as follows:

(1) Different climatic conditions and cultural environments,
(2) Different national characteristics,
(3) Different social values,
(4) Different religions,
(5) Different common practices (holidays, greetings, eating habits, gift-giving, rewards, sickness, injuries, etc.,
(6) Different work efficiencies and level of worker education,
(7) Different knowledge of construction methods,
(8) Different knowledge of construction equipment,
(9) Different knowledge of raw materials,
(10) Different civil engineering abilities and resources.

The Japanese text lists the following as “good” values as perceived in Japan and the U.S. respectively:

TABLE X-1

Japan	United States
Harmony	Competition
Equality	Fairness
Safety	Justice
Team Work	Self-assertion
Diligence	Individual Desires
The Rule of Right	The Rule of Might
Morality	The American Dream
Humanity	Profit (money-making)
Justice	
Obedience	
Benevolence	
Righteousness	
Loyalty	
Thrift	

The Japanese text goes further to categorize the differences in the organizational traits between Japan and the United States:[392]

TABLE X-2 ORGANIZATIONAL TRAIT OF EACH OF THE TWO NATIONS			
Items	**Japan**	**...**	**USA**
Objectives of enterprise	Permanent existence	...	Profitability
Basic principles	Impartial (fair) sharing	...	Fair competition
Characteristically features	Harmony	...	Self-assertion
Business style	Long-term credible relationships	...	Short-term competitive relationships
Working condition	Teamwork	...	Individual
Employment form	Lifetime employment	...	Improvement of position by changing jobs
Employment attitude	Employing persons	...	Employing the functions of persons
Principles of behavior	Attend, learn, and labor	...	Participation in education and manifestation
Wage system	Seniority and achievement	...	Ability and achievement
Assessment of business achievement	Contracts awarded and long-range profits	...	Short-range profit
Enterprise's changes	Slow	...	Rapid
Decision-making process	Bottom-up and mutual-agreement	...	Top-down and individual direction
Working environment	Large, shared offices	...	Booths
Loyalty to organization	Great	...	Little
Competition within organization	Avoid	...	Open
Perception of work	Life	...	Responsibility
Selection criterion tendency	Results-oriented	...	Ideas, philosophy, and processes
Human resources	Fixed assets	...	Floating assets
Reward	Small (bonuses, promotions, and salary)	...	Big

TABLE X-2 ORGANIZATIONAL TRAIT OF EACH OF THE TWO NATIONS			
Items	**Japan**	**...**	**USA**
Punishment	Relocation	...	Dismissal
In-house education	Systematic and seriously taken	...	Considered little, self-enlightenment
Salary difference	Small	...	Big

However, despite the cultural differences as noted above, the practices and procedures by which projects should be managed are really not different and/or should not be different, no matter where in the world the project is located.

The basic goal of the construction contractor is exactly the same in both Japan and the international world:

> *To complete the Project on schedule according to the contract executed with the Employer in accordance with the design drawings and specifications.*

Again, even as stated within this Japanese project management text, contractors are profit-making companies with the goal to obtain as much contracted money as possible from the employer at the earliest possible time and to pay subcontractors as little as possible for what they do at the latest possible time.

However, the employer's and engineer's goals are similar to that of the contractor, and that is to complete the project on schedule and within budget.

To illustrate that North American and European project management is more comparable today than it was even then, Nielsen prepared a table which he updated form the one that Kunishima and Shoji used in 1994. Nielsen indicates that the data on which it was based originally was a compilation of Japanese project management practices that had been compiled by JSCE's Construction Management Committee. The Committee had been formed formally in 1985. The 2005 update is based on Nielsen interviews executives of companies who set the standard for global practice or are Japanese contractors involved in the global market as well as the domestic market for civil works infrastructure construction.[393] [394]

TABLE X-3 CULTURAL DIFFERENCES IN EUROPE, THE U.S., AND JAPAN THAT IMPACT PROJECT MANAGEMENT					
CULTURAL TRAIT	**GERMANY (1990)**	**EUROPE (2005)**	**U.S. (1990)**	**U.S. (2005)**	**JAPAN**
Objectives for business entity	Continuity and social values	Continuity, social values, and profitability	Profitability	Continuity, social values, and profitability	Permanent existence
Basic business principles	Fair competition	Fair competition	Fair competition	Fair competition	Impartial (fair) sharing
Characteristic Features	Reliability	Reliability	Self-assertion	Self-assertion	Harmony
Business style	Client first policy	Client first policy	Short-term competitive relationships with long term focus	Short-term competitive relationships with long term focus	Long-term credible relationships
Working condition	Individual	Individual often within a team	Individual often within a team	Individual often within a team	Teamwork
Employment form	Improvement of position by changing jobs	Improvement of position by changing jobs	Improvement of position by changing jobs	Improvement of position by changing jobs	Mostly lifetime employment
Employment attitude	Employing individual	Employing individual's skills	Employing the individual's skills	Employing the individual's skills	Employing individual
Principles of behavior	Participate, create, and work skills	Participate, create, and work skills	Participate in education and manifestation of skill	Participate in education and manifestation of skill	Attend, learn, and labor
Wage system	Ability, achievement, and rank	Ability, achievement, and rank	Ability and achievement	Ability and achievement	Seniority and achievement
Measure of business achievement	Short-range profit	Short-range profit	Short-range profit	Short-range profit	Contracts awarded and long-range profits

TABLE X-3 CULTURAL DIFFERENCES IN EUROPE, THE U.S., AND JAPAN THAT IMPACT PROJECT MANAGEMENT					
CULTURAL TRAIT	**GERMANY (1990)**	**EUROPE (2005)**	**U.S. (1990)**	**U.S. (2005)**	**JAPAN**
Changes to business entity	Slow	Moderately Rapid	Rapid	Rapid	Slow
Decision-making process	Discussions between superiors and subordinates	Moving from top-down to flat team	Moving from top-down to flat team	Moving from top-down to flat team	Bottom-up and mutual-agreement
Working environment	Individual Offices	Individual offices and spaces	Individual offices and spaces	Individual offices and spaces	Large, shared offices
Loyalty to organization	Medium	Medium to Little	Little	Little	Great
Competition with organization	Avoid	Increasing	Broad	Broad	Avoid
Relations between colleagues	Friendship	Individual with movement to task teams	Individual with movement to task teams	Individual in association with task teams	Sense of commonness
Perception of work	Responsibility	Responsibility	Responsibility	Responsibility	Lifetime Employment with a movement to forcing early retirement
Decision criteria tendency	Results-oriented	Results-oriented with recent process orientation	Ideas, philosophy, and processes		Results-oriented
Human resources	Long-range assets	Long-range assets	Floating assets	Floating assets	Fixed assets
Reward	Big	Big	Big	Big	Small (bonuses, promotions, and salary)

TABLE X-3 CULTURAL DIFFERENCES IN EUROPE, THE U.S., AND JAPAN THAT IMPACT PROJECT MANAGEMENT					
CULTURAL TRAIT	**GERMANY (1990)**	**EUROPE (2005)**	**U.S. (1990)**	**U.S. (2005)**	**JAPAN**
Punishment	Relocation or dismissal	Relocation or dismissal	Dismissal	Dismissal	Relocation
In-house education	Permanent	Moving toward self-education, PMI or other certification	Considered little, self-enlightenment promoted	Continuing self-education, PMI certification	Systematic and seriously taken
Salary difference	Medium	Medium	Big	Big	Small

Nielsen explains in his dissertation that Europe and America have become even closer in the current cultural basis that underlies project management. Japan has pursued a process of making cosmetic changes and explaining why their culture, and thus project management, is different. But, as Dr. Horikawa said, even those Japanese companies that have led the way in the global market "*have experienced bitter difficulties caused by the cultural differences between Japan and client countries.*" The Japanese Consulting Engineer cannot withstand foreign competition nor can they afford not to be competitive on the world market. Both the Japanese owner (the government) and the Japanese Consulting Engineer will have to learn the global style contract administration and allow the development of soundly based project management to create the ability to compete. As noted by Nielsen, merely asserting that the style of contracting is in essence different based on code provides little in terms of capacity building to handle civil works infrastructure construction projects.

With respect to project management development, Nielsen's research in this area shows that the characteristics of personnel executing the works for the Japanese is based on collective group mentality and not making a decision unless it has been blessed by the group or at least a decision that is not against the group consensus. This process is again consistent with the Construction Business Law and related laws as embodied and by the cultural and social background of the Japanese people. As has been discussed in previous chapters, traditional Japanese social norms emphasize harmonious interpersonal relationships and group solidarity. Interpersonal and group conflict can be found in many forms in Japan, but great emphasis is placed on the sacrifice of personal needs and individual self expression to avoid confrontation with the group. Within a group, maintenance of harmonious and smooth interpersonal relations and interdependence, that is, “mutual trust,” are of utmost importance. The more a group emphasizes in-group harmony and solidarity, the more intense that out of group enmity can be. Japanese are taught to accept such tensions and feelings of frustration as a natural consequence of social life, although they may not openly acknowledge the fact.[395] Thus, based on the 2-party system that has existed in Japan, the contracting structure and the cultural dependence on “mutual trust”, there has been no need up to this point in time to develop management or project management skills. These skills simply have not been necessary to provide project management for construction under the Construction Business Law and the Japanese Standard Conditions of Contract for Public Works as they stand today.

Thus, as concluded by Nielsen in his research, the Japanese Civil Works Infrastructure Construction Industry is not prepared and cannot survive in a market that is open to competition, yet continues to operate and function as it has for so many years. The government walks a thin line in committing the country to a period of structural change and dealing with the massive debt the country has accumulated. This change is being accomplished at the same time Japan is also dealing with demographic changes. The government at the highest levels has committed Japan to change. While the changes must be made, the government has left the domestic civil works infrastructure construction Industry in an unenviable position. It has to open the domestic market to those contractors that are accustomed to the global civil works infrastructure construction market.[396] If the Japanese construction market is to survive and the Japanese Consulting Engineer competitive and effective both on the domestic as well as the global market, immediate changes have to be made in both education and practice of project management and the necessary skill sets that are discussed within my dissertation.

3 PROJECT MANAGEMENT – IN GENERAL

With the goal of completing a project on schedule and within budget, it is extremely important to ensure that the project is well defined, planned, managed, and executed in order to assure the maximum profit at the project completion for the contractor and to receive the expected product at the expected price for the employer. Virtually all projects are planned and implemented in a social, economic, and environmental context, and have intended and unintended positive and/or negative impacts. The project team has to consider the project in its cultural, social, global, political, and physical environmental contexts. To do so requires general management knowledge and skills. These skills provide the foundation for building project management and include:[397]

- Financial management and accounting
- Purchasing and procurement
- Sales and marketing
- Contracts and commercial law
- Manufacturing and distribution
- Logistics and supply chain
- Strategic planning, tactical planning, and operational planning
- Organizational structures, organizational behavior, personnel administration, compensation, benefits and career paths
- Health and Safety practices
- Information technology.

In addition to the general management skills, for effective project management, it is essential for the consulting engineer to have interpersonal skills including:

- Effective Communication Skills
- Organizational Influence
- Leadership
- Motivation
- Negotiation and Conflict Management
- Problem Solving

One important aspect, however, to accomplish these goals is to retain the appropriate personnel whose skills:[398]

> *… include an understanding of the importance of historical background, culture, and customs in each nation or region.*

The difficulty with the teaching of precise techniques and project management steps is that projects involve doing something which has not been done before and, therefore, makes each "unique." Because each project is unique, the characteristics that distinguish the service must be progressively elaborated or proceed in steps. These steps must be carefully coordinated with proper project scope definition — according to the contract under which the effort has been authorized to proceed. The execution of these steps involves project management which is the:[399]

> *... the application of knowledge, skills, tools, and techniques to project activities in order to meet or exceed stakeholder needs and expectations from a project....*

Project management consists of nine knowledge areas. If understood and used in conjunction with one another, these nine areas provide a basic structure for understanding project management and, thus, enabling a company to maximize monetary return — whether it is to the contractor or to the employer. These nine areas consist of:

- Project Integration Management
- Project Scope Management
- Project Time Management
- Project Cost Management
- Project Quality Management
- Project Human Resource Management
- Project Communications Management
- Project Risk Management
- Project Procurement Management

This dissertation has highlighted the importance of communications and risk management is other chapters. While project management should be incorporated into the engineering curriculum in a general understanding of all nine elements, more detailed focus is required in not only communication and risk management, but also with respect to schedule, cost and quality. The reason communication and risk management are discussed outside of project management, is that both have a much broader reach within all tasks and activities undertaken by engineers which do not necessarily focus on a particular project. However, within the area if project management, the three essential elements for which the consulting engineer must be completely knowledgeable, are schedule, cost and quality. If these three key elements are not performed, the project or activity could be seriously jeopardized. Thus, these three elements will be the key aspects discussed in this Chapter on Project Management.

4 THE PROJECT MANAGER

In conjunction with the nine fundamental areas of project management, experience has shown that the company's Project Manager, whether it is for the employer, the designer (engineer), or for the contractor, must possess some general management skills to ensure the project runs smoothly. These general management skills include:

- Leading
- Communicating
- Negotiating
- Problem solving
- Influencing the organization

In addition, the Project Manager must also understand the socio-economic influences, such as, standards and regulations, internationalization, and cultural influences. Together, the understanding of these three elements provides a formula for success, despite the specific aims and methods a party chooses, which vary widely, as experience shows.

The Project Manager must ensure he/she has the correct project team or organization established to properly plan and execute the project to, again, ensure the basic goals are accomplished. Although this paper cannot address each of the nine fundamental areas of project management in detail, critical to the project success will be the Project Manager's ability to ensure each of the nine elements are in place and functioning well. With the proper organization in place, human resources management, effective communications and integration throughout the organization must be continually monitored as breakdowns in communication often lead to barriers in achieving project goals. Further, risks to the project goals often occur at project interface points and, if not watched carefully, can also jeopardize project goals.

These three issues, human resource management, communications management, and integration management need to be established at the onset of the project and continually monitored throughout the project, making adjustments as necessary along the way.

Despite whether a project is being designed or constructed by either a Japanese or American company, the first step which must be conducted relative to project management at the onset of a project is to develop a Project Plan. The core planning process may be iterated several times during any phase of a project and includes:[400]

- *Scope Planning...developing a written scope statement as the basis for future project decisions.*
- *Scope Definition...subdividing the major project deliverables into smaller, more manageable components.*
- *Activity Definition...identifying the specific activities that must be performed to produce the various project deliverables.*
- *Activity Sequencing...identifying and documenting interactivity dependencies.*
- *Activity Duration Estimating...estimating the number of work periods which will be needed to complete individual activities.*
- *Schedule Development...analyzing activity sequences, activity durations, and resource requirements to create the project schedule.*
- *Resource Planning...determining what resources (people, equipment, materials) and what quantities of each should be used to perform project activities.*
- *Cost Estimating...developing an approximation (estimate) of the costs of the resources needed to complete project activities.*
- *Cost Budgeting...allocating the overall cost estimate to individual work items.*
- *Project Plan Development...taking the results of other planning processes and putting them into a consistent, coherent document.*

In addition to the core process within the Planning Process are the Facilitating Processes which include interactions among the other planning processes which are more dependent on the nature of the project. Although the Facilitating Processes are performed intermittently and as needed during project planning, they are not optional and include:[401]

- *Quality Planning...identifying which quality standards are relevant to the project and determining how to satisfy them.*
- *Organizational Planning...identifying, documenting, and assigning project roles, responsibilities, and reporting relationships.*
- *Staff Acquisition...getting the human resources needed assigned to and working on the project.*
- *Communications Planning...determining the information and communications needs of the stakeholders; who needs what information, when will they need it, and how will it be given to them.*
- *Risk Identification...determining which risks are likely to affect the project and documenting the characteristics of each.*
- *Risk Quantification...evaluating risks and risk interactions to assess the range of possible project outcomes.*
- *Risk Response Development...defining enhancement steps for opportunities and responses to threats.*

- *Procurement Planning...determining what to procure and when.*
- *Solicitation Planning...documenting product requirements and identifying potential sources.*

Once the Planning Process has been completed, the Execution Processes take place, again including Core Processes and Facilitating Processes. Within the Execution Process, it is important to consider the following:[402]

- *Project Plan Execution...carrying out the project plan by performing the activities included therein.*
- *Scope Verification...formalizing acceptance of the project scope.*
- *Quality Assurance...evaluating overall project performance on a regular basis to provide confidence that the project will satisfy the relevant quality standards.*
- *Team Development...developing individual and group skills to enhance project performance.*
- *Information Distribution...making needed information available to project stakeholders in a timely manner.*
- *Solicitation...obtaining quotations, bids, offers, or proposals as appropriate.*
- *Source Selection...choosing from among potential sellers.*
- *Contract Administration...managing the relationship with the seller.*

5 PROJECT EXECUTION

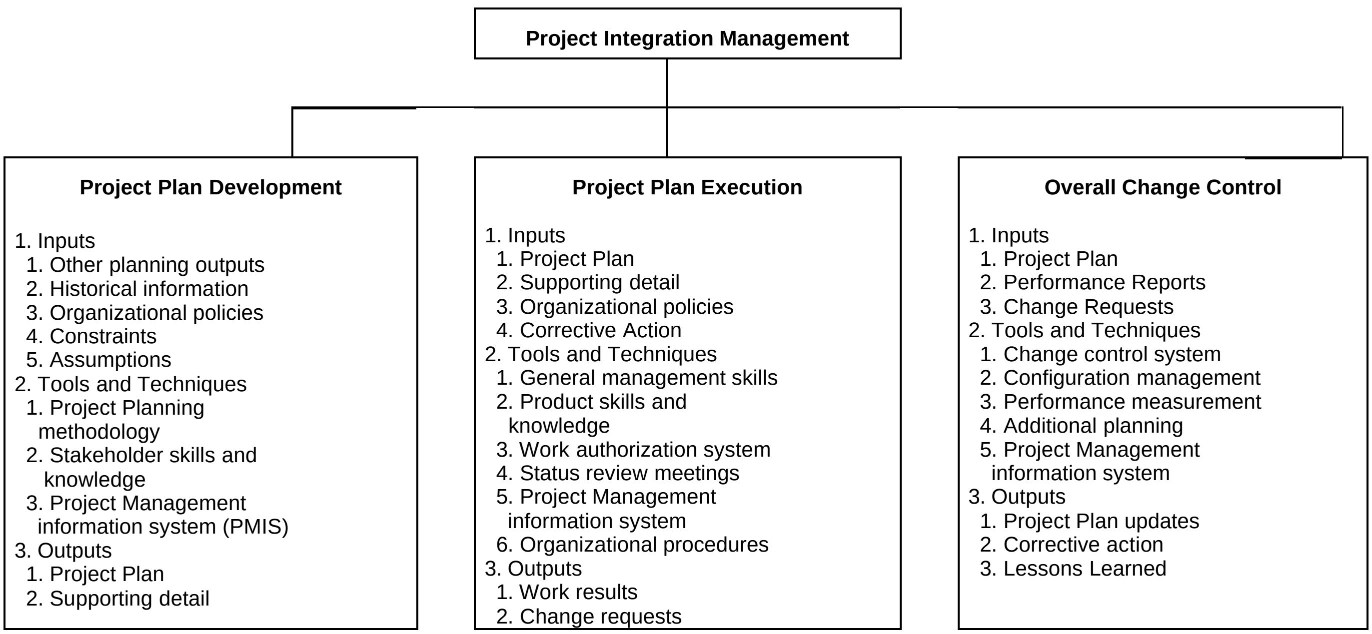
Within the Execution Process, it is important to consider the following:[403]

- *Overall Change Control...coordinating changes across the entire project.*
- *Scope Change Control...controlling changes to project scope.*
- *Schedule Control...controlling changes to the project schedule.*
- *Cost Control...controlling changes to the project budget.*
- *Quality Control...monitoring specific project results to determine if they comply with relevant quality standards and identifying ways to eliminate causes of unsatisfactory performance.*
- *Performance Reporting...collecting and disseminating performance information. This includes status reporting, progress measurement, and forecasting.*
- *Risk Response Control...responding to changes in risk over the course of the project.*

However, once a project is underway, in no way has the project management effort been completed. In fact, this is why so many projects become “troubled projects;” because despite the detailed and well-thought out initial planning that was done; no consideration was given as to how the project would be controlled. Project performance must be measured regularly to identify variances from the plan. Variances are fed into the control processes in the various knowledge areas. To the extent significant variances are observed, adjustments are made to the plan. Controlling a project also includes taking preventive action in anticipation of possible problems.

Figure X-1 illustrates how the following processes interact:[404]

FIGURE X-1: PROJECT INTEGRATION MANAGEMENT OVERVIEW



The above process is very similar to the process described in the Japanese text on *The Principles of Construction Management.* As stated within this text:

> *Pivotal to the whole working procedure is the selection of construction methods and the preparation of schedules.*

This definition goes hand-in-hand with PMI's description of tools and techniques for Project Plan development.

6 FACTORS AFFECTING PROJECT CONTROL

Project Planning methodology can range from simple standard forms and templates to complex computerized systems involving simulations of risk assessment. However, no matter what methodology is employed, it is critical that the Project Manager has the skills and knowledge to develop the Project Plan. Decisions must be made relative to how manpower, materials, money, equipment, and information will be planned, executed, and monitored. These elements translate into three primary factors which must be kept under control during Project Execution:

- Schedule,
- Quality, and
- Cost.

6.1 Schedule

Planning involves scheduling the required work into an orderly sequence of activities that can be used as a tool throughout the project to monitor and control the work. Changes to the schedule have the potential to delay the project and to increase costs, both defeating the desired goals of all the parties concerned. The work results obtained from the execution process are collected and fed into the performance reporting process. During this process, it is not uncommon for changes to occur which expand or contract project scope but do modify two of the key factors which must be controlled, the cost and schedule. As these changes are most often identified while the project is being executed, it is important for the Project Manager to be familiar with overall change control. As stated by PMI:[405]

> *Overall change control is concerned with (a) influencing the factors which create changes to ensure that changes are beneficial, (b) determining that a change has occurred, and (c) managing the actual changes when and as they occur. Overall change control requires:*
>
> - *Maintaining the integrity of the performance measurement baselines — all approved changes should be reflected in the project plan, but only project scope changes will affect the performance measurement baselines.*
> - *Ensuring that changes to the product scope are reflected in the definition of the project scope...*
> - *Coordinating changes across knowledge areas....For example, a proposed schedule change will often affect cost, risk, quality, and staffing.*

The contract under which the parties are working will normally include provisions as they relate to changes typically being:

- Changes in conditions,
- Changes or suspensions of work,
- Changes in the construction period,
- Fluctuations in wages, salaries, or commodity prices, and
- Damages due to force majeure.

In monitoring the changes, the Project Manager will use the Project Plan as a baseline to evaluate changes, performance reports which will provide information on project performance, and changes requests which could be oral or written. The tools and techniques which a Project Manager uses to control changes include:

- Change control system:[406]

  A collection of formal documented procedures that define the steps by which official project documents may be changed. It includes the paperwork, tracking system, and approval levels necessary for authorizing change.

- Configuration management:[407]

  Any documented procedure used to apply technical and administrative direction and surveillance to:

  - *Identify and document the functional and physical characteristics of an item or system.*
  - *Control any changes to such characteristics.*
  - *Record and report the change and its implementation status.*
  - *Audit the items and system to verify conformance to requirements.*

- Performance measurement:

  - Such as, earned value.

- Additional planning:

  - Revision to the cost estimates, activity sequences, and schedule.

- Project Management information system.

From the systems, the Project Manager is responsible for monitoring changes and resultant impacts to the cost and schedule. Responsibility for the impacts, should they occur, must also be carefully identified with timely notice made and resultant costs due to the impacts. It is only through this process that equitable adjustments can be made.

6.1.1 Schedule Control

A schedule defines the activities to be accomplished and start and finish dates for a particular project whether that is planning, design, or construction. If developed correctly and used throughout the project, a schedule can be an effective management tool.

Usually, a contractor has little input into what scheduling method can be used as it is specified in the contract documents, the decision having been made prior to bid or negotiation. The architect/engineer or construction manager makes the determination on the following factors:

- The magnitude of the project
- Existence of project phases and the interrelationships
- The number of contractors involved on the project
- Milestone completion dates (dates established by the architect/engineer which require specific areas of work to be complete by a certain date and by which progress is measured)
- Scheduling expedience by those reviewing the schedules
- Preferences by the manager responsible for effective project monitoring
- Level of detail for activities and logic desired from the scheduling results

Scheduling is a tool for managing a construction project of any size. Schedule management not only aids the contractor, but also the subcontractors and the owner. The purpose of this chapter is to emphasize that the primary goals of scheduling are to minimize delays and to resolve disputes involving delays. The topics discussed are schedule preparation, float time, specifications, delays, dispute resolution and actual case studies.

6.1.2 Schedule Preparation

The initial schedule can either be prepared by the owner, professional construction manager (PCM), or the contractor.

6.1.2.1 Owner-Prepared Schedules

Although owner-prepared schedules are possible, several risks are involved. Implied warranties, implicit in an owner-prepared schedule despite contract disclaimers, may render the owner liable for correctness, adequacy and feasibility; force the owner to provide timely approval on submittals, owner-furnished material and equipment; and require the owner to provide effective coordination of all independent contractors on the project. An owner-prepared schedule may also suffer from lack of owner expertise concerning construction practices and sequences. Only a few owners have practical construction management capability, understand how the job is to be accomplished on a day-to-day level, or know how the contractor will proceed. These and other risks must be carefully weighed against any consequent benefits by the owner who proposes to prepare the initial project schedule.

6.1.2.2 PCM Prepared Schedule

When multiple prime contracts are involved, an owner may choose to hire a PCM firm to coordinate and manage the job. The PCM firm will prepare and monitor a coordinated schedule based on individual schedules supplied by the various primes. By assigning the coordination responsibility to a PCM firm rather than to a contractor, the owner benefits from expert assistance in schedule coordination while still maintaining a close overview of the project.

6.1.2.3 Contractor Prepared Schedule

It is practical and essential for the contractor to prepare and submit the schedule. The contractor assumes responsibility for conformance with contract commitments, planning, sequence of work, and construction means and methods. The contractor must prepare his schedule after a thorough study of the plans and specifications. A breach of contract will occur if he does not follow the required specifications. The contractor must clearly denote when a preliminary schedule is being submitted, and that it only reflects a general outline of how the job will proceed. Once an owner has approved the contractor’s schedule, it is his responsibility to perform certain contractual duties. These duties consist of approval and timely delivery of owner-furnished material and equipment in accordance with the contractor's schedule. The contractor's schedule also has implied warranties to subcontractors, such as site availability, cooperation, coordination, etc.

6.1.2.4 Subcontractor Input to Schedule Preparation

The prime contractor should involve all subcontractors in preparing and updating the schedule. Subcontractors are entitled to share the prime contractor's scheduling information. They should also receive scheduling information from the contractor with adequate time to perform their parts of the work. If a prime contractor refuses the subcontractor's reasonable durations, the subcontractor should take exception to the schedule and go on record as stating he was not in accordance with the schedule. A prime contractor should accept subcontractor input for many reasons. Input provides the best information available upon which to base the schedule. It can reduce later disputes concerning schedules versus actual performance. Input encourages an atmosphere of cooperation between the prime contractor and subcontractor.

In summary, in the best interest of the owner, the contractor must prepare the schedule for his job. In the case of multiple prime contracts, a PCM firm, if selected, can coordinate such primes for the project, thus allowing the owner to have a broad management of the project. The PCM must interface and tie the prime contractors' schedules into an overall Project Schedule.

6.1.3 CPM Development

CPM schedule development can be described as a six step process:[408]

(1) Identify the Work Breakdown Structure (WBS)
(2) Determine activity duration
(3) Establish the logic
(4) Perform schedule calculations
(5) Analyze and adjust the resources
(6) Present the results

STEP 1: THE WORK BREAKDOWN STRUCTURE (WBS)

The schedule is developed by reviewing the contract documents including the plans, specifications, contract, relevant codes, etc. and developing a listing of work items required to accomplish the work. An activity is an item of work in the project.

As part of the breakdown structure you should consider the activities that require time and cost, as well as those that you must monitor or arrange.

STEP 2: DETERMINING THE ACTIVITY DURATION

After the activity list is developed, an estimate of the time required to complete each of the activities is made. The first task is to prepare a quantity take-off from the drawings. Historical production rates are generally used to determine the time allocation for each separate activity. If historical production data is not available, industry sources can be consulted. Subcontractors can also be contracted for their estimate of the time to accomplish particular components of the work. The production rate is multiplied by the quantity take-off to determine the time, or duration for the activity.

STEP 3: ESTABLISHING THE LOGIC

After the activities have been developed the logic or order of activities can be developed. This ordering of activities defines what work needs to be in progress or complete in order for another activity to start. Typically the activity list will be arranged in the order that is must be performed to complete the project. Consideration is given to activities that precede and follow others as well as the combination of activities governing how the work will be accomplished. This process allows the logic of a CPM to be carefully developed. If activities are simply placed end to end, the project duration will be extended. If activities are overlapped too much, manpower and/or equipments peaks will result. The logic should be developed so there is a realistic flow of activities through the project.

STEP 4: CALCULATIONS

After the activities are identified, with durations and logic determined, the CPM schedule needs to be calculated to determine activity start and finish dates as well as float. The most difficult task in the use of the CPM is identifying and interfacing the numerous activities that are required to complete the project.

Float is contingency time available for completion of an activity. Total float is the difference between the activities early start date and late start date or early finish date and late finish date. By necessity and activity with a total float equal to zero is on the critical path for its project activity.[409]

The rule for the forward pass is to choose the largest number at the node. If the larger number was not used, then the activity would have to start before an activity which controlled its start was completed. The forward pass results in calculation of the early start (ES) date for an activity.

The second step in computing the schedule is to perform the backward pass. The backward pass starts at the end of the project and subtracts the duration from the last activity calculated date.

The rule for the backward pass is to use the smallest number calculated at a node. Otherwise an activity would have to complete before a precedent activity had completed. The backward pass determines the late finish (LF) time.

The late start (LS) time for an activity is calculated by subtracting the activity duration from the late finish time. The early finish (EF) time is calculated by adding the activity duration to the early start time.

- ➜ ES — Calculated by the Forward Pass
- ➜ LS — Equals LF minus Activity Duration
- ➜ EF — Equals ES plus Activity Duration
- ➜ LF — Calculated by the Backward Pass

After the forward and backward passes are completed the total float calculation is made. Total float is calculated by subtracting the early start from the early finish date or the late start from the late finish date.

The critical path is defined by the results of the forward and backward passes and total float calculation. By definition the critical path is composed of all activities whose total float equals zero.

The critical path is a continuous chain of activities which taken together require the greatest amount of time to complete in the project. No other chain of activities in the schedule requires as much time. If an activity has a total float of 1 day, it has 1 day of contingency before any delay to it will affect the project completion date. The project completion date is determined by those activities whose float is equal to zero. To illustrate, consider activity, "Final Inspections" which has 1 day of float. For each day past the early finish date the available float is reduced by one day:

TABLE X-4
ACTIVITY: "FINAL INSPECTIONS"

DAY	AVAILABLE FLOAT	COMMENT
1	1	Early Start Date
2	0[410]	Late Start Date

As illustrated above, on day 2, or 24 August, "Final Inspections" has zero float and is therefore critical. The schedule would have to be recomputed at that time and a new critical path determined. Any further delay to the start of "Inspect HVAC System" would delay the project completion date.[411]

STEP 5: ANALYZE AND ADJUST THE RESOURCES

The available resources in a project require analysis and where appropriate, adjustment. The consideration of the following resources will be considered:

(1) Time
(2) Money
(3) Material
(4) Equipment
(5) Labor

At first glance, it can appear that time is the only resource to be analyzed and adjusted in a CPM schedule. This is so because a CPM schedule organizes work activities within a continuum of time. However, the other resources of money, material, equipment, and labor all contribute to the determination of durations and the sequencing of the activities contained in the project schedule. When determining an activity's duration, the manpower, materials and equipment required must be considered. For example, when pouring concrete for our footings the number of concrete trucks, quantity per truck, time to unload per truck, room for truck stacking, and placement constraints all constrain the cubic yards of concrete that can be placed on any given day. On large commercial projects, such as construction of a power plant, the required concrete for a foundation was at times greater than the capacity of the local batch plant and available trucks and a scheduled duration was not achievable because of resource restrictions. The combination of all of the resources determine the duration for the completion of an activity.

Float represents the contingency time available for starting an activity without that activity's completion affecting the overall project completion date. The available float can be used to even out resources, minimizing sharp changes in manpower. The goals of resource leveling are to: address the "real-world" limitations of resources, minimize daily fluctuations in resources, and maintain a constant application of resources.

There are two types of resource leveling: Unlimited and Limited. Unlimited resource leveling maintains the completion date of the project and minimizes the number of resources on a daily basis. Limited resource leveling holds the resources at a constant level and determines the minimum contract duration.

Unlimited Resource Leveling

This is the most common type of resource leveling, since the completion date of a project is normally set in the construction contract and cannot be extended unilaterally. Basic tenets of unlimited leveling are:

(1) Resource rate is kept continuous throughout the activity durations
(2) Critical activities may not be leveled
(3) Free float[412] is used to set the range of shifting for each activity

There is no single correct answer to an unlimited resource leveling, since it represents the assumptions of the scheduler and also represents a feasible solution.

Limited Resource Leveling

This method holds the resources at specified levels and determines the project duration. This is generally not feasible as the contract time is usually defined in the contract documents. It is useful for performing trade-off calculations between the cost of extending the project longer because of the resource limitations, and increasing resources to complete the project earlier.

Procedure for Leveling the Schedule

After Steps 1 through 4 have been completed (work break down, durations, logic, calculations), the schedule computer program should be presented as a bar chart for ease of review. The activities should be ordered with the critical activities located on the top part of the page and the non-critical activities on the bottom half. Next, assume a maximum resource limit to serve as the test value; if the daily resource requirements are greater than the test value, leveling is required. Within the free float limits, shift as many non-critical activities as required to meet the test value limitation. If the test value is unobtainable: raise the test value, exceed the test value for that particular period of time, or reschedule. Repeat the process over the entire project duration.

STEP 6: PRESENT THE RESULTS

Typically, the easiest way to present a CPM schedule is via a time-scale logic diagram with all the schedule activities, logic and critical activities identified. The time-scale diagram allows an easy reference for placing the activities within a calendar continuum. It also allows for a line to be drawn at any date and the activities in progress at that point determined. Both early and late dates can be included. Appended to the time-scale logic diagram should be four tabular reports:

(1) Listing of activities, sorted by total float and early start
(2) Listing of activities, sorted sequentially by activity identification number
(3) Listing of successors and predecessors by activity number
(4) Listing of constraints[413] imposed on the schedule

Each listing should include: activity identification number, activity description, duration, early and late start dates, early and late finish dates, and total float.

The schedule can also be presented in the form of a bar chart to aid in visualizing the flow of work. The bar chart shows a general flow of the work from the top of the page to the bottom and from the left to the right, representing the passage of time.

6.1.4 Using the CPM during Construction

Once the CPM schedule has been developed, it then must be monitored and updated to reflect actual progress in order to be useful in managing the completion of the project. Monitoring of the CPM schedule is achieved by managing the available resources in accordance with the plan. For complex projects and highly time sensitive projects, such as an outage at a power plant, the schedule should be updated daily. On a typical construction project, the schedule should be updated every other week and more often if delays are occurring. Project specifications usually specify monthly updates to be submitted with the request for payment.

A schedule is updated by entering the actual start and completion dates for activities which have been worked on the project. If an activity has started but has not completed, an estimate of the remaining work must be accomplished. There are two ways to approach this estimate: calculate the remaining work and estimate the duration based on the production rate which has been achieved on the activity, or estimate the percent complete and multiply that by the original planned duration then subtracting that total from the original duration to determine the remaining duration. The actual start, actual finish, and remaining work for each activity are entered into the original schedule. The schedule is then recomputed. Then, if all activities have progressed according to the plan, the scheduled completion date will not change. However, if delays have occurred to the critical activities, the completion date will slip. If the total float of non-critical activities has been exceeded, a new critical path and project completion date will result. This update will show the new projected completion date for the project at the time the update was made.

A revision to the project schedule is an update with activity changes and/or logic revisions. Revisions are required when the critical path of the project has changed from the original or baseline schedule since the critical path determines the project completion date. After a revision is made, it becomes the new baseline schedule from which updates are made to in the future.

Whether the schedule is statused to reflect the actual progress or revised to represent the new work plan, additional steps should be taken for accuracy assurance. The process is similar to initial development and approval with the following added suggestions.[414]

- If logic changes were made, they should be identified so the reviewers/analyzers are aware of the changes. Logic changes normally change the critical path. Such change may accelerate the remaining work to reflect an on target status. The reasonableness of the new schedule should also be determined as if it was the original baseline schedule. This is due to the fact that from that point in time forward, the newly developed schedule will become the project baseline schedule; and, therefore, the reasonable test should be performed.
- Verify the start and completion dates, and more significantly, review the in-progress activities for accuracy of the presented status, in particular, the accuracy of the remaining duration. Most computerized software will allow for the status information to be input in either remaining duration or percent complete. If percent complete is based on physical inspection, then a reasonable estimate can be established, however, repeatedly percent complete is evaluated by the actual number of days worked on the activity compared to the original duration. This type of comparison may not yield to an accurate status. For example if a 10-day activity with 90 percent status has 5 days

remaining based on the physical inspection, then it should indicate 5 additional days remaining despite the fact that work has been in progress for 9 days. By showing 5 days remaining, the overall duration is essentially increased by 4 days that is reflecting some production delay experienced on the activity. This is perhaps the one element that is most frequently misunderstood and overlooked.

The overall goal of the schedule development and acceptance is to have a reasonable and flexible management tool to effectively and economically construct the project and to efficiently and promptly react to the dynamic nature of the construction projects. The benefits of a comprehensive review will most definitely outweigh the effort required for such an analysis. This is further amplified if the schedules are used as the means to request time extension or additional compensation.

6.1.5 Float

An important item in any schedule is float. Who owns float is a question which does not have a single answer. The two most common types of float are total float and free float.

Total float indicates how long the earliest finish time of an activity will be delayed before the project completion date is affected. Free float indicates the length of time that the earliest finish date of an activity can be delayed without delaying the early start of other activities. Float can be affected in many ways. Time can expire before the original progress rate is met. Logic changes can increase or decrease float. The updating and incorporation of actual dates to reflect history can increase or decrease float. Incorporating added activities into the schedule during updates to reflect change orders, delays etc., can revise the schedule’s float.

Float can be a very valuable asset to the contractor because it allows flexibility in scheduling and performance. Without float, all items on a schedule become critical with unlimited resources. Both are unrealistic. If a contractor considers float to be solely his, the possibility of a contract modification with the owner should be discussed. This modification would state that float belongs only to the contractor and all contractor-excusable delays should be compensated by additional contract time, even if no critical items are affected. Alternatively, if the owner insists on float ownership, a contractor can decide to extend his activity durations making all paths critical by eliminating any potential float. In this latter situation, any delay on any path will be the cause for a delay claim. A better approach would be for the owner and contractor to share float so that the schedule closely reflects the actual situation. One specification section which provides for shared float ownership states that float is not time for exclusive use of either the owner or contractor. Extensions of time for performance will be granted only to the extent that equitable time adjustments for the critical activities affected exceed the total float or slack along the paths involved.

6.1.6 Interfaces

Other items that must appear on the schedule are interfaces. Interfaces do not represent actual physical construction work, but items which are necessary for timely project completion. Some of the interfaces most commonly included in schedules are owner-purchased materials and equipment, contractor procurement, shop drawing submittals, reviews and approvals and necessary permits.

Another type of contract interface occurs on a project with multiple prime contracts. The individual schedules of the independent primes must be combined into one schedule illustrating the work interfaces of the different primes. Once this schedule has been prepared, it must be closely monitored to ensure some contractors are not delayed by other contractors.

6.1.7 Specifications

If facts regarding schedule requirements can be determined prior to bidding and are properly outlined in the specifications, it will be easy for the contractor to prepare his bid. Clear and concise specs will eliminate doubt, misunderstanding, and result in better prices. If the contractor is to prepare the schedule, an owner must be careful in specifying the method and detail of scheduling required. Sophisticated scheduling techniques can cost thousands of dollars for the contractor. Non-inclusion of this cost in his estimate or bid will cause lost profits and less than full scheduling cooperation with the professional construction manager, owner and other prime contractors.

The following issues should be addressed by the owner and the PCM when preparing specifications for scheduling.

(1) Technical terms or words are to be interpreted with their technical meaning unless context shows contrary intention.

(2) Each part of the specification will be interpreted with reference to the whole.
(3) The scheduling technique to be used and submittal timing must be stated.
(4) The party who is to prepare the schedule must be identified.
(5) Instructions must be included as to how and when the schedule will be updated.
(6) The responsibilities of the prime and subcontractors for the schedule must be identified.
(7) The scheduling of shop drawings must be addressed.
(8) Any contemplated use of the schedule to determine progress payments must be identified.
(9) The procedure for reviewing the schedule must be identified.
(10) A statement must be supplied as to whether or not time extensions will be granted for delays not affecting the critical path.
(11) If a written narrative progress report will be required, the specification must state who will prepare it, when, how and what it will say.

The scheduling requirements should be described fully and the expected performance reviewed at the pre-bid and preconstruction meetings. This will allow contractors to evaluate the scheduling detail required and accurately estimate the cost. The owner must allow sufficient time between the notice of award and notice to proceed so that the contractor can thoroughly plan his work. The owner and the contractor must ensure that all project personnel are trained in the use and application of what is required.

No matter which contracted party schedules, people preparing, reviewing, and approving the schedule must be working on and evaluating the progress of the project work.

6.1.8 Delays

The scheduling specifications must establish the ground rules for identifying, quantifying and compensating for delays. Extensions of time to the Contract completion date must only be granted for delays to activities on the critical path during the delay period. Delay to non-critical activities may be compensated by demonstrating damage, but will not be granted a time extension.

Excusable delay must be defined in the General Conditions and is normally awarded for Force Majeure – acts beyond the control of and unanticipated by either party. Under such circumstances, both parties suffer the time delay, and neither is compensated for damages resulting there from.

Where a delay is the result of an owner or owner-responsible action (such as by a parallel prime contractor, or by an agent), the contractor is entitled to an extension and delay damages if the delayed activity is critical.

Delay damages include the costs of extended General Conditions, home office overhead, as well as increases in direct costs (labor and material), lost profits from lost business opportunity, etc.

6.1.9 Trained Personnel

The combination of a delay or disruption to the planned sequence of work and the requirement that the extent of delay be established through the use of the CPM schedule necessitates the early involvement of a scheduling expert.

Unexpected surface and subsurface water problems require a hydrologist. Problems of rock and soil conditions need the services of a soils engineer or geologist. These experts are widely accepted and utilized when problems are encountered during construction of a project. The same logic and necessity dictate that a scheduling expert be utilized when the project is affected by delays, disruption, and interferences to the planned sequence of work.

A scheduling expert must be able to assist project personnel in day-to-day records of work in progress. The expert must devise codes for computer sorting relating to network activities and produce an as-built schedule, he must provide guidance, and advise on what action should be taken to minimize the cost impact of delays, disruptions, and similar interferences to the performance of the work. The expert's responsibilities also include a time impact analysis and serving as an expert witness if arbitration or litigation becomes necessary.

6.1.10 Documentation

A schedule is only a tool which is used during a project, and documentation must be kept to support it. Original and updated schedules are critical to ascertaining the construction history of the project in the future. Therefore, the scheduler must keep copies of all schedules and updates furnished. An appropriate notation must be included concerning the date received, from whom and by whom, and any accompanying instructions. In addition to schedules, other documentation which must be retained includes correspondence between the owner and contractor, contractors' detailed estimate and cost records, job photographs, change order files, shop drawing logs, contract documents daily reports, visitors, meeting minutes, progress payments, etc.

6.1.11 Time-Impact Analysis

As each change order, interference, strike, act of God, claim, delay, or any unusual influence occurs; a time-impact analysis must be conducted to document the effect on the project schedule. The time-impact analysis is a disciplined approach for demonstrating effects of delays and produces positive results. An up-to-date network is essential to aid in determining the impact of the delay. The responsibility for delay is best determined by high schedule visibility. It must be combined with the determination of delay impact at the time the delays are identified.

When a change or delay is incurred, the person conducting the time impact analysis must go through the following steps:

(1) Study the scope of changes or extent of delay.
(2) Review all reference material such as drawings, sketches, specifications, field directives, correspondence, and cost estimates.
(3) Determine that all affected contracting parties comply with the change.
(4) Determine each activity affected or logically restricted by the change.
(5) Review and determine the duration computations for all affected activities. Use the last updating relating the notice to proceed to the date of change.
(6) From daily sources of information, determine the status of activities in progress that are impacted when a change is issued or when delay occurs.
(7) Prepare an added-activity analysis of the sequence of activities to perform work required by the change or which identifies the delay.
(8) Prepare an independent schedule analysis.
(9) Check to ensure that the resulting time extension is the product of the change, not the result of any time the project is behind schedule for other reasons; plus the time effect of the change order or delay.
(10) Document the time impact of the delay/change.

To aid the owner and contractor in preparing and resolving time impact claims, the following suggestions are offered.

(1) A contractor who requests a time extension or adjustment to the schedule must do so in writing, and in a timely manner. Supporting network data should also be included.
(2) Network diagrams must be current.
(3) During update meetings, both parties must insist that additional activities and/or network changes be incorporated to reflect actual conditions and plans for completion.
(4) The owner and contractor should try and reach a settlement on the issue of time for each change, considering the maximum and minimum positions they are willing to accept.
(5) Detailed minutes should be kept for all negotiation sessions. All offers and counter offers should be included.
(6) When time extensions or network adjustments are denied by the owner, the contractor should go on record as having disagreed with this decision.
(7) Summary time-scaled networks should be used as visual aids in presenting any schedule claim.

6.1.12 Litigation

Although time-impact analysis is a strong tool for analyzing and supporting delays and their effects on schedules, it does not mandate that the owner will grant a requested time extension or contract modification. If the contractor considers a denied claim for time extension and/or damages to be valid, he may resort either to arbitration or litigation as required in the contract. Many contracts contain provisions for arbitration which must be pursued in lieu of litigation. In the absence of an arbitration provision, litigation is the last source of dispute resolution. Whether a disputed claim goes to arbitration or litigation, the same basic procedures must be used in preparing the case for either party.

The CPM schedule and delay analyses do not constitute proof in and of themselves. The results must be supported by proofs establishing factual causation for the delay and responsibility therefore. Use of the schedule to identify and support a delay claim is dependent upon:

(1) The soundness of the schedule (reasonability and feasibility).
(2) The extent to which individual delays can be established by substantive evidence (basic records).
(3) The nature of changes made to the schedule during the claim process (exactness and accuracy in analyzing the project).
(4) Proof that the work sequence shown was the only possible or reasonable method by which work could be completed as scheduled.

A schedule can be a useful tool in litigation or arbitration, if it was approved and accepted by all parties. However, it can be discredited if:

(1) The network was not used in either preparation of bid or management of the project during performance (if presented as being so used).
(2) The diagram and network analysis was prepared specifically for sole use in presentation of the claim and had no relevance to the planned or actual work performed on the project.
(3) The schedule was not the intent of the contractor nor was it reasonable, and did not relate to the work.
(4) The original network contained numerous mathematical errors which would weigh what benefit the network had.

In a hearing or trial testimony, an expert witness must be qualified by knowledge, skill, experience, training or education. For practical experience, the expert witness must have an understanding of the construction estimating process and management of construction projects. The expert witness must understand project recordkeeping, cost accounting systems, and various scheduling techniques used to follow job progress. The expert must also understand the basic working knowledge of the major trade activities involved. The testimony can be supported by the delay analysis and graphic aids.

In summary, preparation for arbitration or litigation is a very detailed process. A checklist for the various activities previously discussed follows.

(1) Ensure that the expert witness is qualified in the area of scheduling. This person must have the credentials, education, experience and position. Most importantly, check references and the track record of the witness.
(2) An onsite inspection and review must be conducted to see how the project records relate to schedules.
(3) The original network that was prepared and approved, as required by the contract, must be introduced as a contract document and validated.
(4) The mathematical calculations must be shown to be correct and that the network was reasonable and feasible. If possible, provide a computerized schedule report.
(5) Show that the network portrays the work originally intended to be constructed.
(6) Show that the sequence along the critical path was logical and reasonable.
(7) Prove that updates of the schedule were conducted, performed adequately, and the results employed in management of the project.
(8) Show that changes, delays and time extensions were analyzed.

6.1.13 Conclusion

CPM schedules are used for planning and monitoring projects. The CPM schedule breaks a project down into smaller identifiable work components. There are three major components to a CPM schedule:

(1) Activities
(2) Duration
(3) Logic

The combination of these components results in a network consisting of nodes and arrows. A series of simple mathematical calculations are made resulting in a project completion date and available float for each activity. Float is then used to level the project resources (money, time, manpower, equipment and materials) and to focus project attention on critical activities. Leveling of resources minimizes fluctuations in resources. Any activity with zero float is critical by definition; therefore any delay to a critical activity will delay the project completion date. By identifying these activities, management attention can be focused to ensure that the completion date is not jeopardized.

In “real world” practice, most CPM schedules are entered into a computer software program and all calculations; including resource leveling is done by the computer using the criteria selected by the scheduler. Preparation of CPM schedule graphics and tabular reports is standardized within the software, and most allow for the customization of schedule information for both analysis and presentation.

6.1.14 CPM Scheduling-Its Importance in Monitoring and Demonstrating Construction Progress

6.1.14.1 Introduction

Delivering a project on time does not just mean signing a contract and hoping that the required completion date will be met. More often than not, the majority of today’s construction projects encounter events and or changes that affect the original plan for executing a project. Further, resources such as labor and material/equipment may be scarce, in high demand and as a result may hamper project execution. Attempting to solve these unforeseen issues during a project without a plan in place to determine the immediate impact is a major risk which can often lead to delay, disruption and disputes between the parties. Experience over the past 20 years has demonstrated that a well developed, updated and consistently used CPM schedule during a project can increase the probability of a project finishing on time and/or assisting in party-agreed extensions of time. Tracking critical activities with a CPM schedule throughout the project allows a contractor to know when the critical path is changing, what activities are being delayed and the flexibility to resequence and/or develop work around plans for various project activities to avoid project delay. In addition, an accurate, consistently used and updated CPM schedule allows either party to demonstrate the history of how the project was executed and if delays occurred to the project, when, where and what activities were specifically impacted by these delays. Demonstrating how a project was executed and what was critical at the time can be especially useful when resolving disputes that may arise as the project progresses, not just at project completion. Both during the project and at project completion, the negotiation of changes and claims are facilitated through the implementation of a CPM schedule. This process is more cost effective than other dispute resolution alternatives. The net result is improved commercial results.

This section discusses the merits of using CPM scheduling on construction projects, how a CPM schedule should be developed, updated and when, including how this process has changed over the last 20 years, and how to effectively use a CPM schedule both during and after project completion. The section will also address what not to do in preparation and updating a CPM schedule and the dangers of schedule “manipulation”. Finally, different applications of CPM scheduling software will be presented including the benefits of using electronic software and the pros and cons of the different applications.

6.1.14.2 The Merits of Using CPM on Construction Projects

When reviewing all aspects of a construction project, few aspects are of greater significance than time. Consequently, it becomes imperative to have a tool which can assist in managing that time. One of the ways to manage time effectively and efficiently is through a thorough understanding of CPM scheduling and its use as a management tool.

CPM is a powerful tool that can assist both owners and contractors in the planning and managing of complex projects. CPM schedules were initially developed in the 1950s in the United States to control large defense projects and have since been routinely used around the world. In summary, a CPM schedule is a useful planning and management tool for several reasons:

- Identifies the activities that must be completed as part of a project, thus laying out how a project will be executed as well as how it might be resourced. In this way, the CPM schedule helps the parties to monitor progress, productivity, level of performance and the achievement of project goals.
- Determines what work activities must be performed. A thorough identification of all activities requiring time and resources must be made during the planning process. Activities are chosen for determining what activities are needed to complete the scope of work specified, or may be related to either payment milestones or pay items.
- Determines what work activities can be performed in parallel. A logical sequencing of these activities must be made, which in turn defines a plan for both owner and contractor activities, required dates for drawing review and approval, material and equipment, and a plan by which the contractor can schedule its resources, including required manpower and working shifts.
- Determines the shortest time in which to complete a project. The time required for each activity must be reasonably estimated or determined. This time in conjunction with the logical sequencing of the activities, will then define the longest path, and thus the total

planned duration of the project. This in turn will identify which activities are critical and will need to be closely monitored in order to avoid time delays to the project.

- Determines the total resources that are needed to execute a project and can generate profiles of how much manpower will be required and when.
- Assists in determining the priorities of work to be completed.
- Assists the parties to see where remedial action needs to be taken to get a project back on course should it be delayed.
- Provides the ability to see when and how an activity will be affected if a delay or change occurs to the project and can then serve as a base for work arounds.
- Provides the most efficient way of shortening the time on delayed projects.
- Allows for continuous evaluation of the planning and progress according to a pre-determined schedule and will provide the basis for a decision making process during the project based on realistic actual and projected progress.
- Benefits the parties both during and after project completion by either assisting the contractor in presenting support for time extensions, price adjustments for delays, suspensions, accelerations, and the time elements involved in changes and extra work or assists the owner in presenting or defending against delay and damage claims for late completion.
- Serves as a useful reference document in the event that a similar project is undertaken in the future.

An effective CPM can make the difference between success and failure on complex projects. It can be useful for assessing the importance of problems faced during the execution of the work.

6.1.14.3 CPM Development and Changes since Its Inception

Schedule Types

The type of schedule associated with a project relates to the complexity of the work to be performed. Before CPM scheduling was developed in the 1950s, most projects relied on what is referred to as a Gantt chart or bar chart. This was a pictorial display of activities that needed to be completed over the course of the project as shown by bars against a time line. For small projects, the Gantt chart may still be adequate where there are few interrelationships. However, since the activity interrelationships are not easily shown on a Gantt chart, it is considered a risky planning and inadequate tool for complex projects.

The CPM schedule is a graphical representation of predicted activities, milestones, dependencies, resource requirements, and activity durations. The project schedule should be detailed enough to show each WBS task to be performed, the name of the party responsible for competing the work, the start and end date of each activity and the expected duration of the activity. The advantage that CPM schedules have had over the Gantt chart is that this process identifies the critical activities that must be completed on time for the whole project to be completed on time, and also identifies which activities can be delayed if resources need to be reallocated to catch up on delayed critical activities.

The large defense projects where CPM scheduling was first introduced were prepared using sophisticated computer software based on large mainframe computers. In the 1950s-1970s, mainframe and then “mini” mainframe computers were very expensive and costly to maintain and operate. Only the most complex and defense related projects were typically performed with the use of a computer program. It was not until 1981 that the personal computer even became available and even then software was not fully transitioned from mainframe language and personal computers were still costly to own. Thus, until the late 1980s, most CPM schedules were drawn and maintained manually. As a result, most were kept simple to the extent possible and most did not include resources, such as cost or manpower added to individual activities. Due to the need for a simplistic approach, CPM schedules at that time were developed via a method termed “arrow diagramming” (ADM) which required that 100% of an activity be finished before another activity could start. There was only one logic relationship between activities: “finish-to-start”. In order to accomplish parallel work, “dummy” activities were inserted within the schedule with no duration in order to maintain the finish-to-start logical relationship.

However, as the years passed and CPM became more of the norm on construction projects, and was beginning to be a specification requirement, it soon became apparent that using only “finish-to-start” relationships forced the scheduler to have to utilize more activities in a CPM network than otherwise might be necessary. Thus, a new methodology was developed for preparing CPM schedules termed “precedence” (PDM) CPM scheduling. With this new methodology, the scheduler could lay out the CPM network by having more types of logical relationships between activities decreasing the number of total activities in a schedule. Logical relationships now included:

- Start-to-Start
- Finish-to-Start
- Finish-to-Finish
- Lags attached to logical relationships, meaning any of the prior relationships depicting a period of time between the identified logic. (i.e. a start-to-start lag of 5 days relationship between Activity A and B means that activity B can start 5 days after activity A starts)

With the addition of the personal computer and CPM scheduling software, development of the schedule became easier with the person inputting the information, merely identifying the activities, the durations, the logic, and the resources. The computer software then processes the early and late dates an activity can be performed, the critical activities of the project and the total length of time it will take to complete the project. The computer software not only creates the logic network diagram, but allows modifications of the plan to be made more rapidly. The CPM schedule serves as an important tool for progress monitoring and support of any delays that arise on the project. The only danger in today's CPM scheduling is that the user may have less intimate knowledge of how the schedule was developed and thus sometimes a false security on the product generated from the computer results to the extent that since it was generated from a computer, "it must be right".

When large complex projects are constructed where there is uncertainly as to the precise duration or occurrence of an activity, a modified form of CPM called PERT, or Program Evaluation and Review Technique can also be used. It is a variation of CPM in that it takes a more skeptical view of the time estimate made for each project activity or stage of the project. It is typically used on large complex projects where there is a multitude of interrelated tasks and the probability of occurrence is necessary. To use it, the following times must be estimated for each activity: the shortest possible time that each activity will take, the most likely length of time, and the longest time that might be taken if the activity takes longer than expected.

Developing the Schedule

Developing a schedule is an iterative process. While the steps appear to be basic in nature, each step requires careful thinking and documentation of assumptions used in order to serve as a basis for future revisions and/or a basis for revising a work around plan, demonstrating schedule delay and/or acceleration. Regardless of the methodology selected for constructing the CPM schedule, the same basic process is necessary in order to develop a CPM schedule which is truly reflective of the scope and sequence of work to be performed. Basic efforts associated with developing a project schedule including the following:

- Define the type of schedule to be developed.
- Define the precise and measurable milestones and/or completion date to be met.
- List all the activities required to perform the scope of work.
- For each activity listed, estimate approximately when the activity might start, the estimated length of time it might take to perform and whether the activity is a sequential activity and depends on a prior activity completing, or whether it can be done in parallel.
- Define the priorities of the project and activities.
- If an activity is a sequential activity, identify which activity (ies) will be required to be completed first.
- If using a CPM schedule versus a Gantt chart, identify names and numbers for the activities and enter this information along with the information from Steps 2-6 into the CPM scheduling software.
- Calculate the program to allow generation of the early and late start and finish dates for each of the activities and to identify what the critical path is of the project along with its critical activities.
- Add, when available and desired, the resource information for each activity to generate total project cost, cash flow and resource profiles.
- Document the assumptions that were used in developing the schedule
- Identify the risks that might arise during the course of the project, which might affect schedule performance.
- Review the results as a project team to assure that the CPM schedule does indeed reflect the work to be performed in the time constraints defined.

6.1.14.4 Effectively Using the Schedule during the Project

The schedule should first be reviewed by the stakeholders who will be responsible for monitoring and maintaining the schedule. Then, once accepted by the project team, the schedule is then ready for submittal to the owner for final approval, thus serving as the baseline schedule from which progress on the project will be measured. By carefully developing the schedule as outlined above, a work plan for executing the project is developed that:

- Conforms with the imposed constraints (i.e. milestones and/or project completion),
- utilizes resources efficiently,
- identifies when specific materials and equipment are to be delivered,
- coordinates external actions [i.e. submittals, reviews, approvals, etc.] and interfaces to other work or projects,
- allows for generation of project spend and/or earnings plan and budget,
- provides the basis for tracking actual performance against the planned performance,
- gives visibility to the need for corrective actions as work is performed,
- provides forecasts of project completion dates,
- provides proper definition to each activity so that all of the activities can be controlled or updated without guessing,
- serves as a basis upon which the impact of changes to the project scope and/or specifications can be evaluated, and
- is a plan upon which to evaluate the impact of delays to the project plan and timetable.

The initial schedule once developed serves as the project baseline. Regular monitoring and progress measurement against the schedule allows both parties to determine how far ahead or behind the activities are with respect to the planned milestone dates and/or project completion. Monitoring is typically done on a monthly basis with the schedules submitted as part of the monthly progress report by the contractor to the owner. In order to accurately measure progress against the baseline, only actual start and finish dates should be entered into the computer program. No major logic changes should be made to the Baseline Schedule as these logic changes may or may not change the critical path and may reflect change to critical activities that may not be reflective of true problems occurring on the project.

Only when the actual progress and events on a project have changed so dramatically from that planned and/or changes have occurred to the project which necessitate a major changes be made to the schedule in the form or either added or deleted activities, changes in sequences and/or planned durations should the schedule go through a major replanning and a new schedule issued on the project termed as a “Revised Baseline” schedule. Any time the critical path of the project changes, the parties need to reassess whether a revised baseline is necessary. This is again important as delays to the projects are measured against the critical path of the project. The Revised Baseline schedule should go through the same steps as discussed above in the schedule development along with documentation of all assumptions used in its development. In many instances the original baseline schedule is a contractual document and therefore may require client permission prior to updating. It is also vital to maintain the history of the project activities noting in a log within the computer program, the actual start and finish dates to each of the activities and all sequence changes that were made throughout the project.

As CPM scheduling has evolved over the last 20 years, so has the techniques applied in development, updating and post evaluation of the CPM schedule. With the onset of the computer, many individuals have entered the CPM industry that do not have the same training or understanding of CPM as was required when CPM was first applied in its initial decade of use. While universities in the United States started offering courses in CPM scheduling in the 1970s, other universities around the world did not teach project management concepts until just recently, in the late 1990s and 2000s, before relying solely on apprenticeship training for personnel involved with CPM scheduling. Even today, there exists quite a disparity between educational training and the application of CPM scheduling for today’s international constructed projects. As a result of the diversity amongst scheduler’s personal backgrounds and experience and the extreme variance between opinions of expert witnesses over the past 20 years in “determining” what happened on a project after the fact, a global concern has arisen as to need for international CPM scheduling standards - both in definition and in methodology - in order to achieve a consistency in approach and application. Basic scheduling standards already exist in the PMI *PMBOK*. However, while these standards serve as a reference in developing and maintaining a schedule, the current *PMBOK* standards do not provide the scheduler with precise definitions and applications for a CPM schedule either during or after a project has completed. Thus, PMI with the guidance of PMI’s College of Scheduling on which the author sits on its Board of Directors[415], has embarked upon the development of ANSI standards which will provide both definitions of CPM scheduling terms and standards for how CPM schedules should be developed, monitored, maintained and used post completion relative to analysis concerning project progress. Further concern has arisen regarding the qualifications of personnel actually developing and maintaining a CPM schedule. Lack of thorough understanding of CPM scheduling can result in inaccurate completion and progress projections and schedule manipulation as discussed below. As a result, organizations such as PMI and the American Association of Cost Engineers International (AACE) National Planning and Scheduling Committee[416] have embarked on certification program efforts that will qualify individuals by both experience and examination. This certification will then provide both owners and contractors a mechanism to evaluate personnel who would potentially be selected for CPM scheduling roles and responsibilities.

6.1.14.5 Dangers in Schedule Manipulation

Unfortunately, in today's construction environment, many schedulers have become so sophisticated with their computer software, that there is a tendency to "outwit" the other party and to portray certain areas of work as critical and other areas of work not critical in order to serve their own purposes. Schedule manipulation can take many forms and should be carefully monitored should the following events occur during the project and/or with the submittal of the initial schedule:

- The inclusion of imposed date constraints on activities: An imposed constraint on an activity means that either a specific imposed date has been applied to either the start or the finish of that particular activity. By imposing a constraint, the computer software will recognize the imposed constraint first and will use this constraint as the priority, overriding any logical relationships with other activities. There are certain instances where an imposed date is justified: the project completion and/or contractual milestones. It may also be reasonable to impose a constraint to an activity that may be severely impacted by weather-such as typhoon season where work could not proceed if not completed prior to the start of the typhoon season. However, any other imposed constraints will necessarily give a false criticality and may show a false critical path.
- Shortening of future durations: Often a contractor sees himself in a bind when delays occur for which he is responsible. One method of demonstrating to the owner that the project is still on schedule is by shortening future activity durations. However, unless the

contractor is planning to add more resources or additional shifts for completion the work, seldom does the reduction of activity durations represent reality. Thus, at some point in the future, the schedule becomes unattainable and the parties find themselves in conflict with each other, further resulting in a potential dispute.

- Revision of logic: While logic revisions may become necessary throughout the project due to changes in the work or project work arounds to recover delay, contractors often, as with the reduction of future activity durations, manipulate the activity logic in order to show a different critical path, and/or to give a false impression that the project is still on schedule. While the contractor may believe the owner will not discover the changes made and while the contractor may believe he can lure the owner into a change order granting additional time and/or money, this is a very dangerous game and one that can be of dire consequence to the contractor, especially if discovered that the changes were made intentionally to mislead the owner. Such actions are highly discouraged.

6.1.15 Schedule Software

Multiple scheduling software programs now exist in the market place: Primavera, Sure Trak, Microsoft Project, and Artemis, to name a few. Each software package provides certain benefits to the user, depending on the desired use for the schedule. Obviously the more complex the software program is and the more benefits it allows, the more costly the software program. When the personal computer first became available, both ADM and PDM methods of software computing were available. However, since the 1990s, very little use of ADM is found in current scheduling software, demonstrating the wide use of PDM methodology in today's constructed projects.

Often the particular software is specified in the Contract to match the software of the owner so that electronic data can be provided with the monthly updates and the owner can review the contractor submitted electronic data with his own software. This also allows the owner to review how a schedule has been developed by the contractor and to determine whether the work as planned accurately represents the work being performed and planned to be performed in the future. However, if the software is not specified, the user must determine which software best meets the need of the project, both during and after the project has completed. For instance, Microsoft Project is one of the least expensive programs and offers a reliable system for relatively small and simple projects. However, on more complex projects that require multiple breakdowns in complexity, resource loading and the need to compare multiple versions of the same activities over time, the user might want to consider a program such as Primavera which allows the user more flexibility in monitoring and demonstrating delays, and the ability to plan different scenarios. The scheduling software systems are continuously being revised to best meet the needs of today's project managers and the more detailed and accurate portrayal of how the work will actually be performed. It is advisable to be completely knowledgeable with what is available and what will best serve both the project, and the project team.

6.1.16 Conclusions

Today's complex construction projects are best planned, monitored and progressed using CPM scheduling. However, in order to provide a realistic plan from which a project can be monitored, a CPM schedule needs to be well thought out in its development with a recordation made of the assumptions used for its development. It is important for all parties to understand and to accept the CPM schedule developed as a means of either accelerating or revising the work should delays occur. Schedule manipulation should be avoided as any attempt to portray work other than what is actually occurring or planned to occur in the field is dangerous and can lead to costly and lengthy disputes. Rather, regular updating of the CPM schedule and progress monitoring is essential, typically done monthly in conjunction with the Monthly Progress Report to the owner, demonstrating the actual condition of the project at any given time and serving as a management tool upon which to base decisions for schedule extension, change order impacts, or acceleration measures. CPM scheduling is best performed with the use of computerized programs best suited for the type and complexity of construction to be performed as well as the needs of the user.

6.1.17 Industry's View of CPM Scheduling

While CPM Scheduling has been around since the 1950's, its application in the construction industry has even today not received 100% acceptance or consistency in how it is used. In order to determine how the industry views its applicability and usage, a survey was developed for the stakeholders in the construction industry[417]. This section summarizes extensive research that was performed of the construction industry relative to the use of CPM; its applicability and acceptance in the execution of today's constructed project. Project Controls, and CPM scheduling in particular, have gone unchanged in the standard arena and little focus for a common understanding and recognition of what is required for CPM schedule development and implementation and use. One of the PMI objectives over the next 1-2 years is to develop a set of standards for CPM scheduling and its use. This standard is currently in draft review with expected release in early 2006. PMICOS is also undertaking a Best Practices guideline which can be used by the stakeholders in the construction industry. The research presented in this paper is being proposed at a key critical time at which its results can be used by this internationally recognized professional institution.

6.1.17.1 Research Base

The research for this section is aimed at addressing the following key areas:

- Establish the views from both owners and contractors as to the use of CPM scheduling and its applicability in today's constructed projects
- Determine what is required of individuals who perform CPM scheduling
- Determine whether standards, certifications and/or Best Practice guidelines are being sought by the industry
- Whether CPM scheduling can assist in the risk management assessment process
- The research then sets a minimum requirement of what is needed in the construction industry to best meet the needs of the construction industry along with proposed recommendations on how this could be accomplished.

It was determined by the author that the largest response would be received if those taking the survey could do so via an on-line based survey. Relative to the construction industry survey, an agreement was secured with the leading professional societies serving the construction industry to send an e-mail to its members notifying its members of the on-line survey. As the professional societies would not make their respective membership lists available, the total number of potential respondents is not known. Surveys were available to members of: the Construction Institute (CI) of ASCE; the Construction Management Association of America (CMAA); The American General Contractors (AGC); PMICOS; Construction Users Roundtable (CURT) and AACEI's National Planning and Scheduling Committee. In addition, a list was purchased from *Engineering News Record* for the top constructors in the world list. A hard copy of the survey was also sent to the Project Controls Manager of these contractors. A total of 430 responses were received composed of approximately 41% owners (private and government), 31% contractors, 19% engineers, and 19% construction managers. The remaining respondents were from universities and consultants serving the construction industry. The industry survey centered on the following subjects:

- Contract requirements for CPM scheduling

- Requirements for schedule updates versus schedule revisions
- Resource and cost loading requirements and usage
- Computerized software required and used
- Scheduling techniques employed
- Applications and primary use of CPM scheduling
- Management decision-making based on CPM schedules
- Advantages and disadvantages of CPM scheduling
- Success of CPM scheduling usage
- Personnel qualifications for Schedulers
- Knowledge regarding professional organizations supporting CPM scheduling
- Opinions relative to CPM scheduling standards and Best Practices
- Opinions relative to university curriculums for the study of CPM scheduling
- Use of CPM scheduling in risk management
- Use of CPM schedules in claims avoidance and claims preparation

6.1.17.2 General observations/conclusions drawn from survey

As noted above, the survey respondents well represented the construction industry and were reasonably equally divided among owners, contractors, engineers/construction managers, all stakeholders in the project and parties who have to live with the decisions based on the CPM scheduling information. It was interesting to note that while some differences existed between owners and contractors relative to the reasons CPM scheduling was used and/or its benefits, there were common opinions amongst all stakeholders relative to the following points:

- CPM scheduling has become a standard project control tool and both owners and contractors use the tool whether it is or isn't required by contract.
- While all parties generally felt that CPM scheduling was a good project control tool for monitoring, planning and executing a project, commonality existed relative to:
  - ➔ CPM scheduling has become so sophisticated that specialists in CPM scheduling are now required to develop and understand CPM schedules.
  - ➔ While Primavera software is the number one choice amongst the stakeholders, it is believed to be complex and difficult to understand thus increasing the cost to the project.
  - ➔ CPM schedules are easily manipulated, especially with respect to logic abuse.

- Of the two organizations which primarily have CPM scheduling as a key focus: PMICOS and AACEI, more than 70% of the respondents had not heard of one of the organizations.
- The majority of those responding indicated that they believed certification of schedulers would improve the industry.
- The majority of those responding indicated that there was an immediate need for standards for CPM scheduling although half of those responding did not know who should develop such standards and the remainder indicated multiple organizations; noting that the organizations should come together to develop common standards.
- Over 92% indicated that they desired to have some sort of Best Practices guidelines that could be issued to both owners and contractors relative to CPM scheduling.
- The majority of the respondents felt that CPM scheduling was beneficial in risk management applications.
- Most participants agreed that there should be consistency in the university curriculums. However, as noted in research that has been performed of the universities in the United States, Europe and Asia[418], there is no consistency in the universities as to how CPM scheduling is taught. By the answers to the industry survey questions, it is apparent that this is a major area requiring reform as CPM scheduling appears to mostly be taught and learned by on-the-job training, thus resulting in non-standard development, usage and interpretation of results from CPM schedules.

6.1.17.3 Industry survey

While CPM scheduling has been around since the 1950s and is assumed to be a basic project control tool that is commonly used on all construction projects, the results of the industry survey demonstrate that CPM scheduling is still not a mandatory requirement nor is it a project control tool which has gained the trust of the industry. Based upon the results of the prior research performed on the course curriculums of the universities, it was not surprising to see some of the responses from industry relative to CPM scheduling.

6.1.17.3.1 Owner Specification Requirements for CPM

Of the owners that responded, only 47.6% indicated that CPM scheduling is always required on their projects. Of those requiring CPM scheduling, 72.5% do specify CPM scheduling in their contracts, but only 55.9% require a Baseline Schedule. Owners were split on whether the CPM specification in their contracts was a standard specification or whether it was customized for a particular project. Over 64% of the owners indicated that they used Primavera as their specified software with only just over 20% requiring MS Project. Other software mentioned included:

- OPLAN
- MS Excel
- Government Proprietary software
- CBCM
- CA Super Project

Interestingly, while almost 46% of the owners indicated that they require precedence diagramming methods, 14% indicated that they still require arrow diagramming CPM scheduling. In addition, owners indicated the preference for using of other scheduling techniques including: almost 50% indicated their preference for bar charts or some form thereof; 27% indicating that they use PERT; 4% indicated requirements for 4D Planning; and another 20% required either Line of Balance (LOB) or Linear Balance Charts (vertical production methods) in their specifications.

Relative to the CPM specification requirements, nearly all respondents indicated that schedule updates were required and over 84% required schedule revisions; however, only 68% indicated that they distinguished between an update and a revision. Updates were deemed to be necessary on a monthly basis submitted in electronic format in over 2/3 of those responding. Almost 50% also indicated that they limited activity durations and nearly 65% indicated that they required activity coding. While the majority of the owners responding indicated that activity durations and coding was important, the owners were split as to whether resource loading was a specification requirement. Over 70% were primarily concerned with manpower loading on activity, while only 50% of the owners required cost loading or trade breakdown. A few owners also noted that they required resource loading for major equipment only, critical items, quantities or that “*resource loading is not defined, it is just required*”.

6.1.17.4 Owner's Viewpoints on CPM Scheduling

Schedule Revisions

Owners have a variety of reasons that they specify revisions in their specifications. The largest response as to why a schedule revision was required was equally shared (72%) between:

- ➜ Project Behind Schedule
- ➜ Change Orders

The next major reason cited was critical path changes (56%). Other reasons noted by owners for requiring schedule revisions included:

- ➜ Resource changes for either manpower or equipment
- ➜ Logic changes/duration changes/or contractor sequence changes
- ➜ When requested by the owner
- ➜ When time extensions are approved

Advantages

The owner respondents were vocal as to specific applications and why they liked or disliked specific scheduling techniques and why CPM may not be the most appropriate application for the type of project being constructed. Owners that preferred merely bar charts explained their response in that they were easy to understand, they can provide near-term look aheads, and are more appropriate on smaller projects as budgets do not allow the cost of CPM scheduling and/or the managers do not have the necessary training in order to review and monitor CPM schedules. Those owners indicating the use of Linear Scheduling and Line of Balance indicated that CPM scheduling was not appropriate as the projects were linear in nature (highway and/or pipeline projects in particular) and linear scheduling was more accurate relative to measuring progress and specifically, production rates. 4D modeling was discussed as primarily being used before the project was executed in determining the best schedule alternatives for a specific project before it starts as well as optimizing communication, planning and visualizing the project. CPM scheduling was indicated as being advantageous in that "what if" scenarios could be performed when submitted in electronic format to determine impacts on changes and delays to the project. CPM also allowed summarization into a bar chart format for ease of understanding by management.

Disadvantages

The two main disadvantages noted by owners in the use of CPM scheduling were:

- ➜ The Construction Managers and Project Managers do not use the software enough to be knowledgeable in its use and what it is portraying; and
- ➜ The contractor is more informed about CPM and can more easily manipulate the schedule and use it for claims.

Owners felt that CPM was overkill for small projects with little cost justification. Owners were also concerned as while their preference was to use Primavera as the required software specified, that their experience was that many contractors still use MS Project which has limitations and does not allow the owner to perform the monitoring that it desires throughout project execution. For those owners using linear scheduling techniques, their primary concern was that few contractors understood this scheduling technique and that it was not well known in the industry.

6.1.17.5 Contractor's Viewpoints on CPM Scheduling

Contract Specifications

Over 50% of the contractors responding noted that they now find that their contracts require CPM scheduling. If CPM scheduling is not required, nearly 67% indicate that they still prepare a CPM for purposes of planning and monitoring their work. While the results did not determine whether Primavera was primarily used as a result of being a contract requirement, despite the responses received from the owners on the perception of software usage by contractors, nearly 65% indicated that they prefer to use Primavera software, with only 22% indicating they prefer MS Project. With respect to resource loading requirements, the contractor respondents were split relative to whether they found resource loading useful. 40% of those responding did not believe either manpower or cost loading was useful while 30% did believe resource loading was useful and 15% did not have an opinion one way or another. The remaining respondents commented that it was considered "extra work", or depended on the specific project. Other comments made centered around lump sum contracting where it was noted it was not necessary in the respondent's opinion to track manpower or costs per activity.

Use of CPM

The primary reasons noted by contractors for using CPM scheduling included:

- Periodic control of work after start of construction (85%)
- Developing Look-Ahead schedules (85%)
- Coordination of subcontractors (82.1%)
- Detailed planning of work prior to construction (78.1%)
- Schedule impact, claims analysis and tracking of changes (75%)
- Coordination of own trades (59%)
- Estimating and bidding (44%)
- Tracking shop drawings and submittals (39%)
- Calculating payment requests for work performed (31%)
- Design Development (28%)
- Operation and Maintenance of Projects (22%)
- Tracking costs (18%)
- Materials Planning (less than 3%)

Over 80% of those contractors responding indicated that they rely on their CPM schedules for making decisions on the project execution. In response to a question on whether the contractor maintains a separate schedule to monitor the work in addition to the contract specified schedule, 28% indicated that they did and 52% indicated that they did not. The remaining respondents indicated that they would prepare a separate schedule based on:

- The need to prepare 4-week rolling for their own forces
- The specific project
- The need for a target schedule to provide better control
- When they are a subcontractor and the general contractor's schedule is not representative of the subcontractor's work
- Whether the owner is refusing to recognize delay and grant time extensions
- The need to review fragnets and provide an indication of change impacts
- The need to have a more summary level schedule for presentation to management

Advantages

Over 96% of the contractors responding indicated that they believed that there was an economic benefit to using CPM and over 89% indicated that they have had moderate to high success in achieving various benefits using CPM. The advantages of using CPM scheduling as noted by the contractors included:

- Improved planning before work starts (92%)
- Improved scheduling (84%)
- Improved understanding of the project (83%)
- Improved project control after work starts (80%)
- Improved communications among the workforce (54%)
- Increased control over risk and uncertainty (53%)
- Reduced delays (50%)
- Minimization of disputes between the contractor and owner (46%)
- Time savings (39%)
- Faster response to problems (34%)
- Cost savings (30%)
- Improved estimating/bidding (28%)
- Helps train future project managers (26%)
- Positive psychological effect on employees (22%)

Other comments that were specifically noted by those responding as to the benefits of CPM scheduling included:

- Imparts a sense of control for the management team enabling to accurately plan ahead
- Useful tool to discuss issues that could be clearer
- Gets owners to react more quickly
- Basis for earn value cost pre-planning, cost reporting and time job cost control
- If owner approved, easier to show delays
- Easily flags adverse trends against the baseline schedule
- Allows ability to do “what if” scenarios

Disadvantages

Nearly 40% of the contractors indicated that the primary disadvantage to CPM scheduling was logic abuse. As noted previously, this was also a concern of the owners and leads into comments that will follow relative to the need to scheduling standards, best practices and certification. The other major common areas of concerns relative to CPM scheduling included:

- Requires excessive work to be implemented (32%)
- Requires too much dependency on specialists (26%)
- Not responsive to the needs of field personnel (21%)

Other comments noted by contractors relative to the disadvantages of CPM scheduling included:

- Must be kept up to date if it is to be relied upon
- No one knows how to use it properly
- Too much interpretation which leads to owner mistrust and misuse
- Owners attempt to use the CPM schedule against the contractor instead of working with the contractor to resolve delays and impacts
- Not understood by laborers or superintendents
- Requires users trained in CPM scheduling
- P3 graphics are difficult to read
- P3 software has become so sophisticated it requires skilled specialists to use the program

6.1.17.6 CPM Scheduling Personnel

The industry surveyed all the stakeholders relative to the skills and qualifications of their respective personnel that develop and use CPM scheduling on construction projects. The industry is almost equally divided on whether the organization employees an overall manager for planning and scheduling with 59% indicating that they did not and the other 41% indicating that they did. However, this percentage switched slightly with respect to specific projects, with 57% of the respondents indicating that they did employ a person solely dedicated to this effort, while 43% indicated that they did not. Of those employing s dedicated scheduler, 84% responded that this individual is expected to perform other tasks in addition to CPM scheduling. 67% indicated that their scheduling is performed by in-house personnel while only 7 % indicated that they used outside consultants solely and the remainder indicated a combination of in-house and consultants. Most interestingly, when it came to the desired background of the personnel performing planning and scheduling, nearly 56% indicated that they preferred someone with an engineering background and 44% indicated that they desired someone with project management background. Some respondents also commented that it may vary project to project and that site experience and/or a certification might be preferred in addition to the backgrounds noted above. Relative to the specific credentials of the scheduler, the following credentials were noted as preferred for someone performing CPM scheduling:

- On-job training (41%)
- Undergraduate engineering degree (39%)
- Scheduling training/coursework (36%)
- No credentials needed (14%)
- Undergraduate degree in construction management (13%)
- Graduate degree (10%)
- Graduate degree in construction management (5%)

Respondents also commented that the following credentials would also be desirable:

- Masters degrees
- Professional Engineering License
- Five years experience on comparable projects
- Prior experience
- Certification such as Project Management Professional (PMP), Certified Cost Engineer (CCE), ICEC certification, AACEI PSP scheduler certification
- Field experience

6.1.17.7 CPM and CPM Standards

When asked for the reasons why CPM scheduling was used, over 82% indicated that it was a beneficial planning tool that makes projects more efficient and cost effective. In response to the question that was asked (to check all answers that applied), relative to the reasons why they used CPM scheduling, the following were noted:

- Contract requirement (63%)
- Claims, after the fact (53%)

- Change Management (47%)
- Other (so noted)
  - ➜ Anticipated shifts in funding needs
  - ➜ Understanding true delay
  - ➜ Earned value management
  - ➜ Bid evaluation
  - ➜ Coordination of multiple construction projects
  - ➜ Identification of delay issues
  - ➜ Bases for 3-week look-aheads
  - ➜ Assists in getting buy-in from subcontractors

The primary uses of CPM scheduling were noted to be:

- Risk Assessment (57%)
- Reduction of claims (55%)
- Projects are more cost efficient (39%)
- To meet a contact requirement (18%)
- Assists in claim presentations (10%)
- Assists in completing the project on time (10%)

Those responding also indicated that 66% of their senior management used and relied upon the CPM schedules in making decisions while 25% indicated senior management did not use the schedules and 9% indicated that they did not know.

One of the crying needs cited in the survey was with respect to the need for standards in CPM scheduling. 79% indicated that standards should be defined in the area of CPM scheduling. However, there was no consensus as to who should develop these standards with multiple organizations cited and 50% of those responding indicating that they simply did not know. Of the two primary organizations focused on the improvement of the CPM scheduling industry, PMICOS and AACEI, 70% were not familiar with PMICOS and 77% were not familiar with AACEI. However, over 53% indicated that they were familiar with PMI's PMBOK although over 89% indicated that they did not train their personnel in the use of PMBOK time management and 92% indicated that they did not attempt to assure that their CPM schedules and processes conformed to the PMBOK time management guidelines. However, while the majority of respondents were not familiar with the time management module of the PMBOK, over 58%

indicated that certification of schedulers would improve the industry and a surprising 92% of those responding indicated that Best Practices guidelines should be developed that could be made available to owners and contractors.

While 78% of those responding indicated that they believed that it was important to have a consistent university curriculum for CPM scheduling, only 17% had indicated that they had ever reviewed a university curriculum to see what was being taught at the university level. However, over 55% indicated that the university curriculums should use the PMBOK as a guide to what should be taught with respect to CPM scheduling.

6.1.17.8 Claims Avoidance and the Usage of CPM Scheduling

Over 67% of the survey respondents indicated that the use of CPM scheduling minimized claims on their projects. Over 82% indicated that they used CPM scheduling in claims resolution and of those responding that they used CPM schedules in their claim resolution, over 85% indicated that they used the existing schedules that were used during the project. Further, over 84% indicated that they believed the use of CPM scheduling was essential in delay claim resolution. However, the methodologies for CPM delay analyses greatly varied with the following noted as being methods that have been used by respondents:

- As-Built (75%)
- As-Impacted (57%)
- Time Impact Analysis (53%)
- Contemporaneous (22%)
- Window Analyses (20%)
- Collapsed As-built (15%)
- Varied depending on project (9%)

6.1.17.9 Schedule Risk Management

The respondents were almost equally split as to whether they had a company-wide risk management program with 47% indicating that they did and 53% indicating they did not. Surprisingly, while 41% indicated that they did have a Risk Management Officer, 62% responded that they did not have a project risk management program for their specific projects undertaken. Despite the fact that no specific program was identified, 52% indicated that they now perform project risk assessments with over 83% indicating that they believed risk management assessments saved money on projects as follows:

- 3-5 % (30.5%)
- 6-10% (19.3%)
- 1-2% (17.9%)
- 11-15% (12.6%)
- 0% (11.7%)
- 16-20% (3.6%)
- Over 20% (4.5%)

46% of those responding indicated that risk assessments were performed with in-house personnel, while 31% indicated a combination of in-house project team and other company personnel. 20% indicated the use of a combination of in-house and external personnel as part of the risk management assessment team. Of those performing risk assessments, 75% indicated that they do not use simulation modeling and over 44% indicated periodic risk assessments throughout the life of the project, with quarterly being the preferred time interval (34%) and 20% indicating a preferred monthly interval.

6.1.17.10 Author Concluding Remarks

Having been in the construction industry for nearly 26 years, and having been a hands-on scheduler on billion dollar programs, assisting contractors and owners in the preparation of schedules, used schedules in risk assessments and finally having used in CPM scheduling in the analysis of claims testifying on the results of those analysis; the results of the survey are not surprising to the author. The author has personally observed the findings that are presented herein and in the author’s own opinions believe that immediate reform is needed for CPM scheduling in the following areas:

- University programs must be reviewed to bring both consistency and relevancy (practicality) into the curriculums in order to better prepare individuals for the construction industry. While universities provide a good base understanding of CPM scheduling, unfortunately, the industry still considers the programs to be too theoretical and that on-the-job training and specific courses offered by Primavera are still the only ways to bring an individual up to speed on CPM scheduling.

- The professional organizations (such as AACEI, ASCE, CMAA, AGC, PMICOS, DBIA, etc.) need to come together in a coalition to address what is required relative to standards for CPM scheduling and to move those standards to ANSI standards so as to provide a more trusting atmosphere and basis from which all stakeholders in the construction project can rely with respect to CPM scheduling.
- Certification of schedulers appears to be the wave of the future. AACEI is on the forefront in its certification examination of schedulers. Additional advanced certifications may be warranted relative to those individuals in a managerial role for the oversight and direction of the CPM schedules in either a company or a large capital project.
- Best Practice guidelines should be developed sooner that later. Organizations such as PMICOS are already far along in their work relative to Best Practices guidelines using expert resources from all areas of the construction industry including owners (private and public), contractors, construction managers, engineers and consultants to the construction industry who have had to defend analyses based on CPM schedules used during the constructed project.

It is the personal opinion of the author that until the above four reform areas are addressed and implemented, the industry will continue to have its doubts over the use of CPM scheduling and that continued misuse, abuse and multiple interpretations of the data will continue; thus reducing the benefits so noted by the stakeholders of reducing the cost, increasing efficiency and reducing claims of the constructed project.

6.2 Cost Control

During the execution of a project, tools for managing and controlling a project become paramount. Project control tools are primarily designed to identify variance from the projects plan-including cost and schedule. This section analyzes the importance of project cost management. In understanding the cost control tool, one must understand the difference between accounting, cost accounting and cost control.

A general definition of accounting is:[419]

> *Accounting is the art of recording, classifying, and summarizing in a significant manner and in terms of money, transactions and events which are, in part at least, of a financial character, and interpreting the results thereof.*

All accounting systems include three basic steps: recording, classifying, and summarizing economic data, all there in terms of money. Classification of monetary information is based on a listing termed a “Chart of Accounts”. A good chart of account structure provides the following:[420]

- A standard method by which a business prepares cost estimates in a consistent manner
- A means for recording and classifying costs to permit direct comparisons with estimates and budgets
- Facilities for creation of cost centers such as departments or sections
- Means for dividing cost centers into smaller segments for ease of control and for obtaining unit return cost data.
- The opportunity for cost engineers to follow the chart of accounts in trending the project costs and in preparing forecasts and management cost reports.

The definition of cost is:[421]

> *The amount, measured in money, cash expended, or liability incurred, in consideration of goods and/or services received.*

Inherent in the Project Management Planning Process is the creation of a budget and a cost control system to provide the Project Manager with cost, schedule, and performance status. Budgets should be developed in a manner which allows control.

As with respect to cost control, PMI states:[422]

> *Cost control is concerned with (a) influencing the factors which create changes to the cost baseline to ensure that changes are beneficial, (b) determining that the cost baseline has changed, and (c) managing the actual changes when and as they occur. Cost control includes:*[423]
>
> - *Influencing the factors that create changes to the cost baseline*
> - *Ensuring requested changes are agreed upon*
> - *Managing the actual changes when and as they occur*
> - *Assuring that the potential cost overruns do not exceed the authorized funding periodically and in total for the project*
> - *Monitoring cost performance to detect and understand variances from the cost baseline*
> - *Recording all appropriate changes accurately against the cost baseline*

- *Preventing incorrect, inappropriate, or unapproved changes from being included in the reported cost or resource usage*
- *Informing appropriate stakeholders of approved changes*
- *Acting to bring expected cost overruns within acceptable limits*

AACEI defines cost control as:[424]

> *The application of procedures to monitor expenditures and performance against progress of projects or manufacturing operations; to measure variance from authorized budgets and allow effective action to be taken to achieve minimum costs.*

The difference between cost control and cost accounting is that cost accounting is the historical reporting of disbursements and costs and expenditures which is used to establish the precise and actual cost status of a project to date. Cost control, on the other hand, is used to predict the final outcome of a project based on up-to-date status.

Job cost accounting

Job cost accounting helps to determine if operations are being performed as intended by measuring costs, as well as resources used in the completion of a project. Where traditional financial accounting is more concerned with just the cost aspect when measuring the success of a project, job costing takes into account all the resources and costs. Job costing is the process that monitors the actual costs, as well as labor, equipment, materials, and subcontractors. The information is then compared to the original budgeted amount.[425]

The job cost accounting system serves two purposes: to monitor and control costs compared to the original budgeted amounts and to collect information for future estimates. The objective of the job cost system is to keep track of the project financial information in a timely fashion that can be used to implement changes and verify the accuracy of the budgeted costs. Costs are considered as direct costs, indirect costs and overhead costs. Direct costs are costs that are directly traceable to the project or in a product situation, the product being manufactured. Indirect costs of work are typically categorized into the following areas:

- Labor Costs
- Material Costs
- Equipment Costs
- Job Overhead Costs

- Profit

Labor is typically concerned with labor rates and productivity. Each can be defined as:[426]

> ***Labor rates****: the hourly rates of employing workmen, based on total labor costs divided by the total number of hours worked.*
>
> ***Productivity****: the rates of production by workmen employed; the amounts of work in specific periods of time paid for.*

Material prices are typically subjected to supply and demand and can be affected by a number of other items such as:

- Quality
- Quantity
- Time
- Place
- Buyer
- Seller

Equipment costs is often referred to as "plant and equipment" costs which identifies two items:[427]

> **Plant**: those things that are "planted" into position such as a concrete-mixing plant and
>
> **Equipment**: those things that are mobile, such as a bulldozer

Owning costs can be identified as:

> **Depreciation**: loss in value of a capital asset
>
> **Maintenance**: major repairs and replacement parts
>
> **Investment**: costs arising from investment and ownership

Operating costs are typically identified as:[428]

> **Fuel**: this would also include lubricants and additives
>
> **Running repairs**: these are minor repairs and replacement of small parts

Transportation: this includes transporting to and from the site and set up and dismantling

Operator: this includes the salary and fringe benefits of the individual operating the equipment

Overhead costs are typically broken down into job overhead costs and home office overhead costs, or sometimes referred to as "operating overhead costs".

Job overhead costs are costs that are the most misunderstood and the most difficult to calculate outside of home office overhead costs. Costs that are of a general nature, but relate directly to the project are considered job overhead costs. The articles of the contract may often give define what job costs may arise on a project during its duration and should alert the engineer as to the cost categories that must be captured in the job costing system. For instance, the following categories could be considered job overhead costs:

- Liquidated damages
- Taxes and duties
- Legal fees and costs that are related to the bid and the contract, not a dispute in the future
- Consultant fees and costs which are required for services such as surveying, testing, etc.
- Contract document sets
- Personnel expenses
- Fees and premiums for permits, bonds, insurance
- Protection of life, work and property, primarily as it relates to temporary works
- Contingencies for delays, damage, emergencies, inefficiency, etc.
- Financing costs for short term financing as required for the works

Indirect costs are those costs that cannot be classified as direct costs as it is either impracticable or impossible to do so. Indirect costs include home office overhead costs and are probably the most debated costs. However, the debate typically does not occur until the end of a project when a dispute has arisen and the contractor makes a claim. How home office overhead costs are calculated has been a debate for decades. They are defined as "*those costs that cannot be attributed to any particular job. It is characteristic of these costs that they are incurred by a construction company whether or not it is actually doing construction work.*"[429]

However, a certain portion of the home office costs are attributable to each project within a company as an allocation of the operating overhead to a specific project for which if the home office did not exist and provide the overall operations of the company as a whole, the project would not exist. Thus, home office overhead costs include the costs of:

Management and Staff: including salary, fringe benefits and expenses; travel to the job sites; other expenses of home office staff attributable to a project
Business Office: Rent; office furniture; office supplies and consumables
Communication: telephone, fax, computer, etc.

Finally, an understanding of total cost and profit is essential to an understanding of cost accounting. One of the primary reasons companies are in business is to be successful which requires making a profit and without it, projects simply would not be completed. However, there are several situations where a profit may not exist, either as it was not planned initially due to reasons of market entry, or staff and equipment usage during slow times, or because the project simply did not go well and experienced either a break-even or loss situation.

Cost Control

According to Clark and Lorenzoni, a cost control system has four major functions:[430]

(1) It should focus management attention on potential cost trouble spots in time for corrective action or cost-minimization action to be taken. It should detect potential cost overruns before rather then after they occur.
(2) It should keep the project manager informed of the budget for each specific area of responsibility and of how expenditure performance compares to budget.
(3) It should create a cost-conscious atmosphere that keeps all persons working on a project cost-conscious and aware of how their activities impact on project cost
(4) It should minimize project costs by looking at all activities from a core reduction point of view.

Cost control must be integrated with other control processes such as change control, schedule control, and quality control. The causes of variances, the reasoning behind the corrective action chosen, and the development of revised estimates should be documented so that they not only are used for change orders (variances) to the original project contract, but serve as part of the project historical database for either dispute resolution processes or for other future project planning.

Cost control requires that the project “costs” be broken down into various categories which is structured on an integrated control structure that takes into account what work is being performed, who performs the work, who is accountable for the work, what the project’s cost accounting code is, what the project’s contractual relationship, the project location, the project system, etc. This is best achieved with a work breakdown structure commonly referred to in the industry as WBS, or a Bill of Quantities (BOQ), which are the items for payment under the contract.

A WBS can graphically portray the work to be done, whether it is a division of engineering, procurement, or construction and helps to correlate tasks, schedules, estimates, performance, and technical interfaces. It acts as a vehicle for integrating baseline cost and schedule and thus is an aid to meeting project objectives. The WBS can further provide a mechanism for accumulating and forecasting costs and schedule data in support of overall project analysis and reporting. It is typically a matrix in which each item is referenced by two codes: a definition code that defines the location and type of work being performed and an execution code that shows how the items will be packaged for contracting.[431]

The WBS is typically accompanied by a cost breakdown structure (CBS) for cost planning which is a catalog of all the cost elements expected in a project and when summed, equal the project budget. While the WBS is made up of project elements that are related to work tasks, the CBS comprises project elements that are related to cost control accounts.

A cost control system consists of five control elements that are tied to various stages of a project: (1) establish a **baseline estimate** to use as a plan to monitor and control costs. The estimate should include the quantities, the unit costs, productivity, wage rates, etc.; (2) Once the baseline is established, **monitoring** can begin. The cost data collected must be the same WBS as was used to establish the baseline estimate; (3) Monitoring then allows the engineer to perform **Variance Analyses** that compare the actual data collected to the baseline estimate. Changes from the baseline estimate can be identified, thus providing early warning signals that allow decisions to be made; (4) Once changes are identified, **Corrective actions** can be taken before a problem arises; (5) As the project progresses, the baseline estimate may need to be reforecast in order to portray an accurate **forecast** of the costs at completion.

Cost control systems and processes should be closely aligned and integrated with the schedule of the project. Schedules produce state and completion dates, the percent complete, and the duration of the remaining tasks-all essential ingredients for the engineer to have in order to calculate cash flow and variance analysis. The budget estimate provides dates for work hour and craft breakdowns, quantities to be installed or produced, expended work hours, an costs that are used for the schedule to determine durations, percentages completed, labor force loading, earned man-hours and overall costs.

6.3 Quality Control

Quality, as defined by PMI, is:[432]

> *… the totality of characteristics of an entity that bear on its ability to satisfy stated or implied needs.*

As noted by PMI, project quality management processes:[433]

> *…include all the activities of the performing organization that determine quality policies, objectives, and take responsibilities so that the project will satisfy the needs for which it was undertaken. It implements the quality management system through the policy, procedures, and processes of quality planning, quality assurance, and quality control, with continuous process improvement activities conducted throughout as appropriate….. The Project Quality Management processes include the following:*
>
> > ***Quality Planning-****identifying which quality standards are relevant to the project and determining how to satisfy them*
> > ***Perform Quality Assurance-****applying the planned, systematic quality activities to ensure that the project employs all processes needed to meet requirements.*
> > ***Perform Quality Control-****Monitoring specific project results to determine whether they comply with relevant quality standards and identifying ways to eliminate causes of unsatisfactory performance.*

It is also important for the Project Manager to recognize that modern quality management compliments modern project management. For instance, as stated by PMI, both disciplines recognize the importance of:[434]

- *Customer satisfaction — understanding, managing, and influencing needs so that customer expectations are met or exceeded. This requires a combination of conformance to specifications (the project must produce what it said it would produce) and fitness for use (the product or service produced must satisfy real needs).*
- *Prevention over inspection — the cost of avoiding mistakes is always much less than the cost of correcting them.*
- *Management responsibility — success requires the participation of all members of the team, but it remains the responsibility of management to provide the resources needed to succeed.*
- *Processes within phases — the repeated plan-do-check-act cycle described by Deming and others is highly similar to the combination of phases and processes....*

In addition, quality improvement initiatives undertaken by the performing organization (e.g., TQM, Continuous Improvement, and others) can improve the quality of the project management as well as the quality of the project product.

In planning for quality, the Project Manager must determine which quality standards are relevant to the project and how to satisfy them. Such quality standards for international work are now set forth in the ISO 9000 standards, which are often incorporated into the contract.

Quality assurance is then all the planned and systematic activities implemented within the quality system to provide confidence that the project will satisfy the relevant quality standards. Quality control involves monitoring specific project results to determine if they comply with relevant quality standards and identifying ways to eliminate causes of unsatisfactory results.

Quality Control in construction typically is the process of assuring compliance with minimum standards of material and workmanship in order to insure the performance of the project in accordance with the design. Standards to be measured are usually included in the specifications of the contract. Implicit in the measurement of quality is that traditional quality control practices are the notion of an acceptable quality level which is an allowable fraction of defective items.[435]The Quality Control process considers three key activities: The inputs, the tools and techniques for performing quality control activities and the outputs which allow management review and corrective actions to be taken if needed.

The inputs required for effective quality control include:[436]

- A Quality Management Plan
- Quality metrics
- Quality checklists

- Work performance information
- Approved Change Requests
- Deliverables

The tools and techniques for performing quality control on a project can include:

- Cause and effect diagrams-commonly referred to as “fishbone” diagrams, these illustrate how various factors may be linked to potential problems or effect.
- Control charts-the purpose of a control chart is to determine whether or not a process is stable or has predictable performance. Control charts also illustrate how a process behaves over time including whether the application of a process change resulted in the desired improvement. For example, the control chart could be used to determine whether cost variances or schedule variances are outside of acceptable limits.
- Flowcharting-this process assists in analyzing how problems occur. A flowchart is a graphical representation of a process. While there are many styles, all process flowcharts show activities, decision points, and the order of processing. They can also show how the various elements of a system interrelate and assist the project team in developing approaches for dealing with problems and issues when they arise.
- Histograms-this is a bar chart that shows a distribution of variables.
- Run charts-these charts show the history and pattern of variation. It is a line graph that shows data points plotted in the order in which they occur. Run charts are effective when performing trend analyses for measuring technical performance and/or cost and schedule performance (i.e. how many activities per period were accomplished with significant variance?)
- Scatter diagrams-this diagram shows the pattern of relationship between two variables and allows the quality team to determine whether there is any possible relationship between changes.
- Statistical sampling-this method of quality control involves selecting a sample from a population of interest for inspection. However, without adequate interpretation, small sample testing results can be misleading. Samples must be representative of the entire population under consideration and are expected to be chosen randomly so that each sample would likely to be chosen.[437]
- Inspection-this is the examination of work to determine whether it conforms to standards.

The outputs can include such items as:

- Quality control measurements-these represent the results of the QC activities that are fed back into Quality Assurance.
- Recommended corrective actions-this involves corrective actions taken as a result of a QC measurement
- Recommended preventative actions-this includes actions taken to mitigate or eliminate a condition that may occur that was identified through a QC measurement
- Requested changes-as a result of the recommended actions, this would be a change request to the project

7 SUMMARY

Although Japanese and U.S. Project Managers come from different cultural backgrounds and may have different priorities in the values in which they lead their daily lives, when the time comes to plan, execute, and monitor a project, the basic principles upon which this must be performed to ensure that the project is completed on schedule, within budget to the expected quality with minimal risks are, essentially, the same.

The key to success is choosing the appropriate Project Manager and team and ensuring that these individuals are properly trained in what the basic principles are with an understanding of why they are important. Once the basic principles are understood, the manner in which they are executed may vary according to technology and means and methods which most effectively and efficiently allow Project Execution to take place. These techniques will be the tools employed to ensure contract administration effectively takes place with proper record keeping, project monitoring, and reporting. With this in place, the goals of completion on time and within budget have a greater chance to succeed.

Project management essentials include project manager responsibilities, defining and meeting client requirements, risk assessment and management, stakeholder identification and involvement, contract negotiations, project work plans, scope and deliverables, budget and schedule preparation and monitoring, interaction among engineering and other disciplines, quality assurance and quality control, and dispute resolution processes. Considerations must also include asset management which seeks effective and efficient long-term ownership of capital facilities via systematic acquisition, operation, maintenance, preservation, replacement, and disposition. Goals include optimizing life-cycle performance, minimizing life-cycle costs, and achieving maximum stakeholder benefit. The three most critical project management tools for every engineer to understand are schedule control, cost control and quality control. These three factors not only apply to design and construction works, but any activity in which an engineer has management responsibilities. Failure to meet any one of these areas will result in the project and/or activity not meeting its intended goals.

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[389] Parts of this Chapter are based on published papers of P. Galloway: "Harmonizing Japanese and U.S. Practices for Effective Project Management", *Taisei Corporation M.I.T. Conference*, Tokyo, Japan, November 1, 1996, "Employing Effective Project Management to Achieve Project Success", *Taisei Corporation P.M. Conference*, Tokyo, Japan, October 31, 1996, "International Contract Administration Issues: Project Documentation, Dispute Proofs, Programmes and Productivity", *Training Workshop on International Construction Contracts and Contractor Claims* organized by The International Development Law Institute (IDLI), Rome, Italy for the Finnish International Development Agency (FINNIDA), Helsinki, Finland, October 13-16, 1992, "Contract Administration", Masters Degree Course, SINNEA, *Institulo Di Studi Per La Cooperazione E La Piccola E Media Impresa*, Bologna, Italy, September 25, 1992, "Effective Construction Contract Administration", *University of Wisconsin -Madison, College of Engineering*, Madison, WI, April 7-10, 1992, "International Contract Administration Issues: Project Documentation, Dispute Proofs, Programmes, Productivity", co-authored with K. Nielsen, *IDLI Conference*, Rome, Italy on December 12, 1991

[390] Kunishima, M and M. Shoji, *The Principles of Construction Management*, Sankaido, Tokyo, Japan, 1994.

[391] K. Nielsen, Doctorial Dissertation on proposed Japanese construction standard form of contract for civil works, 2005

[392] Kunishima and Shoji, *The Principles of Construction Management* (November 1995), ed. Sankaido, p. 24.

[393] Modified from original table form M. Kunishima and M. Shoji, *The Principles of Construction Management*, Sankaido, Tokyo, Japan, 1994 (English version, 1996) page 24. It was first presented by the K. Nielsen as "Trends and Evolving Risks in Design-Build, BOT and BOOT Projects", given at the ASCE/ICE Triennial Conference, Session IV: Pitfalls in International Engineering and Construction: What to Watch For, Philadelphia, PA, US, October 17-20, 1996. It was subsequently published in the modified form by the K. Nielsen in "Trends and Evolving Risks in Design-Build, BOT and BOOT Projects", *The International Construction Law Review*, Volume 14, Part 2, April 1997. It has sense been the subject of additional input from interviews conducted in late 2004 and early 2005 with executives of contractors from Europe (ABB, Kvaerner, Foster Wheeler Italy, Foster Wheeler Spain, Foster Wheeler UK, Foster Wheeler France, Walter, Zublin, Snamprogetti, Alstrom, Federici, Syseca, Siemens and Ansaldo), the US (Bechtel, Fluor, Foster Wheeler, Shaw, Wilbros, Dresser Rand, Halliburton, Kellogg Brown & Root, Chicago Bridge & Iron, The Washington Group, Black & Veatch, Mortensen and Zurn Industries); and Japan (Nippon Steel, Toyo, Chiyoda, Taisei, Kawasaki Steel, Shimizu, Kajima, Toyoda, Fuji and Obayashi).

[394] K. Nielsen Doctorial Dissertation on the proposed Japanese construction standard form of contract for civil works, 2005

[395] Wagatsuma, H., and A. Rosett, "The Implications of Apology: Law and Culture in Japan and the United States," 20 *Law and Society Review* 463, 1986.

[396] K. Nielsen, Doctorial Dissertation on the proposed Japanese construction standard form of contract for civil works, 2005

[397] Project Management Institute Body of Knowledge, *PMBOK*, third edition, ANSI/PMI 99-001-2004

[398] Ibid, p. 38
[399] Project Management Institute Standards Committee, *A Guide to the Project Management Body of Knowledge*, Project Management Institute, Upper Darby, PA 1996, p. 6.
[400] Ibid, p. 32
[401] Ibid, p. 32
[402] Ibid, p. 33
[403] Ibid, p. 33
[404] Ibid, p. 41
[405] Ibid, p. 44
[406] Ibid, p. 45
[407] Ibid, p. 45
[408] M. Ramey, "A Basic Primer for Understanding a CPM Schedule"
[409] An exception to this is in the case of negative float, the critical path is the largest negative path. Negative floats occur when the project is delayed past the project completion date, and no extension of time has been granted.
[410] Available float is measured at the start of the work day. Therefore, at the a.m. of the late start date, the available float is 1 day, at the close of the work day, the available float is 0.
[411] This example assumes that progress on the rest of the scheduled activities has been completed in accordance with the schedule, thus there are no other delays which would influence the completion date calculation.
[412] Free Float is calculated by subtracting the early finish date from the early start date of the successor (i.e. following) activity. Free float is the amount of time an activity can be delayed before it delays the start of the next activity.
[413] Constraints are restrictions placed on the activities in the schedule such as: start or finish on a certain date, start or finish no earlier or later than, mandatory start of finish, zero total float, zero free float and hammocks.
[414] Reza Nikain, "Reviewing the Contractor's CPM Schedule: An Owner's Perspective", (undated)
[415] Ms. Galloway is a member of PMI's College of Scheduling Board of Directors. See www.PMI.org/PMICOS or www.pmicos.org
[416] Ms. Galloway is a member of AACE'Is National Planning and Scheduling Committee
[417] See **Appendix B** for a copy of the survey that was sent to all stakeholders and the results of those responding
[418] See paper authored by Patricia D. Galloway, PE. Entitled A Comparative Study Between the US/Europe/Asia of University Courses on Critical Path Method Scheduling and How These Courses Compare to the Time Management Body of Knowledge of the Project Management Institute.
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[430] F.D. Clark, A.B., Lorenzoni, *Applied Cost Engineering*, Marcel Dekkar, New York, 1985

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[432] Ibid, p. 84

[433] Project Management Institute Body of Knowledge *PMBOK*, third edition, ANSI/PMI 99-001-2004

[434] Ibid, p. 84-85

[435] C. Henrickson, *Project Management for Construction,* Version 2.1, 2003, http://www.ce.cmu.edu/pmbook/

[436] Project Management Institute Body of Knowledge *PMBOK*, third edition, ANSI/PMI 99-001-2004

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XI. RISK MANAGEMENT [438]

1 INTRODUCTION

All projects, especially construction projects, experience the onset of problems from the moment they start. Experience with transnational projects in many geographical regions suggests a higher probability that difficulties facing managers are far more complex and more likely to threaten failure. In short, transnational projects face great risks. The methodology developed and explored in this chapter is risk minimization through risk identification, risk assessment and risk management. The key tenet is prevention, much like medicine today, seeks to reduce the risk of injury to health by identifying and proactively addressing the risk before disease occurs. Risk, however, is broader than typically considered. One of the reasons that the subject of risk is so complicated and important is that it brings together technical issues with social ones. If risk is regarded as a purely technical matter, mistakes are likely to be made. If the technical issues are ignored, this is also dangerous. Ideally, one needs to have a clear appreciation of both the technical components and the social aspects of a risk in order to manage that risk successfully. Often, the issues need to be examined in a way that might seem surprising or departs from common sense. However, this is true of much of engineering — engineers would not be skilled professionals if following common sense were all that is required.[439]

It has only been relatively recently that the interaction between technical and social issues has been recognized by the engineering community as issues that cannot be separated, but must be considered simultaneously in the dilation of engineering solutions. Increasingly, it is recognized that successful engineering, which almost by definition makes a difference to the lives of people in society, needs to put the social implications of engineering practice at the heart of its concerns. Engineering is essentially about proactively improving the environment in which we live. The buildings of roads, bridges, dams, power plants, buildings, telecommunications, etc., are all directed at this. Thus, engineering is first and foremost an activity that interacts deeply with society. It requires a profound understanding of society's needs and aspirations and an ability to communicate and debate with the community how best to meet those needs. It is an economic activity concerned with the optimum use of scarce resources. It is a cultural activity that impacts on lifestyle and behavior. It does all of this within a disciplined technical framework able to deliver the engineered products best suited to meet society's needs.[440]

The engineer is often looked upon as the person who designs and constructs a project, a person who is very technical in nature and not generally considered a manager or having the knowledge and capability to analyze the overall project. However, experience has shown that the "pure" non-technical MBA candidate, although extremely knowledgeable in management, does not understand the basis behind potential risks and problems which arise during the course of a design and/or construction or an engineered project. Thus, it becomes necessary to look towards the engineer who has developed a hands-on experience base in both technical and managerial oversight to perform Project Risk management services. The engineer can add tremendous value to the project with his or her combined technical and social skills whether he/she is a third party consultant, the project consulting engineer, or as serving as the project risk manager. Both skills are critical for identifying, assessing, monitoring and communicating the risks along with risk action plans to the stakeholders of the project. While this chapter focuses on risk definition, risk identification, risk assessment and the process of risk management, the engineer plays a vital element to the entire risk management process and is assumed to be a project participant in the entire risk management process described herein.

Starting with the dictionary definition,

Risk –is the "*... possibility of loss or injury: ... a dangerous element or factor*". Risk thus is both a potential condition and a specific element which may result in that condition. All projects undertaken contain risk of loss. All contracts contain individual elements of risk that might result in loss. The risks in not meeting project goals have even greater consequences as well.

Project Risk Management- what is it? It is <u>not</u> the construction management of a project; it is <u>not</u> the oversight of a project; and it is <u>not</u> project inspection. Risk is a difficult topic to define. From the day an idea is born for a project, the project is faced with risk, risk that the project will not end up the way the owner wanted it, whether that be in quality, scope, time or cost. Generally, project risk can be defined as:

> *Any activity, event, or action which tends to cause a negative impact to the planned goals of project scope, quality performance, execution time, or cost.*

PMI in its *PMBOK* defined risk management as *"a systematic process of identifying, analyzing, and responding to project risk."*[441] The effectiveness of a risk management system can be measured by its ability to accomplish the following:

- Cost and schedule estimates are at an acceptable level of accuracy.

- Execution risk has been identified and evaluated.
- Contract risk has been identified and evaluated by analyzing the legal requirements and contract structure, the project delivery method and organization risk, and the scope of work and performance standards.
- An action plan has been developed to mitigate the impacts from identified risks.
- A reliable performance system is in place to monitor the risk.

Thus, project risk management is the minimization of risk through the use of good project management tools, techniques, and advice provided to senior management, who has the ultimate control of a project, to identify the risks associated with a project, thus allowing decisions to be made to ultimately minimize cost and delay.

An infrastructure project has a life that stretches from its identification as a potential need through in-service use. To assure risks are addressed and handled requires project management processes and tools are required at all stages of this project timeline. Today global project management standards are developed, promulgated, taught, and applied. The reason is obvious. Project management is an essential function that is the single greatest means of assuring that a project is successful in meeting its objectives: from cost to functionality. Similarly, project management is the single greatest means of assuring that a party with a role in the project execution (owner, engineer-constructor, contractor-subcontractor, vendor, etc.) achieves its commercial, professional and related goals. Nonetheless, project management also is the most widely found cause for a party's failure to meet project objectives and party goals.

Thus, given that risks are inherent in every project and given that project management is often found to be the reason for project failure, the need for risk management has become paramount in all construction projects. While the term "risk" has been defined, one must also define what is meant by "risk management."

Risk Management is a systematic process intended to reduce or eliminate financial loss inherent in projects. For example, managing risk at a project stakeholder level often involves different approaches:

- ➜ If you are the owner, key initial risk management maybe determining whether to go forward with a project and reassignment or insuring risk should the answer be yes.

- If you are the contractor, a primary risk avoidance decision approach is a bid/no bid decision or how to identify and manage risk.

Thus, risk management has emerged as essential for all projects no matter where they are executed in the world. Risk management techniques are evolving as a key project management process to maximize achieving goals for any construction project and the respective stakeholders in it throughout the project's life.

2 THE RISK ISSUE

Projects and their management are varied, maybe nowhere as broadly as transnational projects intended to meet commercial, industrial or public purposes. Despite many differences in such projects, there are common characteristics:

- Project execution is often accomplished through many contracting parties with little or no direct legal or contractual responsibility between them. Many informal partnerships also survive without formal agreements.
- Cultural differences in management approaches cause decreased efficiency in addressing the dynamics of a project life cycle.
- Technology and "local or industry" practice often changes during the period within which a party performs their role in the project.
- The performance of obligations (technical and contractual) by contracting parties occurs over a lengthy period.
- Responsibilities and party interfaces blur as performance patterns and trends evolve over the extended period of project execution.

Historically, given these characteristics, when transnational projects have performance and/or execution problems such as late site availability, unsuccessful capacity management, poor partner performance, or unforeseen sub-surface conditions like antiquities or hazardous wastes, there is a significant risk of cost increasing and performance time extending at significant cost to many parties. Thus, there is a real risk to the management, planning, financing, execution and quality of a project or program and a threat to the initial cost and time frames. Coping with this complexity is not simply a matter of applying existing techniques more rigorously. Project-based risk management has to explore all the potential risk issues. Risk management employs new management techniques to deal effectively with the shifting sands of this complex environment. Without risk identification and planning, and the ability to anticipate the constantly shifting pattern of actual project knowledge, the reduced ability to affect attainment of goals increases the risk of failure.

Risks are inherent in every project which can occur from the time of the inception of the idea for the project all the way through to the completion of the project. So, what are the risks that need to be managed? Risks are primarily to the account of the owner who ultimately bears the financial responsibility for the design and construction of the project. These risks can occur with respect to how the financing of the project may have been established, to the wording of the contract, to potential conflicts between contracts for different parties on the same project, to the execution of the design or construction. Experience demonstrates that most risk to achieving project goals occurs at the same place that many disputes commence. These are typically the interfaces that are inherent in all levels and in all aspects of a project. As stated by Mr. Kris Nielsen, President and CEO of Pegasus Global Holdings, an international management consulting firm, in his paper entitled “International Construction Projects—Managing Risk in the Field”, these interfaces can include:

- **Physical Interfaces:** The interfaces between structural components in the exterior wall, the coordination of electrical elements with piping systems; meeting tolerances for manufactured windows or door within the completed construction of walls.
- **Contractual Interfaces:** The interfaces between contracts or contract elements, such as, coordination responsibility for the same work by different subcontractors; differences in notice requirements between different provisions of a single contract; conflict between standard contract terms and the General Conditions or Special Conditions of the Contract.
- **Participant Interfaces:** The interfaces between parties, such as, requirements of difference financing agencies for different elements of the same project; timing requirements for the execution of work between different parties’ scope of work; coordination of design consultant activities.
- **Craft Interfaces:** The interfaces between various trades or crafts employed in executing the work.
- **Document Interfaces:** The interfaces between plans and specifications, such as requirements for foundations in the civil drawings which do not conform with the requirements for the placement of electrical and mechanical equipment or structural components; tolerances specified in specifications which are difference that those shown on drawings or which are not consistent between elements which must match (e.g. walls with built-in door or windows) incomplete details for matching components.

- **Multinational Participant Interfaces:** The interface between cultural practices project participants in multinational projects from different cultural backgrounds with differing management, administrations, or ways of doing business, including the work experience base, normal commercial sector practices and management approaches to supervising crafts or resources (e.g./ significant equipment versus labor to accomplish the same task).

The impact of risks to a project can be so severe, that it is essential that risk be a primary focus of senior management. This is not to say that first attempts to resolve risks shouldn't also be performed at the lowest management/supervisory levels. Facts are more easily known by the individuals charged with identifying and managing the project risk, since they will have firsthand knowledge and can deal with those issues However, the process and execution of project risk management must be understood, addressed by, and promoted by senior management.

3 RISK MANAGEMENT PHILOSOPHY

> *The best processes are useless if they are treated as a box ticking rather than real concentration on ensuring that the process adds value...Strong leadership within a team can often provide remarkable results at times of crisis as can an organisation clearly focused throughout on risk management, with each risk being managed at an appropriate level within the organisation by individuals and teams who have the awareness of risk as part of their culture.*[442]

The discipline of risk management has made considerable progress in the last few years. Corporations are taking a high level interest in risk management with identification of risks that affect not only projects, but the very corporation itself. Spurred by the banking industry's concentration on risk management practices coupled with the more recent United States Sarbanes-Oxley's rigorous standards for corporate governance, some corporations have adopted what has been deemed "enterprise risk management" which seeks to integrate available risk management techniques into a comprehensive, organization-wide approach.[443]

Most senior managers recognize the value of insurance for catastrophic risks. The prescriptive medicine represented by the insurance industry has accomplished much. But insurable risks deal only in the chance of catastrophic loss, not the lost chance of commercial profit or failure to meet public infrastructure needs. Hence, efforts to avoid losses in property, liability, and personal injury cases are the scope of insurance risk management. On the other hand, the broad multitude of factors which can enhance or degrade the successful attainment of project goals throughout project activity can also be identified, evaluated and managed. Successful risk management will always affect the company's and/or project's ability to successfully meet cost goals. The ultimate objective of risk management is to help manage company and project specific performance so that fewer performance problems with consequent dispute resolution probability are avoided. With respect to projects, it is also a means of allowing flexibility in project evolution and execution since diligent risk analysis at project onset will prepare for project variants.

Risk analysis and management is applicable in any area where risk of non-attainment is perceived to be a problem, for example:

- Conventional engineering and industrial projects
- R&D management
- Public Program management
- Public procurement tender arrangements
- Acquisition and merger activity
- The process of collaboration itself.

Each level in the company must share its own perceptions of the key risk issues with other interfacing levels. A Project Manager cannot identify the vital issues to higher management unless he or she understands the impact of the issues on the business. But this sharing must not dilute or confuse the accountability for risk management decisions. The business manager is still accountable for the business risk, but decisions are made in the knowledge that the project or operations manager accountable for technical risk management understands what is at stake for the business, and vice versa.[444]

Risk management should begin at the corporate level with risk policies in place for which the managers execute their respective roles and responsibilities. A risk policy should be supported by a set of risk management principles such as[445]:

- Risk management is the responsibility of persons accountable for the successful completion of any activity, program, project, process or service relative to the achievements of any objective.
- Risk management is a continuous process and not a single task only undertaken prior to moving to the next process step or phase.

- Risk management encompasses the implementation of cost effective control and contingency plans with the intent of exceeding goals and objectives including the minimization of cost, time and liabilities.
- The active management of the risk shall be an integral part of the normal management and review process to define future actions and/or plans and to ensure their satisfactory execution.
- Formalized risk management processes are essential for satisfactory negotiations with clients, partners, suppliers and regulators.
- Activities that may affect the company image or reputation shall be subject to formal risk management.
- A documented risk process is used.

In addition, for corporate risk management programs, the underlying tenets should reflect the company's risk philosophy during the entire life cycle that it's involved in a project. A few of the more basic tenets from typical corporate risk management programs include:

1. Risk management must be a high priority, throughout the entire organization.
2. Risk management must be an active, not a passive effort.
3. Risk management processes must be formalized and consistently employed to the greatest extent possible.
4. All projects must have an appropriate balance between risk and reward.
5. Contractual terms are fundamental to the protection of the organization's interests.
6. All departments or operations are responsible for managing risks so as to protect the interests of the company.
7. The company must execute projects so as to ensure maximum achievement of goals.

Care must be taken to be certain that the true purpose – project success – is not lost in the maze of possible project management approaches.

To do this, companies must create an atmosphere or culture where all resources are focused on the management of project risks. Dependence on individuals no matter how skilled or experienced is dangerous. As noted previously, the risks are evolving and have greater consequences. Even the most experienced project managers are no longer individually capable. The breadth and seriousness of risks faced and the decline or inappropriateness of old skills make it essential that risk management be institutionalized, i.e. that it be built into the structure of the organization.[446]

In addition to a comprehensive focus on projects and risks, the structure of the risk management program must also achieve two other conditions: (1) the systems created must be useful and effective on a day-to-day basis on the front-lines of project management performance; if it is not useful to those doing the project management, it simply is not effective, and (2) the company must be organized to provide skilled resources to reinforce those front-line teams when risks materialize.[447] To accomplish this result requires the dedication of company management and the implementation of innumerable procedural and organization details.

Risk assessment and management are not add-ons to mainstream operating activities. They must be embedded in ongoing operations and continuously employed. This continuous process is based on an overall framework, consisting of four stages: risk identification, assessment, management and feedback. From time to time the process is interrupted for review and audit. While good record keeping and documentation are fundamental throughout, they are absolutely crucial for audits.[448]

As is the case in any attempt to steer an organization in a particular direction, many levels of effort are required. Specific procedures must be developed and implemented, training and incentives must be put in place and the entire process needs to have management support. One overriding essential is that management creates an atmosphere where it is “OK” and a virtue to disclose and elevate problems. It is equally critical that all corporate personnel and departments recognize that their highest priority must be support of projects and the management of risk faced by them.

3.1 Risk Management Characteristics

Successful Risk Management Systems (the “Systems”) employed by owners, contractors, and project finance lenders and others have the following characteristics:

Start Early - The earlier risk management begins on a project the greater the benefits achieved. As a contractor’s project matures from tender submittal to contract execution to project execution the number of variables that the contractor has to manage risk is greatly reduced. As well, steps taken to correct risk impacts are more costly when addressed late into construction than they would have been earlier in the design phase.

Objective - The system must provide an objective analysis. The only way risk can be managed at any level within an organization is to minimize bias from the analysis. Large disputes and project overruns occur even when the company and the project team are familiar with the industry and the project environment. The system should consider the level of company experience, familiarity with applicable technology, past engagements with the client and project location in the evaluation of certain risks for example. These “familiarity” factors should not however be used to eliminate any risks from being considered and evaluated.

Uniform Technique - The system must provide a uniform technique and methodology for two reasons. Company and project management make key decisions based on the analysis. If the analysis is done differently on projects or even within the same project, the analysis cannot be relied upon without a complete review and dissection of each analysis performed. Secondly, like other company policies and procedures, the risk management system must be managed and communicated in order to work. Opinion–laden, individually developed approaches to managing risk will undermine the required project team input to the exercise and often lead to the “surprise” disaster project which veteran owners and contractors have all been a part of.

Flexible - Most Systems prescribe project thresholds in terms of dollar value, project scope or project delivery method (EPC, Lump Sum, Maximum Price Guarantee, etc) to determine the level of scrutiny projects must undergo. The system used to evaluate risk must be flexible enough to allow projects of varying cost magnitude and complexity to be evaluated with the same fundamental techniques. These techniques must be applicable to each of the industries that the contractor serves.

Thorough - While the system must flexible to adapt to large and small projects, it must also be thorough enough to address risks appropriately on every project. Large disputes have occurred on reimbursable, moderate sized projects. Someone will be held accountable for budget overruns on reimbursable projects, which means that there will likely be some disputes to resolve as budgets dwindle late in the project.

Simple - While being thorough, the system must also focus on being as simple as possible for a number of reasons. First, risk will be managed by or through a project management team that is busy with a variety of tasks so the system must function without being overwhelming. Many cumbersome systems fail because they are abandoned by project staff too busy to maintain them. Second, new staff, project team members, and subcontractors or consultants who provide inputs into the company's risk management project program, will need to learn and function within the project program almost immediately. A steep learning curve is essential.

Expand Evaluation - Risk management cannot be left entirely to a small group of people who are not directly connected with the project. As discussed later, ***each project is a unique set of risks*** and risk management programs that rely on the past experience of key staff alone to identify risks are prone to miss issues created from the unique combination of client, location, scope, and contract and technology novelty risks. The system must expand the risk evaluation beyond company management and project management to be most effective.

Expand Communication - Project risks and changes to a project's conditions must be communicated by the team in a manner that will allow everyone to understand the key risks that are being managed by the project team, how they are being addressed and how this risk and its chosen management method will impact their individual efforts. The system should also allow an easy transfer of risk information to each group in the life cycle of a project responsible for managing risk. The system should communicate the risks that the tender submittal group identified as important to the contract negotiation group. The contract negotiation group should be able to communicate their risk concerns and actions taken via the System to the project execution team, and so on.

Prioritized Response - The system must identify in clear objective terms, which risks are of most concern and then deliver manageable action plans that allocate project resources to address the more significant risks on a priority basis.

Cradle to Grave - The system must provide for the management of risk from the earliest possible stage in the life cycle of a project to the final close out of the project. Risk management programs often that fail identify risk early in the life of a project and then fail to address project risk change during tender negotiation and especially during execution of the project.

Integration – The system must be capable of interfacing with the customary project controls tools used to develop bid tenders and manage projects. Information from these project tools is used to manage the project and therefore should be a direct input into the system. Likewise the output from the system should be capable of being used in the cost management, schedule management, quality management and other project management process without duplication of effort to gather information or maintain records.

4 ASSESSING RISK

4.1 General Methodology for Identifying and Assessing Risk

The principal objectives of risk management for both the owner and the contractor can be stated in five goals:

(1) Cost and schedule estimates are correct to an acceptable level of accuracy.

(2) Execution risks are identified and evaluated, beginning with the question: Is the plan appropriate for the specific project?

(3) Contract risks are identified and evaluated, including the analysis of:

- Compliance with corporate legal requirements,
- Contract Structure / Project Delivery Method/ Contract organization risks, and
- Scope of Work / performance standards / deliverables

(4) Action plans are developed to avoid or mitigate impacts from the risks that were identified.

(5) A reliable risk management performance system is in place to monitor and report on action plans during each stage of the process: project planning, bid tender, contract award and execution of the project.

Since a project has an inherent element of risk, the ability to manage such risk through decisions is most effective when the fewest decisions are “cast-in-concrete”. Unfortunately many project decision points occur when scope and quality definition is least easy to predict, that is early in the project planning and design. The ability to effect decisions before they are cast in concrete is the greatest when the least knowledge is available. Thus, there are broad envelopes of risk that threaten project goals.

For example, when risk is allocated contractually, as in many European projects where the contractor is allocated all knowledge, of let’s say, the hydrological conditions to be expected, actual conditions encountered can differ significantly from those upon which a design was based. As the project is executed, actual experience would reduce the risks of comparable problems for work yet to be performed.

This problem is typical also of projects conducted under multinational funding where a funding agency prescribes detailed deliverables and timescales. Multinational shared cost research projects typically are defined up to one year before funding commences. Planning is phased over a three-four year period with only annual review points when significant change can be made. Variants then have to be negotiated under conditions where the original contract appears to be breached or is in danger of being so. Not the best atmosphere for maintaining project motivation. Variants are too often interpreted, wrongly, as a sign that errors have been made. The problem could not partially resoled by upfront recognition of the areas where variants might be expected.

The transnational project management objective is to reduce the time variance between the actual knowledge and the ability to influence the project so as to increase the potential for project goal attainment. Ideally, the maximum knowledge coupled with the maximum ability to make decisions will reduce then risk potential. Experience with transnational projects demonstrates that the risk situation can be improved by recognizing when and how the risk of not meeting project goals occurs.

Risks may not be totally eliminated, however, they can be minimized through a systematic step by step approach which will identify, assess and respond to those risks. The risk management process consists of four basic steps:

(1) The *identification* of potential or actual risk.
(2) The *assessment* of the risks identified
(3) The r*isk management process*- which is the development of risk mitigation action plans and execution reviews on a regular basis to assure project management responsiveness.
(4) *Adjusting Management* to account for project dynamics.

4.2 Risk Identification

The variables of transnational projects make identification of all risks virtually impossible. None the less, there are specific techniques useful to enhancing the attainment of project goals, especially in today’s global environment.

Risks need to be identified by brainstorming sessions with whatever the stakeholders are deemed to be at the time. For public/private partnership projects, this would include the financier, the owner (or government), the designer/contractor consortium and the regulator (or other stakeholders such as unions, safety regulators, environmental agencies, etc). For a traditional design-bid-build project, this would probably be a two or three step process with each stakeholder (owner, designer, and contractor) performing their own internal risk assessments in order to minimize their own respective perceived risks.

The identification process must commence with the listing of the risks as they appear at a given point in time or they may evolve in the future. The project Risk Manager would meet with the owner with senior management present, for a day or two, to identify all the potential risks which could arise during the life of the project.

The identification process can begin with a risk matrix to focus on a potential party, collaborative organizational structure, and/or scope of work that may present particularly acute risks. Project contractors, procedures, standards, government regulations, project design documents, and so on, can be used to compile a list of activities necessary to achieving project goals. Each activity can be weighted for its potential risk of failure. Risk here is defined as the potential for inadequate delivery of a project of the scope and quality required within the cost and schedule budgeted. Potential risk can be numerically weighted as follows: high risk-1; moderate risk-2; low risk-3.

The project risk identification process is merely the alarm signal for the potential or actual risk that project goals will not be met. Then comes the more difficult and demanding part. As a manager or the Risk Manager, the first risk management consideration must be the relationships of the parties and interfaces as defined in the contract documents. Thus, the next step would be for the project Risk Manager to review the contract or contracts after they are drafted to identify additional risks that may be inherent from the clauses contained therein or conflicts that may arise between the contracts. It is preferable for this review to occur prior to contract execution to allow revision of the contracts. Otherwise the task becomes one of monitoring throughout the remainder of the project of now known risks that may arise.

However, no matter what the forum is for the initial risk identification, the risks need to be collected and recorded in a formalized document such as a risk register[449] that will be maintained over the duration of a phase, program, and/or specific project. The risks are typically identified based on the respective individual stake holder's past experience on past similar projects and/or contracts. Risks should be continuously identified throughout the program and/or project with new risks added as they are perceived and/or emerge while old risks should be discarded if they are no longer applicable or monitored for any changes and change in the risk mitigation measures to be employed should they arise.

4.3 Risk Assessment

As in the risk identification stage, it can be very helpful to produce a simple pictorial representation of risks and their controls to identify coverage, by producing a risk control matrix. A second matrix can be established reflecting potential issues or problems with experience and the project review suggest could occur. The problems can be weighted or ranked by their potential "risk of occurring" (a subjective judgment). For example, a value of 1 is highly likely to occur; 2 has an even chance of occurring; and 3 is unlikely to occur. Similarity, potential impacts to the project or a party's responsibility can be weighted or ranked. For example, a value of 1 is a significant impact; 2 is a moderate impact; and 3 is a low impact. As in the first matrix, when the two values are multiplied and the resultant value is a 1 or 2, there is an area of the project requiring careful risk management evaluation.

Risks should be assessed against criteria determined before or during the risk identification phase. Risks should be assessed for their likelihood of impact to the program and/or project along with an agreed ranking for each. The impacts may need to be further broken down into a number of different categories relating to money and/or time. Once ranked, the risks can then be "mapped" so that the risk profile can be seen at a glance, such as the inclusion within a risk matrix. Such a tool then serves as a clear communication tool for anyone wanting to see what risks have a high or low potential of occurring as well as a high or low potential of impacting the project if they do occur. Information should include the type of risk, the specific risks within each risk type, the severity of the risk, the probability of occurrence, any expected timing (in months or years depending on the project), and the changing probability over time.

The risk matrix can be as detailed and complex as required including the use of risk modeling tools, or it can be as simple as a three by three matrix table. The choice depends on many aspects, including the users of the information, budget for the risk management process and the financial impact of any of the identified risks occurring. This information is then included in the risk register along with the management strategies that have been agreed to be employed should the risk arise along with the individual (or company) that will be responsible for carrying out the risk control/reduction and/or mitigation plan.

If it is not otherwise clear who owns and manages the risk then columns should be added to identify the relevant managers. Once the risk and control structures have been placed on the matrix, the cells can be filled in to show:

- Which risks is a given control intended to address?
- Which controls are effective in reducing a given risk?
- Who is tasked to manage the risk?

Additional columns can be added in the matrix for the quantification step, if this is applicable (e.g. cost of risk control) at the simplest level, the applicability can be indicated by a “yes” or “no” in relevant cells. More information can be included in the matrix by using a scale, such as High, Medium, or Low, to indicate how effective the control is in dealing with the risk. The risk control matrix is a powerful tool for displaying different levels of information on relations between risks and controls. Even in its most simple, qualitative form, before any quantitative information is included, great insight can be gained by looking at the overall risk-control pattern.[450]

The risk control matrix will allow one to clearly see the specific parties and their responsibilities for each activity which can in turn be identified and numerically weighted. For example: primary responsibility-1; secondary/approval responsibility-2; no responsibility-3. For a specific activity, when multiplication of “risk potential” weight and “responsibility” weight is a value of 1 or 2, more detailed review is appropriate during the project. Problems or failures typically occur at the interface points with the lower levels of combined weights.

In consideration of each of the matrix developments, for each risk, the following parameters should be considered:[451]

Severity: What percentage of the company’s value, or the project’s budget/completion could be affected by the risk? Consideration should be given to factors that could increase or decrease the risk impact.
Probability: What is the likelihood of the risk occurring? Consideration should be given to prior situations and/or projects that are similar in nature and/or face similar constraints.
Timing: When during the process or project does the team believe that the risk is most likely to occur? Identification should be made of the time period(s) where the risk could have the greatest impact.
Changing probability over time: In the deliberations, the team should attempt to determine whether the likelihood of the risk is increasing, decreasing or constant.

The mega infrastructure projects of today are typically carried out by multi-national consortiums, whether that is by the owner or the contractor side. While each stakeholder comes from a different country and a different perspective, the risks should be comprehensively measured in a common currency. In this way, each company, when viewing the risks from a common viewpoint, can compare and aggregate the risk and link them to decisions regarding capital allocation, pricing and risk transfer.[452]

4.4 Risk Management Process- Development of Risk Mitigation Action Plans

Once the risks have been identified and assessed, the next step is to determine what options should be considered to achieve one or more of the following:

- Avoid - make a fundamental change so the risk is no longer an issue.
- Reduce - reduce the chances that the potential event will happen.
- Mitigate - reduce the consequences of the risk, if it should happen.
- Transfer - transfer the effects of the risk to another organization more capable of handling it.
- Do Nothing - accept that the risk may be realized and therefore accept the consequences.

Before determining which option to consider, management should consider the discussions in the risk assessment with respect to what was recorded in the risk register including:

- The likelihood and impacts of the risk.
- The effectiveness of the strategy in meeting its objectives.
- Other consequences, desirable and undesirable, of the strategy on the issues.
- The cost of implementing the strategy.

These considerations will allow an evaluation of the effectiveness of the options, and thus allow decisions to be made. Too often owners will not take the time to fully perform a complete assessment and management of the risks, instead believing that the risks can be transferred to contractor. However, never is the case where risk can be fully transferred. Thus any contract clauses that are intended to achieve the transfer of risk will need careful examination.

By having such a risk register and risk matrix in place, one can then have the necessary tools for the next step-the development of risk mitigation action plans. For every major risk identified, there should be someone or a team responsible for preparing a formal risk management plan as so discussed in the prior step of the risk management process. The formalized document will include information gathered from the risk register developed from all the prior steps that outlines the risk assessments made and assign responsibility for executing countermeasures.

The formalized document will constitute the necessary action plans to address the risks by considering the potential impact and the nature of each risk. Action plans are intentionally written to integrate into the existing management processes of the project. Every risk is managed in one of three ways:

- The risk is kept and controlled
- The risk is transferred to a third party to manage and they are compensated to do that.
- The risk is insured against defects.

Once a risk is identified and evaluated for potential impact, each of these options should be considered. The appropriate selection made based on cost, confidence in outcome and the nature of the risk evaluated.

4.4.1 Management Action Review

Project risk management evaluation provides both a qualitative and quantitative assessment of management action. The qualitative aspect provides an indication of the expected effectiveness of transnational project and transnational party management in terms if the effectiveness of the organization, processes, systems, procedures, and personnel under potential problem situations. The quantitative aspect deals with the ongoing execution reviews in functional responsibility areas.

The four phases of the management action review include:

- Planning process review,
- Organizational review.
- Execution review,
- Control processes review.

The effectiveness of the overall risk management process is determined by evaluations several sub-processes which are sequential in any specific management effort.

First is the *planning process review*. Its focus is to determine whether the parties to the project can initiate and complete the requisite activities to assure risks are recognized and responsive actions planned. For example, does the contractor's schedule reflect known or highly likely events (like the annual flooding on a river to be bridged?)

Next, *organizational reviews* focus on whether there is a developed, responsible management organization to implement the results of the planning process. For example, do multinational engineer and contractor joint venture organizations reflect an ability to make timely decisions during execution of the project?

Regarding *execution reviews*, the degree to which the parties succeed in accomplishing intended objectives is tested, based upon an evaluation of the overall performance/ was the organization responsive? Were alternatives identified and reasonable evaluated?

Finally, the *control processes are reviewed* to determined the existence, quality and use of cost, schedule, resource, financing an related planning and monitoring systems it accomplish the project within goals The results of these analyses are integrated with one another to develop a comprehensive and expected portrait of the management process. Then, for example, specific factors and events which can result in cost escalation and/or schedule extension are pinpointed in a more detailed risk matrix than employed in the identification step above.

4.4.2 Execution Review

Regular review of project information and control reports, to identify actual impacts on project goals, provides insights into events which have an effect o the ability, or desirability to maintain those goals This approach is especially effective if performed by a non-involve party, such as a consultant. This review is not intended to be exhaustive or to result in substitution for good project management.

In addition to monitoring the risks that are identified on the Project Risk Register, the project Risk Manager should periodically review a sampling of project documents such as shop drawings, logs, correspondence, daily diaries, photographs, and CPM schedules for the process of identifying potential risks that may arise during the course of the project to bring to the attention of senior management. This allows senior management to be pro-active and make decisions relative to the risks before the risk becomes a problem and liability.

The project controls reporting systems (particularly schedule, resource use and cost), can be employed to identify the costs of the solution or management approach, and the resultant reduction in impacts previously identified. The actual project controls reports can also be employed to monitor the continuing emergence of the risk and its impact. Such reviews also enable a focusing to proper time frames and project records to determine causes for the risk and projections of risk management effort effectiveness. Where there are complex notice provisions (such as in FIDIC), or requirements for the use of Alternative Dispute Resolution (ADR) approaches, these risk analyses can also determine when notice should be or could have been given. Although these techniques are similar to those that may be employed in after-the-fact evaluations of impacts, they are being used in a proactive approach to reduce the incidence or impact of project risk.

One example of a proactive review which has been applied successfully is for the project Risk Manager to review the contractor's CPM schedule when submitted. This review is not to usurp the construction manager's duty and responsibility for review of the schedule for logic, durations, and reasonableness in accordance with contract document. The project Risk Manager's role is to review the CPM schedule for potential manipulation of the schedule which could create misleading critical paths and/or activities. In addition, there may be certain logic and/or activities that create inherent risks that would not necessarily be identified by the Construction Manager. Further, when the contractor files an intent to file claim, or makes an assertion that owner action has caused certain delays to the project, the project Risk Manager can assist the owner in providing a third-party review of the delay and its impact on the project.

Another example would be the review of correspondence. The content and tone of letters can often raise potential issues which become risks that must be addressed. Since the project Risk Manager is not continually on the project, and does not have daily familiarity with the project records, these nuances are more easily identified by the Risk Manager from the project documents. Again, these potential risks can be discussed with senior management to determine what actions must be taken and decisions made to circumvent any future problems.

Review of patterns and trends and identification of potentially major impacts result from the analysis of project documentation. Will the multi-national contractors' decision to progress the road works from east to west, rather than the originally planned west to east increase the project's potential risk from adverse weather in the early summer rainy season? How was this change analyzed in the schedule? Do regular updates to the schedule suggest a trend toward delay in project completion which further increases delay risk to the project from adverse weather? The identification of such events is compared to similar evaluations performed at earlier dates to provide additional information regarding actual impacts, casual factors. Alternatives available, recommended actions, and effectiveness of those taken.

Such integrated reviews:

- Isolate the existence or potential of such risk impacts
- Relate these to event occurrence
- Assess their controllability by management and the extent to which management actions have influenced results.
- Facilitate management's ability to adjust their framework and/or execution approaches as necessary.

The approach for dealing with risks throughout the project is dealt with through action plans that are initially developed in the initial risk assessment. The action plans must focus on the "root cause" of the Risk Event to be affective. For example, defining the risk as a "non-payment by the owner" does not lead to any particular action by the contractor. There may be dozens of reasons why the owner has not paid. However, non-payment by the owner due to "failure to substantiate installed quantities in accordance with the contract" as a condition to meet on each invoice would precipitate discrete steps to secure what "substantiate" means.

As the project matures, events occur and scopes change creating new risks thereby altering the priorities of previously identified risks. The risk management process must be updated to reflect these changes throughout the duration of the project, thus giving rise to the term "Cradle to Grave Review."

Each Action Plan must have the following elements:

- Designation of whether the action plan is monitor, mitigation or prevention
- Description of the action to be taken.

- Definition of the measurement taken to trigger action.
- Responsibility for the action to be taken.
- Record what element would be affected by the action plan

It is very important that the action plan fit the characteristics of the risk since it is unreasonable to assume that the human and financial resources on every project are unlimited. A key function of an effective risk management system is to prioritize resources to address the most important risks first.

Table XI-1 "Relationship of Action Plans to Risk Ratings" below relates the type of action plan to the risk ratings reached in the evaluation process.

TABLE XI-1 RELATIONSHIP OF ACTION PLANS TO RISK RATINGS		
Action Plan Type	**Likelihood of Occurrence**	**Severity of Impact**
Monitor	Low-Medium	Low-Medium
Preventative	Low-Medium	High
Mitigation	High	Low-Medium
Combination	High	High

On risks that are likely to occur, resources should not be expended on trying to prevent occurrence, but rather on mitigating the impact. Similarly, if the severity of the impact is rated High, resources should focus on preventing the risk from occurring. If on the other hand the risk is both likely to occur and have a sever impact on the project, use what works.

Figure XI-1 illustrates the type of analysis which independent consultant regularly reviewing the project risk management would employ. **Figure XI-1** represents the typical series of activities that are undertaken during such a management evaluation review process.

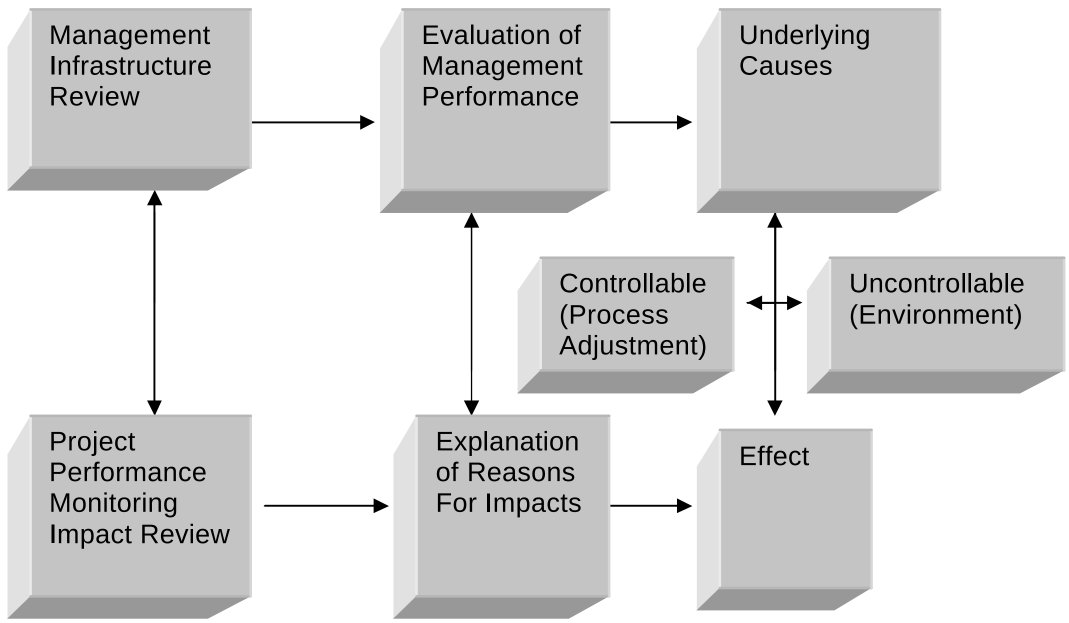

FIGURE XI-1-PROJECT RISK MANAGEMENT EVALUATIONS REVIEW PROCESS

On a horizontal plane, two concurrent efforts are undertaken. The top horizontal plane evaluates qualitative project management process. First is a determination of changes to project management organizational structure, system, procedures, personnel, and so on (the management infrastructure). A review of project records develops a sense of why changes have occurred. Where they in response to issues, problems, or events which occurred on the project? Were they intended to meet new stages of project execution, for example, in moving from research to prototype in a research project?

Continuing horizontally in **Figure XI-1**, the review identifies the effectiveness (real or perceived) of the changes. Was the procurement time from identification of item to be procured to placing of a purchase order reduced by procedural change? Was the quality reduced by procedural change? Was the quality reduced as evidenced by rejection rates for the procured item? Again continuing horizontally, if there have been performance failures, what are the causes?

Concurrently with these review, **Figure XI-1** in the lower horizontal plane reflects evaluation of quantitative project measures and results of project execution. First, what do project management and control reports reflect relative to schedule compliance, maintenance or budget, quality issues and so on? Second, what appear to be the reasons for variance from plan? Third, would these reasons typically cause the impact reflected in the reports?

The vertical arrows demonstrate the relationship between quantitative and qualitative evaluations. The concurrent evaluation efforts are interdependent and iterative. Frequently, cost overruns are the driving force to make an organizational structure change. Yet, such a reaction many not handle the cause of the problem, and the project will continue to experience cost overruns. Last, the evaluation is intended to determine if experienced risks have been managed, and if not, can further changes meet actual causes-schedule management process, adjustments of controllable events, and so on? Or were the risks environmental and one time issues? If so, will the changed project management process meet the challenge more effectively? Thus, **Figure XI-1** reflects a periodic review to assist in improving the management of risk as actual project execution occurs.

This approach provides a blend of qualitative (management process review) and quantitative (impact) evaluations. Both of these analytical activities are accomplished concurrently and provide linkage between the cause of an event or change and the effect of that event of change. This linkage enables understanding of underlying reasons and implications of identified events. The linkage also provides the empirical evidence necessary to determine whether the event or change was controllable (result of incomplete project risk management) or uncontrollable (the result of an isolated project execution issue). In the example of a change in the direction of the progress of the road work, this form of review can reduce controllable risks and. Thus, reduce the potential for uncontrollable risk impact, such as, from annual floods.

Detailed risk management execution review can also focus on discrete problems and causes. For example, during the execution of a dam project in Southern Europe, there were apparent delays in timely receipt of "for construction" documentation.

The Issue was identified as the disconnected sequences for processing "for construction" drawings demonstrated. Timely recognition of the issue by the consultant retained by the multinational constructor joint venture led to corrective management actions. The result was an improved ability to meet project goals.

4.5 Adjusting Management

To succeed, project risk assessment and risk management require consistent application. For senior managers to accept the process, they must have belief in the capabilities of the reviewers. Experience, again, suggests some criteria to be considered.

To be effective in project risk assessment and risk management, a broad-based experience in management issues, industries and projects is a necessity. Experts who have not experienced in one capacity or another the frustrations and failures arising out of poorly organized projects, inappropriate delivery systems, poorly drafted contract, late and incomplete designs, slow approvals, improper material, poorly supervised labor, disruptive changes, bureaucratic administration obstacles, unanticipated interferences, defaulting sub-contractors, impossible payment, back-charges, defective workmanship, or insolvencies, have not earned "their wings". Similarly as an example, eastern European transportation project experience is useful and necessary in evaluating a project in that part of the world. None the less, experience in other types of projects, locations, and industries will be more significantly beneficial. The knowledge and experience provide more than just the limited perspective provided solely from only such a project in that specific region. Thus, there is not a "we have it under control or we have always done it that way" perspective. There are "lessons to be learned" from other transnational projects and the complexities of their respective environment.

Effective project risk assessment and risk management results from senior management decisions to review understand and act appropriately. Project risk assessment and risk management evaluations are not a substitute for their management decisions-making any more than they are substitute for project management. The effort is to provide a defined process of focusing and enabling of management actions without bias, but with balance and comparable experience.

The adjusting management is best performed through the use of Risk Profiles. The Risk Profile is one of the tools used to systematically guide the implementation of sound, effective risk management on engineered and constructed projects. A Risk Profile may be used in every project situation. A Risk Profile is a dynamic tool that needs to be updated and changed through each stage of the project life cycle.

The fist task of a Project Risk Profile should be accomplished in the risk management phase to identify the scope of risk contained within the project as established by the project stakeholders and as allocated within the contract documents. When the scope of work is completed a profile of the specific risks inherent within the project emerges. Developing the Risk Profile requires attention to various fundamental principles and sequential steps that must be undertaken to complete a useful profile and mitigation mechanism.

First, the fundamental principles:

- Elements of project risk in every project and on every page of the contract document set associated with a project, from the formal signature page to the last cited code or exhibit.
- Elements of risk exist independent of the protections or limits of liabilities established within the contract document set and, for the purpose of managing the project, risks should not be ignored because of the protections or limitations of the contract. Neither the owner nor the contractor should manage a project to a contractual limit of liability, rather, projects should be managed to control risks and its sources.
- No one person is competent to identify and/or evaluate all of the risk elements associated with a project and its contract document set.
- Communication of risk and its potential sources among all project constituents is critical. If the appropriate parties have not identified potential sources of risk, they cannot implement action to avoid or mitigate that risk.
- Each engineered and constructed project is unique. As such, the Risk Profile must be developed and tailored to meet the specific needs and peculiarities of the project.
- Having developed a project specific Risk Profile, it is necessary to audit the project against it, as well as to update the Risk Profile periodically. This process allows the inclusion of new risk sources that may potentially occur during execution and also facilitates addressing changes to risk elements originally identified.

Once the fundamental principles of risk and its sources are understood, an effective Risk Profile can be generated to provide the project management team with a mitigation mechanism. A Risk Profile generally first identifies elements of risk into three categories:

- project organization and relationships
- hard scope of work; and
- soft scope of work.

Project organization and relationships involve those formal, informal and scope-dependent relationships that exist in every project where more than one party is involved. This is typical the case and the trend in international practice. These relationships can be shown in a pair of organization charts in which different levels of formal responsibility and roles can be identified. The project organization and relationships are concurrently direct and indirect, formal and informal and, unless known and properly identified, represent a major source or risk, as previously discussed.

The hard scope of work is generally the easiest component to identify, as it consists of what are commonly known as deliverables within the contract document set. A hard scope of risk element normally requires a product, some tangible action or a quantifiable result. Hard deliverables include such items as monthly progress reports, cost estimates, schedule updates, design packages, etc. Hard scope items carry clear terms of success or failure (the project team both completed and submitted the design package or it did not) and often have significant liquidated damages associated with them.

The soft scope of work consists of the stated obligations, responsibilities and duties that require interpretation to define. These issues are often difficult to measure compliance against or to prove. Soft scope risk elements exist in provisions of the contract documents set that use the words “coordinate”, “assure”, “best efforts”, etc. A soft risk element can be disputed on a number of different levels from interpretation of the requirement itself, to how the execution of the element is to be judged. In most projects, soft scope claims are the easiest to make and the most difficult to defend against.

Listing the risk elements inherent in a project via these three categories is only the first step. It is also necessary to evaluate each of those risk elements for likeliness of occurrence and potential impact on the project as previously discussed.

5 IN THE BEGINNING –THE OWNER’S RISK ASSESSMENT

All of the risks on a project belong initially to the owner. The decision to proceed with a project is a gamble in which the bettor must balance the possibility of loss (present and future) or inability to meet the need for the project against the possibility of gain or improvement in the quality of life for users of an infrastructure project-such as a power plant. In effect the owner is betting money that he can overcome the risks of the project and, if successful, can significantly earn a return.

Successful organizations do not enter any project on a “gamblers hunch”. They conduct extensive cost/benefit analyses and risk assessments of every project they intend to undertake. Only when the balance between potential return and risk of loss is “right” do organizations move to take the gamble. There is no specific ratio of risk to return or usefulness followed by all organizations. For example: In the power industry in the United

States, the risk-to-return ratio was historically very conservative, with utilities generally able to almost exactly predict the cost to return ratio of every power project undertaken. Unfortunately, in the 1970's and 1980's, the utilities undertook a series of projects which would have a devastating impact on the industry as a whole - generally referred to in the industry as the "nuclear holocaust." What happened? In part the industry did not accurately identify risks inherent in the projects and so did not conduct accurate cost/benefit analyses on those projects. A mistake for which some utilities are still paying.

The power industry attempted to identify the risks based upon over 100 years of power generation experience. All of that experience was founded in known generation technology - boiling water with gas, oil or coal to generate steam to turn turbines. The power industry believed that a nuclear reaction was simply another fuel source for boiling the water. Nuclear material was simply seen as a cheaper way to produce the same amount of energy. When the decisions were being made to undertake nuclear power projects, almost no one was citing the fuel or the technology needed to utilize the fuel as a risk. In fact people were relieved to think that there was a peaceful use for atomic energy. By the 1980's the fuel and its technology were the risks which killed nuclear power generation.

The industry did not identify or measure the risk correctly and the cost of that mistake was in the hundreds of billions of dollars across the industry. One example: A medium nuclear plant was undertaken at a 1971 with an estimated cost of $315 million. It was expected to take 5 years to construct. By 1985 the plant was completed, over six years late and at a total cost of $1.2 billion. It never got licensed to load fuel, was partially demolished and converted to a coal-fired plant at an additional cost of approximately $67 million and taking an additional 2 years to finish. Total cost for the construction of a coal-fired plant of that size was approximately $150 million in 1971 and it took just under 4 years to construct. The utility in question now has the single most expensive coal fired plant in the world at over $1,267,000,000. And it took only 16 years to build.

Who made the money the utilities lost-technology vendors, suppliers, engineers and construction firms.

Throughout a project's life there are organizations with a stake in the project with project management personnel or the equivalent responsible for assuring goals are met and ever-present risks are managed. Stakeholders must identify and use risk management tools that are applicable to the risks faced and assure effective return in managing those risks if they begin to affect the project.

All projects start as an idea; that is, a concept for a facility, structure or power project that will fill a specific need, within a specific time, and at a specific location. In general terms there are no limits or boundaries on concepts – if it can be imagined, someone can turn the concept into a project. However, not every concept should be transitioned into a project. Therefore, it is during the early stages of a project that stakeholders test the physical, technological and expense versus return feasibility of the concept. A concept must pass three tests to be practical:

- Can the project be physically engineered and constructed?
- Does the technology exist to engineer and construct the project to meet the purpose intended?
- Does the expected benefit of the project justify the cost of engineering, constructing and operating the project?

If a concept fails any of the three tests, then realistically it should not be built. Yet, there are examples of projects being built in almost any location in the world which fail one or even all of the tests. However, in almost every case the execution of those projects had serious economic or social side affects, some intended and some unintended. Ancient to recent history is full of examples of projects which never should have been undertaken because the concepts failed to pass one or more of these three tests. Also, risks from not balancing stakeholder goals can become "locked in" once the project is financed or funded.

There are enormous risks involved in moving a project from concept through feasibility to financing. It is no longer enough to have a "good idea" upon which to seek money. In today's global economic structure the "good idea" must be backed by hard analysis and deep examination of the multitude of risks involved in executing and assuring a useful life. As projects become increasing complex and as competition for a share of the finite pool of global financial resources to fund construction projects increases, financing-funding sources must make well based decisions on which investments have the best chance of a significant return (economic or social). These decisions are tied to identifying potential risks and if these risks are manageable.

Risk management tools used early in the project's life include risk models and data banks that allow a rating of potential risks and provide input to shape project management processes as the project moves into its execution. Such risk management tools focus on providing developers (public and private) and financing organizations with the means for determining risks from project and context specific conditions, and how the subject project compares to other potential projects.[453]

The types of risk which should be evaluated for any project include eight primary areas focused both on project specific and project context issues:

5.1 Project Specific

Project specific risks are those risks which involve the actual project contemplated. These risks include:

Delivery/Operations This risk factor involves those issues or concerns associated with engineering, procurement, construction (EPC) execution and operation of the project.
Technology This risk factor involves those issues or concerns associated with the technologies involved in the EPC methods and operation technology of the project.
Financial This risk factor involves those issues or concerns associated with the financing of the project, including the EPC period and operations or equity financing.
Procurement-Contractual This risk factor involves those issues or concerns associated with the contractual and procurement approaches/systems/processes used for both EPC and operation of the project.

5.2 Project Context

Project context risks are risks that are inherent with respect to where the project is being constructed. Project context risks are most commonly the areas where the highest cost risks to a project can occur yet are often the areas that are most overlooked when evaluating a particular project. Project context risks should be considered equally as important as the project specific risks. Project context risks include:

Political This risk factor involves those issues or concerns associated with the local, regional and national political situation confronting the project.
Environmental This risk factor involves those issues or concerns associated with the environmental problems, concerns and activities confronting the project during the EPC execution and the project operation.
Social This risk factor involves those issues or concerns associated with the social and cultural impacts of the project to the community and region within which it is to be located.
Economic This risk factor involves those issues or concerns associated with the macro economic impact of the project to the community and region within which it is to be located.

Once the risks are identified, the owner must decide how it wants to manage those risks. Insofar as an owner position in managing risk on any capital project is concerned it is important to remember that what you don't know can hurt you. In effect the owner has three choices concerning elements of risk which are inherent in a construction project:

1. Keep the risk and attempt to control it.
2. Allocate the liability and responsibility for managing risk to other parties in the project.
3. Insure the risk.

However, if an owner fails to identify a risk element, it by default gives up the option to either allocate or insure against the impact of that risk. The owner decision will depend on a host of factors, including his own competencies, his financial position and his risk comfort level. In the construction industry three categories of risk are generally off loaded by an owner: engineering and design; construction, and; acts of God. Acts of God are insured. As to engineering and construction, the owner pays for another party to assume all or a certain portion of the risks that may be typed under those two broad categories.

Every decision the owner makes regarding risk changes the margin between cost and benefit. If the owner chooses to insure against a certain risk the owner must shift some of the potential profit into the actual cost side of the formula. It becomes a complex exercise to balance the off-loading of risk from the owner because every risk off-loaded will cost the owner more money. Theoretically, when the cost of off-loading the risk is the same or greater than the cost of the owner keeping control of the risk, the owner should keep the risk in house.

The owner must make hundreds of such decisions long before any other potential party to the project is even aware of the existence of the project. A discussed above, at the beginning of the project, owner's have all of the project risk. The project is a financial investment that they will only undertake if it will be profitable, or on some occasions is required for regulatory compliance. In either case, the owner will develop a series of project goals that the project must meet in order to be approved and be successful. Owners will have to balance the criticality of these goals and prioritize them. For instance, if the owner wants the shortest schedule possible, the owner may not have the timetable to minimize construction costs by allowing for competitive bids for the construction scope after engineering is completed.

The owner has two key tools to apportion risk to contractors:

Selection of the Project Delivery Method: The manner in which the owner divides up the scope of work on a particular project. The owner does this in order to best address risk to its Project Success factors. These project delivery methods include: turnkey, design-bid-build, design build and a number of variations and combinations of these three methods.

Selection of the Contract Form: The compensation mechanism for the contractor. These include: lump sum, guaranteed maximum price, unit price, reimbursable models and combinations of any of those.

The owner also will likely set qualification criteria (i.e. may request a design competition, etc.) to select the best contractor for its specific project. Therefore, the key objectives initially for the owner's risk management system are to:

- Define the project success goals;
- Prioritize those goals
- Identify risks to the project success goals;
- Optimize the project delivery method and contract form to manage risks to those project success goals;
- Determine the criteria for contractor selection;
- Prioritize risks and actions to be taken, placing more priority on those risks that pose the greatest potential impact to the project; and
- Manage risk due to change and variance from plan.

By the time a contractor gets involved in an owner's project, the owner has already made the basic decisions as to risk. In effect a contractor would not even be involved in an owner's project if they had not already decided to off-load certain risks by purchasing the contractor services. By the time that a project is let the ratio has been set and the owner has the two holy numbers cast in stone - the cost against the potential profit.

The owner cannot control the future profit so he must control the cost. While he may have decided to off-load his risk by having the contractor accept that risk for money, he is not willing to re-acquire that risk at a loss, or pay additional sums to the contractor for the risks which in his mind he has already paid the contractor to take off his hands. If the owner has paid a set amount to engineer a facility, he will not feel in any way obligated to pay more for that facility than we told him it would cost. If the contractor runs into problems during engineering that increase that cost then in the owner's mind we have proven that his decision to off-load the risk was correct. In an owner's mind, the contractor agreed to the price of the work knowing that the risk existed and accepting that the contractor would bear the cost if the risk became a reality.

Decisions as to whether to retain, allocate or insure a risk depends upon the evaluation of an individual risk. Generally, a risk should be assigned to the party in the best position to manage or control that risk. However, risk allocation is not simply resolved by making a choice as to which party will be paid to take responsibility and liability for a particular risk element. Risk allocation is a management decision as to how best and who best to manage and control a risk element so that it will have the minimal impact on project cost, schedule and quality goals. Allocation of a risk element to another party does not imply that the owner may simply act as if that risk element has been eliminated from the project. An owner cannot escape all of the impact which accompanies a risk element which manifests and is not controlled.

To monitor risk management on a project the owner must have the cost, schedule and quality control systems in place which enable it to track the activities and progress on the project. Likewise, the owner should require its contractors to utilize project control systems designed to monitor and manage cost, schedule and quality on a project. The contractors systems should be compatible with those used by the owner so that data flow between the two parties is as easy as possible. The monitoring of allocated risk elements is to some extent predicated on an owner having a requirement that every party engaged in the project has and follows an acceptable, formal risk management program. The total risk profile should include the processes and project control systems by which allocated risks will be monitored and enforcement actions will be taken.

6 AFTER THE FACT: RISK AND THE CONTRACTOR

As noted above the contractor's involvement in a project does not occur until after the owner has established the holy numbers and decided the risk strategy that is to be employed on the project.

The contractor must identify risks associated with the conditions of this particular project created both by the contract terms and by the execution environment of the specific project in a relatively short period of time. The contractor has a matter of weeks to perform this task in order to develop an appropriate estimate, whereas the owner may have taken many months to prepare the terms and project structure to best manage its risks. In addition, the burden to identify and quantify change is almost always placed on the contractor. As a result, a contractor's risk management systems tend to be more qualitative in the analysis, simpler in structure and very adept at monitoring the affects of change on project risks.

The key objectives for the contractor's risk management system are to:

- Select bids, which offer an appropriate balance of risk and reward by assessing risk before committing to preparing a tender;
- Quickly and thoroughly identify and assess the risks associated with the particulars of the contract and execution environment so that an appropriate estimate can be developed considering the costs and resources needed to manage identified risks;
- Track the risks and actions taken to address the risks (mitigation/prevention) during each phase of the project from estimate to bid tender to negotiated contract through execution;
- Prioritize risks and actions to be taken placing more priority of those risks that pose the greatest potential impact to the project; and
- Manage risks due to change and variance with plan.

TABLE XI-2
RISK MANAGEMENT BENEFITS FOR EACH PROJECT PHASE

Phase of Project Life Cycle	Key benefits of risk management
Bid/No Bid	Conservation of bids costs-bid only projects with acceptable balance or risk and reward
Proposal Stage	Provides more accurate estimates. Allows contractor to accept risk by managing it Confidently- competitive edge. Identifies areas key for negotiation.
Execution Stage	Address risk early at less cost. Preserve entitlements during project.

During preparation of the bid it is critical to identify all of the potential sources of risk so that they can be accurately evaluated and priced. Following award and during contract negotiations, while the contractor may be able to modify or place upper limits on his risk exposure, he is not usually in a position to dictate to the owner the basic terms under which he will accept the contract. Regardless of that attempt to cap the potential loss, once the contractor has decided to tender a bid it has, in effect, accepted the risk elements that exist within that project scope of work as established within the contract document set. A risk identified during preparation of the bid or proposal, but forgotten during execution is essentially a disaster waiting to happen. It is not enough to identify the risks which exist in a contract or project. The project execution must be monitored constantly to ascertain whether those risks identified do emerge and then to assure project management is addressing the emerging risk reasonably and timely.

Unlike the owner, the contractor does not have an option to off-load any of that accepted risk, even if he chooses to subcontract a portion of the work. While his subcontract might show the risk as having been passed on to another party, the owner cares nothing for that document or its intent. In every contract situation the contractor is solely and directly responsible to the Owner for the risks assumed under the contract document set. The only pre-project risk avoidance action the contractor can exercise is at a bid/no bid decision point. *If the contractor determines that the risks transferred within the owner scope of work exceed the potential for profit, then he should not bid the work.*

Accepting that the contractor is, in fact, hired specifically to accept a risk that the owner is unable or unwilling to bear, then his only recourse is to assure that he manage the risks contained within the project so as to preclude the possible losses or at least mitigate the impact of any of those risk elements inherent in the project.

Any change to the agreement has the potential to introduce new risk elements into the body of the project. If the contractor does not demand a compensating change to his pay under the original agreement for accepting that new risk element then he is assuming all of the potential loss that might be attributable to that risk radical for free. *Every change - whether formal, informal, major, minor, early, late, easy or difficult - contains risk elements, and those risk elements may have both a direct and indirect opportunity for loss associated with them*.

There are policies and procedures developed and issued by most companies which, if followed, are intended to prevent situations like those presented above from occurring. However, no policy or procedure ever written takes the place of thinking ones way through a situation. Elements of risk can come from any direction and from any source during the full life cycle of a project and it would take thousands of pages of policies or procedures to address every possible situation. A company’s policies and procedures are not intended to provide an answer to every risk situation; they are intended to provide a sound, flexible base from which risk management actions can be developed and implemented.

It is important to realize that risk exists at every stage during a project; you never reach a "safe state" or point at which risk disappears from the project. Experience has shown that even in projects that contractors have completed on time and under budget, owner may raise contractual or execution issues which could cost the contractor hundreds of thousands of dollars. The risk management function is a continuous process of identification, evaluation and management action. The risk management process is time critical - the longer it takes to recognize and respond to a risk situation the fewer options available to the manager to apply against that situation.

Risk management tools are the key to minimizing the impacts of emerging risks, mitigation of potential claims and achieving maximum project success. Typical risk management program processes address: identification of potential risks in a prioritized manner, protocols are developed that define and monitor execution, monitoring systems can recognize risk emergence, the risk management tools most applicable to a risk are available, periodic performance auditing assures effectiveness, etc. These elements of the risk management program are developed into a Risk Profile (discussed previously) that is updated as needed and interfaced with all aspects of a project management effort.

For the contractor to become truly "risk positive" every member of a project team - be they business stream, operations or support function - must understand and practice sound risk management. There are many ways to do this, but the following have proven successful:[454]

6.1 Total Team Involvement

Because of the number and complexity of the challenges to project success there is no substitute for involvement of the entire project team in the process of understanding the risks the project faces and in recognizing how and when risks may become manifest.

One very helpful mechanism is to have the project team do a thorough review of the as-bid assumptions (scope, schedule cost, and risk assessment) and compare this to the as-sold conditions that must be addressed. This has many beneficial aspects:

- it identifies any changes from as-bid to as-sold;
- it educates the team on the baseline for the project, i.e. the scope, schedule, cost and risk assumptions from which changes and impacts must be measured and upon which risks may operate; and

- Since this must take into account the contract terms actually agreed to, this exercise should result in a carefully formulated commercial management plan.

The result should be that all essential members of the project team understand the project baseline, the risks anticipated, planned mitigation measures, and the commercial administration plan.

6.2 Risk Assessment during Execution Must Be an Iterative Process.

There should be periodic sessions where the project team revisits the baseline and the risk assessment. This re-enforces the team's knowledge of the baseline and the importance of early recognition of impacts to it. Reassessment should certainly take place at each major project milestone, e.g. start of detailed design, start of construction, etc.

6.2.1 Peer and Management Review

As with the pre-bid stage, it is recommended that the project team's re-assessments be reviewed by a disinterested person or group. Brainstorming sessions with the project team contribute greatly to the effectiveness of the reviews. Regular management reviews of the project with emphasis on risk identification and mitigation are essential to this process.

6.2.2 Dedicated Resources

One member of the project team should have as his/her first priority the duty to recognize when risks might materialize and to alert the project manager and team when mitigation efforts must commence. Far too often when project conditions are most demanding, this effort is relegated to a low priority. In fact, it should remain one of the highest.

6.2.3 Project Controls and Risk Detection

Since project control reports frequently involve too much lag time, the project team should develop other mechanisms for determining when a risk might be materializing. Symptoms or indicia of developing problems should be defined and disseminated to all. Reliance on after-the-fact reports will not get the job done.

6.2.4 Focus Corporate Resources

As indicated above, the breadth and complexity of risks and demands on project team resources are so great, that it is essential that a support structure be available to reinforce the team on short notice. In-house technical, financial, tax, insurance specialists, contract/claim managers, attorneys, and outside experts should be in place in advance.

6.2.5 Effectiveness on the Front Line

Finally, and most important, the guidelines or systems that are developed to address risk must be useful and effective at the day-to-day execution level of the projects. There are so many complexities that systems must be tailored to assure that the team can accomplish the essential steps at the project level.

7 SUMMARY

Obviously, not all risks can be identified or managed to minimize or eliminate their impacts. Nonetheless, the process can be extremely effective and many risks can be avoided, minimized and transferred if identified early and continuously monitored throughout the project execution. Once all the project participants recognize that there is risk inherent within the project and the execution of their scope of work, the process of managing that risk can become part of an effective method in reducing disputes and achieving project goals as originally intended. Since the impacts of not achieving project goals affect most project participants, there is a great need to recognize project risk management as a process that that enhances the ability to properly manage projects.

It is possible to execute a construction project without a risk management program and it is possible to attain the cost, schedule and quality goals of a project without a risk management program in place. It is even possible to execute simultaneous construction projects within a complete capital program without a risk management program in place and still meet the cost, schedule and quality goals of those projects. However, recent experience within the construction industry is that such successes have become increasingly rare throughout the industry. This is due in part to the fact that the tools and processes by which construction is executed have changed significantly in the last 20 years (i.e. computerized design, fast track execution, etc.) and in part to the fact that the contractual basis and legal interpretation of the construction party relationships have changed. Construction project execution has become more complex in reflection of the complexity of the tools and the legal/contractual environment.

Every owner and contractor in the industry is passing through a period when it seems almost impossible for all parties to meet their respective cost, schedule and quality goals. Every owner and contractor is faced with trying to discover why that is so and what can be done to overcome the barriers to success. In the vast majority of instances it has nothing to do with the physical process of designing or constructing a project but with the systems by which each party attempts to manage those physical processes. Improved management of the construction process is the best way to regain control over cost, schedule and quality goals, and alignment of the project management system and project control tools with a comprehensive risk management program has been proven to be an effective method for improving the construction management process.

The broad multitude of factors which can enhance or degrade the successful attainment of project scope goals throughout project activity can be identified, evaluated, and managed. Successful project risk management, then, always affects the bottom line. The ultimate objective of project risk management is to help manage project performance so fewer performance problems occur with their consequent expenses and bottom line impact.

The savings pay for the effort. Normal capital budget and/or maintenance and repair (M&R) budget planning frequently contains contingencies of 10% to 20% of expected cost-particularly so for projects with significant complexity. For example, a $100 million in capital and M&R expenditures per year can realize up to a reasonable achievable reduction of 5% in the actually experienced increases in expenditures. This level is a quarter of the typical budgeted contingencies. Similarly, there is the avoided cost of not diverting project management for performing their normal functions.

The benefits can be substantial. In presenting the results of improving project management from comparable project risk management concepts, an official of a multi-national company noted[455]:

> *We believe we put plants on the ground about 5% less than other similar industries…. (and) this means your new plant will give a return greater than the cost of capital for the expected life of the plant.*

Whether public or private, a project which has recognized and managed risk will come closer to successfully meeting project goals and providing successful project use or operation.

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[438] This chapter is adapted from the following articles: "Anticipating Problems: Project Risk Assessment and Project Risk Management", Kris R. Nielsen and Patricia D. Galloway, Chapter 6,

Collaboration Management: New Project and Partnering Techniques, 1994, John Wiley & Sons, Edited by H. Chaughnessay; "Risk Management Techniques Evolving Project Management Tools for All Seasons", Kris, R. Nielsen, *3rd Civil Engineering Conference for the Asian Region Conference Proceedings*, Seoul, Korea, August, 2004 and "The Owners' Role in Managing Project Risk", Jack L. DIgnum, *Associated Owners and Developers Conference Proceedings*, Miami, New York and Atlanta, September-October 2004; "A New Game Plan for intelligent Risk Identification/Allocation, Charting the Course to the Year 2000-Together", proceedings, *A Landmark International Multidisciplinary Conference on Dispute Avoidance and Resolution in the Construction Industry*, DART, October 16-19, 1994, University of Kentucky, Lexington, KY, USA, P. Galloway, "Risk Management – Now More Than Ever", Published Proceeding, *World Engineers' Congress, Session C2. Sustainable Development of Mega-cities on Model of Transportation Structure, Model of Public Transportation First and so on.* Shanghai, China, November 2-5, 2004, "Problems in Underground Construction: Lessons Learned from Failures and Methods Developed for Success", co-authored with M. Petrov, proceedings, *Underground Space for Sustainable Urban Development*, ITA-AITES 2004 World Tunnel Congress, Singapore, May 2004 . "Risk Management Analysis Techniques for Projects With Significant Environmental Issues", co-authored with K. Nielsen, proceedings, *ASCE-SAS Second Regional Conference and Exhibition*, Beirut, November 16-18, 1995, The American Bar Association Forum on The Construction Industry presents: International Construction Law – Opportunities and Risks in the '90s – Stouffer Mayflower Hotel, Washington, DC; November 5-6, 1992Co-Presenter, "Project Risk Management - Achieving Goals", co-authored with K. Nielsen, proceedings, *11th INTERNET World Congress on Project Management,* Florence, Italy, June 16-19, 1992

[439] *The Societal Aspects of Risk*, The Royal Academy of Engineering, UK, 2002

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[447] "Organizing For Effective Project Risk Management", James Leonard, Counsel Tetra Tech, New Jersey, USA, *Construction Super Conference Proceedings*, London, England, November 2001

[448] *Common Methodologies for Risk Assessment and Management*, The Royal Academy of Engineering, UK, 2002

[449] *Common Methodologies for Risk Assessment and Management*, The Royal Academy of Engineering, UK, 2002

[450] *Common Methodologies for Risk Assessment and Management*, The Royal Academy of Engineering, UK, 2002

[451] "Countering the Biggest Risk Of All", *Harvard Business Review*, April 2005

[452] "Countering the Biggest Risk Of All", *Harvard Business Review*, April 2005

[453] These risks reflect those developed by the private company, Pegasus Global Holdings, Inc. in complex models it provides Clients. See "www.pegasusconsultinginc.com" for more information.

[454] "Organizing For Effective Project Risk Management", James Leonard, Counsel Tetra Tech, New Jersey, USA, *Construction Superconference Proceedings*, London, England, November 2001

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XII. DISPUTE RESOLUTION

1 INTRODUCTION

Because construction projects are “unique” and individualistic in nature, disagreements are inevitable. No two construction projects are alike, and even if the project may be similar, the parties are always different-different cultures, different backgrounds, different experience and expertise, and different means and methods for accomplishing the goals and objectives of the project. Therefore, the likeliness of a dispute or conflict is highly probable since different individuals perceive and react to information and situations differently.

A major cause of construction project failures is the lack of early stage planning and communication about what to do when disagreements arise. Risk assessments and risk allocations are not performed as often as they should, and/or they are abandoned into the project at some point in time and/or the risk is so passed arbitrarily to one party, that the risk-shifting ends at the threshold of the party least able to handle the risk. As discussed in many of the previous chapters, identifying and setting up appropriate and reliable project management systems to manage potential problems and issues as they arise will best serve to resolve disputes quickly and enhances the chances of success for the project.[456]

Thus, in order for the consulting engineer to be an effective member of the project team, the consulting engineer must understand what conflict is, how to best deal with and handle conflict and then to be able to resolve conflict should the disagreement and/or dispute not be resolved. To accomplish this needed skill set, the consulting engineer must first be able to communicate effectively (discussed previously in the chapter on Communication), understand how disputes are to be resolved under the contract, and to be aware and understand the different forms of alternative dispute resolution methods. While disputes can also arise between the manufacturer and the consumer, or the manufacture and the owner purchasing a manufactured product, the focus of this section is primarily on the construction industry and consulting engineers. However, the area of delay and disruption analyses are applicable to any industry and the concepts should be learned and understood by all engineers in all industries if again, engineers are to take the lead in negotiating and resolving disputes between parties in the course of business and as part of the professional responsibility.

2 HISTORY OF DISPUTES

Outside the court system, up until the 1940s, most disputes on construction projects were resolved through informal arbitrations or through decisions of the engineer or architect and were done so at the project level. However, after World War II, the state of affairs began to deteriorate. The postwar period saw an incredible influx of infrastructure projects around the world, mostly to reconstruct destroyed infrastructure devastated in the war. The construction industry expanded dramatically, primarily due to technology advances in both transportation and communication which increased mobility of contractors and engineers from around the globe. As contractors and engineers became more mobile, venturing into unfamiliar regions and seeking more work from owners was new to them. As competition increased, margins decreased, particularly in periods of rising inflation. Contracts became more complex and requirements regarding environmental protection and regulatory intervention increased as well as multiple third party stakeholders entering the scene.[457] All of these influences increased conflict and as a result, increased disputes.

3 JAPANESE CULTURE AND DISPUTE RESOLUTION

One of the best-known laws of pre-Meiji days was: “Should a quarrel or dispute occur, one shall not unnecessarily meddle with it”, and a person who helps another person in such a situation in Japan without clear authorization is suspected of taking an unjustifiable advantage.[458]

Japan, being isolated and the most homogenous population on the planet, was still able to maintain in essence a “hand shake” deal with the entire details of the contract contained on one page. In the Japanese domestic construction industry, the mode of operation has been that a “drastic change order” or excessive additional works rarely were handled within the initial contract. Japanese contracting has been unilateral in nature. Even if disputes arise between the owner and the contractor, self settlement is preferred to avoid litigation. Cooperative attitudes are deeply embedded in Japanese culture and the Japanese society has traditionally placed great value on group harmony based on long-term trust. Claiming individual rights has basically been viewed as disruptive to group harmony.[459] The Japanese respect via their culture, the concept of “harmony” and despise “conflict”. While disagreements certainly arose, “deals” were able to be worked out and few matters ever went to “litigation”.

The behavior in Japan is much more cooperative than antagonistic. This does not mean that there are no conflicts that arise in Japan; rather, it means that while there are disagreements with government policies and directives, public-private interactions are carried out in a generally cooperative and productive manner.[460] However, the traditional Japanese perspective on conflict, similar to other Asian cultures, will have to be modified if Japanese Consulting Engineers are to be competitive and successful in the global marketplace.

The Construction Contractor's Law was established in May 1949 with the aim of legislating the business of construction contracting in Japan. The legislation has been amended several times. Articles 25-25.24 provide for a quick and simplified system of settling disputes related to construction contracts as established by the Construction Disputes Committee to supplement civil courts or other systems. The Central Construction Disputes Committee of the Ministry of Construction and the prefectural Construction Disputes Committees are authorized to conciliate, mediate and arbitrate disputes.[461] Article 18 of the Japanese Construction Laws "Principles of Contractor Contract of the Construction Works" states:

> *The parties of the construction works contracts go into the fair contracts based on the agreement on each mutual equal position, and carry out the contract in goof faith and sincerity.*

This basis has operated well in the Japanese domestic market. However, in the international arena where the parties have different values, different sense of ethics, come from different cultural and business backgrounds, etc, the idea of "good faith" is seriously questioned and settlement of disputes is typically handled in a confrontational manner.

Much of the reason for the lack of understanding of how to deal with and resolve disputes by the Japanese Consulting Engineer is embedded in the very nature of the Japanese culture. This culture permeates throughout every aspect of Japanese business including its construction contracts. Japan's contracts are very different than contracts in the western world. Japanese contracts are written on the basis of "mutual trust" whereas western contracts are written on the basis of "mutual mistrust". Mutual trust leads to "maintenance of fairness of right and responsibility" that has to be mutually respected by either party or business partners.[462] In the Japanese construction industry, the stronger party's one-sidedness is hidden under the practice of the mutual mistrust principle. However, in international contracts, in the midst of "mutual mistrust", parties make their feelings known and known strongly to the other party (ies).

Exacerbating the contract issue is the basis upon which Japanese Consulting Engineers are trained. As noted earlier, the Japanese engineering education system lacks the necessary basic tool for conducting business-project management skills. Even if one argues that there is project management in Japan, the current Japanese project management system lacks the necessary skill sets to solve problems in the domain of “mutual mistrust” and when confronted on international projects, typically leads to defenseless and fragile arguments, and seldom with any factual documentation to prove the position of the Japanese company. Because the Japanese culture is to look for “harmony”, due to the lack of experience in resolving conflict, exacerbated with the lack of the full understanding of the English business language, lack of understanding of construction contracts and lack of experience in similar situations, in a conflict situation, the Japanese Consulting Engineer typically chooses settlement by ‘compromise’ or are pushed backwards in a less than favorable settlement.

With the opening of Japan in the midst of WTO requirements, the decline of public infrastructure works projects in Japan and the need to move offshore to seek opportunities, the lack of dispute resolution skill sets has put the Japanese Consulting Engineer at a disadvantage.

As a result of the increase in disputes, the industry sought alternatives to the court system since neither the judges nor jury of one’s peers, or the delays involved, were conducive to settling disputes and maintaining relationships between the parties. Thus was borne the concept of “alternative dispute resolution”.

4 CONFLICT RESOLUTION

4.1 The Definition of Conflict

An American woman named Mary Parker Follett, who lived from 1868-1933, wrote several articles summarizing the fundamentals of management and problems arising out of politics and economical studies. One of the articles she wrote was entitled “Constructive Conflict”. Her view on conflict was as follows:[463]

> *When people do without conflict, people mean they do without un-identical points, namely, ‘Diversity’. Here, it is very important to notice that these two words are not the same. We may think to do without conflict, but it is impossible to do so without diversity. ….In the realistic aspects of life diversity if one of the*

> *most important characters….To be afraid of this means being afraid of life itself. Conflict is happening of diversity and does not totally mean it would end in nothing. Adversity it is the normal process and because of this the difference socially valuable comes up to the surface and is thought to be beneficial to all the concerned parties.*

Conflict, as seen by Follet, is not a “right or wrong” scenario, but rather is the ability to see the difference of opinions and differences in interest among individuals. In resolving conflict, Follet outlined three methods in her article:

(1) Domination-Method by which one party suppresses the other (Obey by intimidating)
(2) Compromise-Method by which the parties concede mutually and find agreed points
(3) Integration-Method by which both parties integrate each other’s ideas and requirements and agree on new points.

While domination is the simplest and quickest form of resolution, in the end it is seldom successful. Compromise is a very common means of conflict resolution, but seldom presents a new way forward for the parties. By “integrating” the desires and requirements of both parties, there is a greater ability to resolve disputes that may arise in the future.[464]

Successful negation of conflict is best obtained when the Follet concept of integration is applied. However, to be successful at integrating ideas, the consulting engineer must be able to address the situation calmly, eliminate conflict by recognition and start negotiating in a flexible manner, seeking out the objectives and requirements of the other party. Of course, in order to maximize this situation, the consulting engineer should possess all of the skill sets that have been previously discussed herein and should have in place good project management systems in order to have the factual support on which to proceed with negotiations.

4.2 Steps for Successful Conflict Avoidance and/or Resolution

Several steps can be taken at the beginning of the project that will foster conflict resolution and assist in bring the participants in the project together as a team with common goals and objectives and common means and methods of how to communicate information and identify problems as they arise during the project. These steps include the awareness of the need to develop several key deliverables:[465]

- Risk Management Plan-(discussed in more detail in the chapter on risk management)-defines the risks associated with the project and develops action plans to deal with specific risks as they arise by the party (ies) best able to control or manage them.
- Pre-planning partnering-workshops conducted with the consulting engineer and the design team (if a traditional design-bid-build project)
- Communications plan-defines the means and methods of communications between the parties and the public and includes meeting schedules, topics, attendees, deliverables and responsibilities
- Partnering-A formal workshop conducted with all the stakeholders on the project
- Dispute Resolution-The contract should define the various steps that will be taken to resolve claims and disputes as they arise on the project or post the project so as to meet the needs of all the stakeholders on the project. A consulting engineer should also be familiar with the different methodologies in analyzing delay and cost overruns that should be used as tools in assisting in the resolution of disputes as they occur on the project and as a means of presenting causation and entitlement at the completion of a project in case resolution is not obtained during project execution.

4.3 Partnering

One method of conflict resolution that has been successfully applied in the last decade is “partnering”. Partnering is a commitment by all stakeholders to achieve goals and objectives that are agreed upon prior to a project’s commencement. Representatives of all stakeholders are present at a meeting held shortly after project commencement where the stakeholders get to know one another, share common concerns and role-play situations that could arise during the project in order to prepare the parties involved to quickly resolve situations when they arise-thus better preparing themselves for conflict resolution.

Partnering was first introduced to the American Construction industry in 1989 by the U.S. Army Corp of Engineers. The concept was to build a mutual understanding of the goals and objectives of all the stakeholders on the project.[466] A partnering session is typically conducted by neutral individual who facilitates the discussion and partnering workshop. During the workshop, the facilitator assists the parties in being able to recognize risks, obstacles that may arise during the project, and develop methods and ways to avoid, control and/or cope with potential sources of conflict. The eventual outcome is a joint agreement that is signed by all the stakeholders and participants of the workshop that sets forth their goals and expresses their commitments to the project. However, to be successful, the partnering workshop must be facilitated by a skilled, experienced facilitator who will take into account the unique aspects of a given project, matching specific procedures and techniques to the parties and the project.[467] If done effectively, partnering has the advantage of resolving conflict and reducing the number of claims that might arise on the project.

Partnering must also not stop at the initial partnering workshop, but must be continued at regular intervals throughout the project so as to remind and focus the parties of the project that they are a team and only in collaboration as a team can the project achieve success. In addition, should problems arise on the project; a skilled facilitator can often use similar examples in the workshop with role playing by the parties which can go a long way in the facilitation of resolution of the issues arising on the project. Partnering workshops also foster communication, one major area that seems to always break down during the project, especially if problems do arise. Many disputes arise due to lack of or miscommunication. Thus, it is essential to continue to foster communication and the benefit of accurate and timely communication throughout the project. Partnering has been noted as successfully achieving this goal-an important goal in the resolution of disputes as they arise during a project.

5 DISPUTE RESOLUTION

5.1 Introduction

Disputes arise due to "claims" being filed by a party on a project. Claim, as defined in international contracts is "demanding action" and becomes the concrete method by which a dispute is resolved.[468] The word "claim" was not in the Japanese vocabulary and to openly disagree was not culturally accepted. Looking at a Japanese dictionary, the word claim is defined as: *"complaint involving request for damages given by contracting parties in business deal. (In general) "To complain", "order" "Make claim."*[469] However, contrast the meaning of the word claim to the definitions as found in the American Heritage Dictionary of the English Language: *"a demand for something as one's rightful due: affirmation of a right."* While both meanings are correct, the meaning interpreted in international contracts is the later.

A claim can be classified under four different categories:[470]

- A claim for the progress of works
- A claim for additional works and/or variation orders
- A claim due to changing conditions
- A claim for breach of contract

It is the responsibility of the consulting engineer to understand the methodologies and approaches to claim and dispute resolution. However, before delving into the details of what to look at relative to analyzing a claim, in order for the consulting engineer to be effective in the resolution of a claim, the consulting engineer must first be fully knowledge of the work, the related conditions of contract, and the need to confirm the conditions of contract. Should a claim arise, the consulting engineer should have the knowledge to perform the following steps:

- Clarification of the Scope of Work
  - ➜ Review the contract drawings and inconsistencies between them
  - ➜ Review potential inconsistencies between the contract drawings and items and the Bill of Quantities
  - ➜ Review the Variations (change orders) made to the contract and whether conflicts now exist with other provisions of the contract and/or drawings
  - ➜ Review the specifications and determine whether there are any inconsistencies between the specifications and the drawings
- Determine whether there are ambiguities and/or clarifications needed within the Contract Documents
  - ➜ Review the General Conditions of the Contract
  - ➜ Review the Special Conditions of Contract
  - ➜ Review the Contract Drawings
  - ➜ Review the Contract Specifications
  - ➜ Review other Contract information referenced
- Review the Schedule and determine whether any delay to the project has occurred
  - ➜ Determine what is contained in the schedule and whether it is reflective of the scope of work and work being performed
  - ➜ Determine whether the schedule conforms to the contract completion dates
  - ➜ Determine whether there are any “manipulations” included within the schedule
  - ➜ Determine what the penalties (Liquidated Damages) are for delay to the project

- → Determine how far behind schedule the project is at the time and the reasons for the delay including the party responsible for creating the delay.
- → Determine whether there is any ability to accelerate the project to overcome the delay

- Review the Contract price and determine whether there are cost overruns
  - → Reviewing and analyzing the changes in costs to the project and/or changes to the methods of cost control become the basis for compensating the contractor for changes to the conditions of contract.
  - → Determine whether changes to the scope of work, or conditions under which work was assumed to have progressed have changed
  - → Determine if there are affects of a change of work to planned resources, material, and/or production rates
  - → Determine whether additional costs have been expended for acceleration

5.2 Claim Analysis

As discussed previously in the Project Management chapter, three key components of the project management system can either make the project successful or result in not meeting the objectives of the project stakeholders and/or the contract: schedule, cost or quality. While issues with quality of work can be determined by a direct cost impact to either the owner or the contractor, most claims submitted on international contracts today boil down to the impact on cost and schedule, and for which quality may be an issue. Thus, in light of these two key elements of project management, it is essential for the consulting engineer to have an understanding of how to resolve either schedule delay/acceleration and/or cost overrun claims when they arise. While various methodologies exist within the industry to present delay/acceleration claims and damages claims, the author has limited the discussion to those methodologies used by the author over the past 25 years and for which have been the most successful in resolving claims, either during the project or post project completion when the claim now enters a new era of “disputes” and resolution is handled through alternative dispute resolution methods.

5.2.1 Schedule Delay Claims

In today's global construction environment, the primary variable in determining ultimate cost for comparable scope, location and quality is time. Any construction project requires a significant period of time in which to execute all of the complex steps necessary to meet all physical completion and operational requirements. Today's Engineer, Procure, and Construct (EPC) contracts are also especially prone to delay due to multi-national consortiums and major subcontracts.

Frequently, the actual time to complete the project is greater than the original time allocated. This difference in time from original plan to actual is defined as delay. Examples of elements which can increase potential for delays include:

Multiple parties providing design, fabrication, and construction of the various project elements;

- Financing delays;
- Lengthy performance period;
- Evolving technologies (both construction and design);
- Procurement of components from multiple sources regionally and internationally; and
- Coordination of a large volume of components and pieces with specific installation and interrelationship requirements over the extended construction period.

These complexities require careful planning and sequencing of individual design, procurement and construction activities.

Today, the planning, scheduling, and execution of project activities are generally portrayed in network based scheduling systems denoted as CPM scheduling. Determining whether the completion of the total project or a phase of the project has been delayed can be a difficult analytical task. Since delay usually leads to cost increases, there is a need to properly determine (once project completion or phase delay occurs) a proper allocation of delay, causes and responsible party (ies). With this allocation, there can be a technically sound foundation for acceptable resolution of delays cost attribution -- "who will pay for the delay." With multiple parties, all subject to their own performance mandates, isolating an actual delay cause and assigning responsibility is frequently difficult.

In complex projects, there is a significant potential for concurrent delays, that is, delays which are on different chains or paths of activities which may or may not be critical at the time of the delay event. Additionally, there may be multiple causes occurring concurrently by different parties. Concurrency must be evaluated in the analysis process to provide equitable resolution and attribution of responsibility. With the increasing use of CPM scheduling, the process of sorting through concurrency issues is facilitated.

5.2.1.1 Legal Claims for Delay

Delays to a project can be a result of many things, such as weather, labor strikes, permit delays, late delivery of engineering drawings, unforeseen ground conditions, equipment failures/breakdowns, low productivity, strikes, etc. Delays are classified legally into three categories:

1. Compensable Excusable Delays:

These are incurred project critical path delays which were beyond the impacted party's control. Examples for a contractor include delayed engineering drawings, prohibiting the contractor from starting work, owner suspension of the work, restricted access to the owner interference, drawing errors and omissions, etc.[471] Typically, a contractor is entitled to receive not only actual project completion time impacts, but increased costs incurred from these delays, generally time-driven or time-dependent costs which foreseeability were incurred as a result of the delay.[472]

2. Non-Compensable Excusable Delays:

These are incurred project critical path delays which occurred beyond the control of either party and are typically due to "Force Majeure" causes, such as, abnormal weather,[473] organized labor activity, e.g., strikes; acts of war or civil disobedience; and under certain conditions, unforeseen subsurface or conditions different than reasonably foreseeable.[474] When these delays occur, a performing party generally is entitled to additional project completion time, but is not entitled to additional compensation for these delays.[475]

3. Inexcusable Delays:

These are incurred project critical path delays which are neither excusable nor compensable. Such delays are typically party actions which could have been avoided and have resulted in project delay. The culpable party may seek neither time nor delayed-related cost compensation for these types of delays.[476] In addition, the contractor may be required under the contract to pay liquidated damages[477] to the owner for actual delay incurred.

The end result of any concurrency evaluation is the determination of whether the delays are excusable or inexcusable for a particular party or parties and whether such delays, if excusable, are compensable.

Legal resolution of delay responsibility and recovery requires a sound technical evaluation of delay and elimination of concurrency. The analysis must provide an adequate allocation of responsibility for measured delay and cost impacts.

When a project experiences a delay or a completion longer than one assumed and/or contracted for at the beginning of the project, it is standard industry practice to perform a schedule delay analysis. One typically conducts a schedule delay analysis in order to ascertain the following:

- The critical path through the execution of the project;
- The total critical path delay to the attainment of the contractually guaranteed date for provisional and final acceptance of the project;
- The root cause(s) for the delay events which impacted the project critical path; and,
- The party / parties responsible for the delays which impacted the project critical path.

5.2.1.2 CPM Delay Terminology

Although CPM scheduling has been described and discussed previously in the Project Management chapter, it is important to emphasize a few terms and basic parameters before discussing delay analysis methodologies.

CPM scheduling is a standard project management tool used on complex construction projects to plan and control the work in a manner which highlights when each contractor's activities need to be completed to support the project schedule completion date. CPM schedules identify and describe the activities that must be performed, the sequence in which they must be performed and the time it will take to complete each of them.

The contractor uses the CPM schedule to proactively plan and execute its works as described by PMI's PMBOK.[478] PMI defines project management as the application of knowledge, materials and tools to meet project objectives. For each participant in a project, there are expectations. The project management process is directed at meeting the participants' expectations, especially of the project's scope, quality, time to perform and cost. With respect to time, the PMI Core and Facilitating Processes identify various aspects of the schedule activities: the execution duration of activities and the planned allocation of resources (labor, equipment, construction materials, etc.).

CPM methodology employs certain terms of art used to describe scheduling concepts. Among these are "activities," "milestone," "duration," "logic," "lag," "early start," "early finish," "late finish," "late start," "critical path," "float," "constraint," "baseline schedule" and "updating." These terms are defined below.[479]

A CPM schedule is a graphical network which divides the work on a construction project into discrete tasks referred to as "activities." Activities identified on a CPM schedule are often grouped together to show how a particular aspect of the work will be completed, i.e., excavation, concreting, tunneling, etc. Although the grouping of activities can be natural, the most important goal is to define the activities in a manner that permits the work to be managed and controlled. A "milestone" is a key event that occurs during the execution of a project and can either signify the start of the completion of important work scope. The "duration" of an activity is the length of time, typically measured in days, required to complete the activity.

The "logic" of a CPM schedule describes how an activity is linked to other activities by determining those activities that must logically precede or follow it. Obviously, not all tasks can be performed at the same time; some activities must be completed before other activities can begin. For instance, if work on Activity B cannot commence until the work on Activity A has been completed, the relationship between Activity A and Activity B can be described as "finish-to-start" logic. However, some activities are independent of others and can proceed concurrently. For example, if the work on Activity B can begin on the same day as Activity A, the logic between the two activities is described as "start-to-start." The logical relationship of activities sets forth the sequence in which the activities will be performed. A "lag" is a method of either delaying or accelerating the logical relationship. For instance, if Activity A has a "finish to start" relationship with Activity B, and a 10-day "lag" is applied to this relationship, then Activity B cannot start until 10 days after Activity A has completed. Utilizing a negative 10-day “lag” would accelerate this relationship.

A CPM schedule calculates four dates for each activity. The “early start” of an activity is the earliest date when it can possibly start, determined by the linked logic with any preceding activities. The “early finish” is the earliest possible date at which an activity can complete and is determined by adding the activity’s duration to its early start date. The “late finish” of an activity is the very latest date when it can finish and still allow the project to complete by its agreed date. The “late start” of an activity is the latest date an activity can be started if the project completion date is to be met. It is calculated by subtracting the activity’s duration from its latest finish date. A schedule’s critical path is the longest path of logically-connected activities which, when the individual time durations of each activity are added together, equals the overall duration of the project (or the agreed upon time for project completion). When an activity is “critical,” it must be completed within the allotted duration for that activity. If a critical activity is delayed, it delays the entire project by the exact same number of days.

“Float” is the amount of time the completion of an activity can be extended beyond its early finish date before it becomes part of the critical path. Float is determined by subtracting the activity’s early finish date from its late finish date. By definition, critical activities cannot be extended beyond their late finish date without delaying the project’s completion date. Critical path activities that finish on the planned project completion date have a total float value of zero. Critical activities that have been delayed and add time to the critical path can create negative float if the project’s planned end date has been constrained. A “constraint” is a restriction placed on the date an activity can be performed. A constraint overrides the existing logical relationships and imposes either a start date or a completion date. If non-critical activities are constrained and delays occur to these activities, negative float will also appear for this string of activities even though there is no impact to the overall project critical path. Non-critical activities have additional days beyond their early finish date when they can be completed before they become critical. This additional time is referred to as total float. For example, if an activity has ten days within which it can be completed before it becomes critical to the project, that activity’s total float is ten days. Typically, the total float is used for the benefit of the project. Thus, any party involved in the execution of the project, including the contractor, engineer and owner, has use of the available float which results from calculations made to activity durations, sequences and logic that have already taken into account consideration of productivity, weather and other execution factors.

Under proper CPM scheduling practice, the contractor submits a CPM schedule to the owner shortly after the NTP is issued. This is the “baseline schedule” against which the contractor should regularly measure actual construction progress and trends. The comparison process is referred to as “updating” the schedule. Updating the schedule with progress achieved reveals whether activities on the critical path are proceeding as planned. Properly updated schedules not only indicate which activities are falling behind schedule, but also show changes in the schedule’s critical path. When the actual progress information is entered into the network and recalculated (rescheduled), it may cause the critical path to change.

Under proper CPM scheduling practice, the baseline schedule remains in effect until it no longer is a viable approach to executing the project. Should this occur, the contractor must notify the owner and provide a revised schedule which reflects the changes which must be made in the various activities to ensure timely project completion. Revisions may include activity additions, deletions and logic and/or sequence changes. Revised CPM schedules can arise from delays that have occurred to critical path activities, which result in negative float, from delays which have consumed the total float available to non-critical activities and pushed them into the critical path, or scope additions that require a different execution approach. When the revised CPM schedule is accepted by the owner, it becomes the new baseline schedule (re-baseline) against which the contractor updates progress -- unless and until another change in the critical path necessitates additional revisions.

While there are multiple methods used in the industry to analyze schedule delay, only three methods have been routinely accepted by arbitration panels and court systems around the world. These include (1) as-planned versus as-built, (2) as-built critical path, and (3) the Window Analysis. Each of these methods should be understood by the consulting engineer in either analyzing delay to the project to arrive at resolution, or to be able to evaluate an analysis presented by another party. In any case, the basis of the analysis is the CPM schedule.

As discussed previously in the Project Management chapter, it is essential that the schedule be initially prepared before or as soon as possible after the NTP of the project and that it be evaluated for reasonableness and practical completion. An unrealistic baseline schedule will be the cause of multiple future problems and will only hinder resolution of the issues. It is then extremely important that the schedule be regularly updated and that the schedule update incorporate actual progress to the schedule and does not "modify" the baseline unless changes or situations to the project have changed to such an extent that a Revised Baseline is warranted that would then change the critical path of the project. It is also important that a critical review be performed of the schedule to assure that there are no impractical durations and/or logic relationships and/or constraints that would also tend to distort the true critical path of the project. Should any such flaws and/or manipulations exist within the schedule and/or its updates, the individual analyzing delay to the project may need to make noted adjustments in order to have a reasonable baseline and/or update upon which to measure delay.

The discussions below are not meant to be a tutorial on each of the methodologies which would result in their own distinct chapters, but are to merely describe the process and basic premises of the methodologies. The discussions are based on the author's nearly 30 years of experience in this area and having been testified in arbitration and court venues around the world and having both performed and analyzed hundreds of delay situations. The sections are also based on numerous published papers by the author on the subject.[480]

5.2.1.3 As-Planned Versus As-Built Analysis

This is the most simplistic and general way to analyze delay. If the schedule contains relatively few activities, (300 or less), then one might simply plot the planned dates compared to the actual dates for all the activities in the schedule and then make a determination from this visual as to what drove the project to completion and what then "appears" to have delayed the project. When a schedule has few activities, this approach can be accepted by the fact that there is probably little room for multiple critical paths or for many different approaches to the work. However, while simple in nature as it is essentially only a bar chart comparison of work, the as-planned versus as-built does not look to criticality of work, nor determines whether the critical path changed during the project, nor recognizes that while an activity may have appeared to have taken a long time just by the very nature of the actual bar showing significant time to complete, it does not identify whether there was continuous work being performed on that particular activity or whether the activity really had any time impact to the project completion. It further does not reflect any changes that may have occurred to the project during the execution of the work and thus, does not give consideration as to whether a longer time duration was for a change for which a party may have already been compensated and is not entitled to any additional time or money, In this way, the simple as-planned versus as-built analysis becomes too simplistic and too general to make any specific conclusions as to delay, what caused the delay, and who was responsible. Accordingly, it should only be used in the fewest of situations and only when no other options are available.

A more realizable as-planned versus as-built analysis is by using the as-planned critical path of the project so at a minimum, the individual analyzing the project is only looking at the critical activities. Since only critical delays can delay project completion, at least by looking at the critical path, the delays are more focused and responsibility more accurately assessed. However, if the project encountered multiple changes or unforeseen conditions during the project that would change the critical path of the project, then again, the delay being assessed may in fact not be accurate and thus may not reflect the true impact and party responsible for the impact.

Thus, an as-planned versus as-built analysis should only be used in limited situations and should only be used if there are few activities on the schedule and little change to the critical path occurred. Even then, one needs to be aware that subjectivity is easy to build into this method of analysis and may not reflect the true cause and effect and responsibility for the delay.

5.2.1.4 As-Built Critical Path Analysis

The as-built critical path methodology is applied by taking the actual critical path through the project that cannot be established until the project is completed by looking in hindsight as to what drove the critical aspect of the project and what were the driving activities to project completion. In order to then calculate the project impact, one must look at those same activities on the baseline schedule and using the as-planned logic from the baseline schedule, calculate the delay to the project comparing the as-built critical path to the as-planned durations and logic for these same activities.

While this method can certainly present a “true” impact to the project, its primary disadvantage of course is that it relies on hindsight and does not reflect what the parties knew at the time nor does it reflect what may have been critical at the time upon which decisions would have been made with respect to potential time extensions or resequencing, which in fact may be the result of what is later shown on the critical path. Resequencing may have been the result of one party’s actions that while critical at the time, as a result of the resequencing, would not show up on the project's as-built critical path. As a result, responsibility may be assessed to the wrong party and for the wrong reasons. In addition, as is true in the as-planned versus as-built methodology, the as-built critical path does not reflect other critical paths at the time for which true project delay was occurring nor does it typically allow for concurrent critical path analysis for which multiple parties may be responsible. Calculations of delay are also not typically equal to the actual project delay encountered since it only reflects the actual critical path and not the critical paths at the time where delay to the project actually occurred. Since by definition, a delay can only occur to the project if it affects the critical path, any omission of a critical path at the time will necessarily result in inaccurate delay calculations.

Thus, while less subjective than a mere as-planned versus as-built analysis, the as-built critical path analysis also contains subjectivity and further incorporates hindsight, something neither party had advantage of during project execution. However, should a situation arise where the schedules that were used during the project were so unreasonable or were so flawed and/or manipulated such that performing analyses on the contemporaneous schedules would also lead to inaccurate or misleading results, the as-built critical path may provide an alternative method for analyzing delay which can more closely identify the true impacts to the project and provide a reasonable basis upon which the parties can negotiate resolution to the delay issue.

5.2.1.5 Window Analysis Methodology

Window Analysis Methodology uses the contemporaneous project schedules to establish what the "real time" critical path of the project is at any point in time through the project. That critical path may and typically does change over the course of the project. Thus, each formal update of the schedule during the course of the project is reviewed to determine whether the critical path changed and if so, how and when the critical path changed. At each change in the critical path, a new window time period is identified. However, before a valid critical path can be identified, it is necessary to review and analyze each schedule to determine whether the schedules were reasonable relative to whether the work shown on the schedule could in fact have been accomplished as planned for the window period in question. When electronic schedules are available, the underlying assumptions upon which each of the schedule activity durations and logic ties were based can be reviewed and analyzed in order to validate those underlying assumptions. This process thus serves to determine whether the schedule itself was *reasonable,* a basic premise upon which Window Analysis methodology is based. If the assumptions were reasonable, then the schedule can be analyzed as it was used to manage the project and can be utilized as the basis for delay identification, duration, calculations, critical and near critical paths, etc. However, if the contemporaneous project schedules are based on faulty or suspect assumptions (i.e., applying numerous unnecessary and non-contractual constraint dates or including activities that are sequenced incorrectly), then the contemporaneous project schedule has to either be discarded or it must be “adjusted” to show the proper underlying assumptions.

Each window starts with a contemporaneous plan for the future work and ends when the plan is revised. The "window in time" is defined by the calendar period between these schedule changes. Use of contemporaneous project information ensures that the analysis addresses delays to activities that were critical as the project occurred. In recent years, courts and arbiters have held that contract extensions should be based upon current schedules for the time period in question, not schedules created later with the benefit of hindsight. A contemporaneous evaluation of delays requires the analysis to begin with the project start date (or other key early date) and stop at periodic intervals during the project, such as when the baseline schedule is revised or when the critical path shifts. Such an analysis best reflects the parties’ knowledge at the time the delays occurred. There have been cases where “as-built” analyses have been rejected because variances between the as-built schedule and updates of the project schedule cannot be explained adequately. Another benefit of the Window Analysis is that the determination of the critical path to the project is easier because the project is evaluated in separate, distinct time periods.

The Window Analysis minimizes information gaps by utilizing contemporaneous project documents, including project schedules and updates, to identify critical activities and time periods, as well as to measure the impact of delays. Schedules on complex construction projects can contain thousands of activities and appear overwhelming when reviewed in their entirety. The Window Analysis creates a mechanism whereby these schedules and their revisions can be reviewed in a manageable and ultimately more useful manner.

Window Analysis methodology evaluates the changes to the planned start, duration and sequence of critical path activities within a specific time period. When the critical path of a specific time period is completed on a date later than planned, the schedule is considered delayed. Conversely, when the critical path of a specific time period is completed on a date earlier than planned, the schedule is considered accelerated. Once the delays and gains were identified and quantified for each window of time, a delay analysis was performed that included an evaluation of the magnitude of the causes of and the responsibility for those delays.

For the delay/gain quantification one must consider activities that were on the critical and near critical paths. By definition: [481]

> *Critical paths have either a zero or negative float, and schedule activities on a critical path are called "critical activities".*

The person analyzing the schedule should review the specifications to determine how much float outside the Project critical path should be considered to define a near critical activity. If no time is identified for being "near-critical", it is then typical to define a "near critical activity" as any activity which is within 10-15 days float of a project's critical path. Using that definition enables the individual evaluating delay to expand the schedule delay analysis beyond a single critical path to those activities which might easily become critical within a subsequent window period.

Window Analysis has become the most widely accepted method of schedule analysis today, primarily as it bases its analysis on the contemporaneous project schedules used by the parties at the time and looks at the critical path at the time the delays occurred. It provides a self-checking mechanism in that the delay or gains when added for each window time period must equate to the actual project delay. In the consistency that each delay to the critical path will cause the same delay to project completion, it then confirms that by analyzing the critical path at the time of the delay, the delay quantified will thus be equal to the total delay experienced on the project.

5.2.2 Damages[482]

Damages are the most difficult to prove and establish. While entitlement may be established, if the party cannot link cause and effect, the party will not be able to recover damages, regardless of whether the party "was entitled to do so." In review of disputes, the individual evaluating or preparing the claim must first assure that the allegations are based on the facts of what actually happened on the project. The next step is then to establish that there was a cause for the allegation and a resultant impact. Once the cause and effect is established, then damages can be assessed provided that they are directly linked to cause and responsibility and are reasonably calculated using actual project cost records and damage methodologies that are commonly accepted in the industry.

There are many different types of damages and calculation methodologies for damages. This section presents the more common types of damage quantification methodologies along with the proofs that have been shown in the industry to be required in their use, development and presentation. As in the schedule delay section, it is not the purpose of this section to describe the precise steps for the damage calculations for each method, but rather to discuss the methodology and its required proofs.

5.2.2.1 Delay Damages-Extended Home Office Overhead

When a project is delayed beyond its original completion date, there was will be various delay driven damages that are to be calculated. The most obvious are the direct costs of the labor, material and equipment that were required to remain on the project for a longer period of time than planned. These costs are calculated from the actual project cost records which then identify the precise cost of those resources extended over the delay period. Other delay type of damages could be as the result of disruption and inefficiencies and/or multiple changes. Those damages are calculated using specific types of methodologies which are discussed later in this section. Owner delay damages are typically covered through a pre-set amount of a daily amount for liquidated damages that are assessed to the contractor for delay for which the contractor is responsible. Other damages such as lost profits or additional consultant costs, etc may also be incurred and depending on the contract terms may be assessed against the contractor and like contractor direct damages, are based on actual project cost records.

However, the damages which are the most difficult to asses from the contractor’s view point are the damages that are incurred from support of the home office for sustaining the project which cannot be calculated using actual cost records or “receipts.” Typically, home office personnel do not track their costs to a specific project. Further, the loss of bonding capacity or financing or indirect support for the project is not found to be a precise number, but rather is calculated based on corporate financial records and is usually related to the volume of the specific project as compared to the overall volume of the company during the period of time the project is being executed and then “extended.” The damages due to overhead costs resulting from compensable delays are sometimes calculated using a method derived in the U.S. legal system entitled the “Eichleay Formula”, which has been recognized and accepted (although not universally nor in all U.S. jurisdictions) as a method for calculating unabsorbed and extended home office overhead. The Eichleay Formula first divides the total contract billings by the total company billings for the contract period to obtain a percentage of the volume of work for a particular project compared to the total volume of work for the company over the same period of the contract. The resulting percentage relevant to the specific project is then multiplied by the total fixed overhead costs incurred by the company throughout the contract period to arrive at a total overhead cost directly attributed to the project in question. To derive a daily contract overhead rate the total overhead cost for the project is divided by the total number of contract days. Finally, the daily contract overhead rate is multiplied by the number of delay days *for which the owner is responsible.* Thus, the damage calculations for extended home office overhead are only applied to the delays for which the contractor is not at fault.

5.2.2.2 Actual and Constructive Acceleration damages

Acceleration is an attempt to speed up the process of the work to achieve an earlier project completion or to overcome previous delays. It is the performance of the construction work at a faster pace than anticipated in the original schedule, often accomplished by increased labor, management, and other resources; by performing more tasks concurrently instead of consecutively; or both.[483] Acceleration may be directed or constructive. Directed acceleration is when an owner specifically instructs the contractor to increase the pace of work or to complete by an earlier date. The U.S Army Corps of Engineers defines directed acceleration as: [484]

> *…the buying back of a time extension due the contractor under the terms of the contract in an effort to complete the work within the existing contract completion date.*

Constructive acceleration, on the other hand, is based on the premise that a contractor is entitled to a time extension for excusable delay, but it is not granted by the owner. If the owner fails to recognize excusable delay and demands performance in accordance with the original schedule, an acceleration of the work is imposed upon the contractor because the contractor is expected to do the same amount of work in less time. The U.S. Army Corps of Engineers defines constructive acceleration as: [485]

> *An act or failure to act by the Government which does not recognize that the contractor has encountered excusable delay for which he is entitled to a time extension and which required the contractor to accelerate his schedule in order to complete the contract requirements by the existing contract completion date.*

This situation may be brought about by the Government's denial of a valid request for a contract time extension or by the Government's untimely granting of a time extension.

5.2.2.2.1 Recovery of Acceleration Damages

When a contractor experiences either directed or constructive acceleration, the contractor may use a variety of actions to recover the schedule:[486]

- *Resequencing work activities*
- *Increasing labor force by:*
  - *Enlarging the number of crews or crew size*
  - *Working overtime*
  - *Adding new shifts*
  - *Combinations of the three…*
- *Adding extra equipment*
- *Expediting Material and Equipment deliveries*

The contractor may be entitled to recover these additional costs even though it did not achieve the required completion date. Unless it specifically guarantees the date, the contractor is required only to use its best efforts.[487] Arbitration panels and U.S. Courts have also recognized acceleration as a cause of lost labor productivity.[488]

> *There are two fundamental legal requirements that must be met before acceleration can support a claim to recover excess performance costs. First, there must be a firm period within which the work must be completed. But more than that, time must be a part or the essence of the contract or made so by subsequent agreement of the parties, as when an owner agrees to a contractor's proposed schedule…..Second, the contract must allow time extensions…..It is only after these two requirements have been satisfied that the failure to grant a time extension for acts or omissions not the fault or responsibility of the performer and the insistence on meeting the contract completion date can result in acceleration claims.*[489]
>
> *Various U.S. contract appeals decisions that have pondered acceleration claims have dissected the principle and found five elements that they believe must be present to establish an acceleration claim:*[490]
>
> *(1) There must be an excusable delay.*
> *(2) There must have been timely notice of the delay and a proper request for a time extension.*
> *(3) The time extension request must either be postponed or refused.*
> *(4) The owner or other party must act by coercion, direction, or in some manner that reasonably can be construed as an order to complete within the unextended performance period.*

(5) The contractor must actually accelerate its performance and thereby incur added costs.[491]

The elements that must be proven for an acceleration claim depend on the type of acceleration damage being claimed. Thus, one must first determine if the acceleration was directed or constructive. In proving a directed acceleration claim, one must demonstrate the following:[492]

a. *The owner issued verbal, or if contractually required, a written change order;*
b. *The contractor reasonably attempted to accelerate its work;*
c. *Actual acceleration occurred;*
d. *The contractor incurred additional costs as a result of the acceleration.*

A constructive acceleration claim encompasses many of the same components as a directed acceleration claim. When an appropriate change order is missing, a contractor may establish an implicit change which resulted in constructive acceleration by proving the following elements:[493]

1. *The contractor experienced an excusable delay;*
2. *The owner had knowledge of the excusable delay as demonstrated by timely notice of the delay and a proper request for a time extension;*
3. *The time extension was either postponed or refused;*
4. *An order to accelerate, as manifested by some order or direction from the owner or its agent, can be reasonably construed as an order to complete the project within the unextended performance period, or an order demanding a larger effort than would be necessary to complete the work within a properly adjusted schedule or completion date;*
5. *Acceleration efforts by the contractor resulted in additional costs.*

A prerequisite to making a constructive acceleration claim is to demonstrate that the delay was excusable.[494] These delays are those that are beyond the contractor's control and are unforeseeable. Like delay claims, the basis for a constructive acceleration claim is that the contractor should not be held responsible or accountable for delays that were not his fault.[495] When a contractor is delayed by an excusable delay, he is entitled to a new contract completion date to account for and negate the impact of the excusable delay on the contractor's performance. Refusal of the owner to grant a time extension may entitle the contractor to claim for constructive acceleration.[496] However, in order to make a claim for constructive acceleration the contractor must demonstrate that it gave timely notice of the delay, and requested a time extension.[497]

In an acceleration analysis, the currently planned schedule when the acceleration is ordered or occurs constructively is often important because it demonstrates the contractor's status at the time of the excusable delay. If the contractor is late because of its own acts, the currently planned schedule will demonstrate how late the contractor is. It is often advisable to study the schedule updated at the time of the delay before determining how late the contractor is due to the excusable delay. If the updated schedule shows some delay for which the contractor is responsible, the time extension request would not necessarily fail as there may be concurrent delay with excusable delay, which acts to pardon the contractors delay. The owner ultimately controls whether to accelerate.[498]

5.2.2.2.2 Required Proofs for Acceleration Damage Claims

The proofs required for directed and constructive acceleration are similar, but are more stringent relative to the proofs for constructive acceleration. In regard to "constructive acceleration", the author found that:

- The contractor may recover acceleration costs even if the required completion date was not met, if it is determined that the contractor used his best efforts in doing so.
- Acceleration can also be a cause of lost productivity.
- To succeed in proving a constructive acceleration claim, a contractor must demonstrate that:
  - ➜ There was a firm period of performance to complete the work after the implied acceleration order occurred;
  - ➜ Time extensions were allowed under the contract;
  - ➜ There was excusable delay;
  - ➜ Timely notice was provided or demonstration that that the owner was clearly aware of the delay;
  - ➜ A time extension request was made and either refused or postponed;
  - ➜ The contractor was either directed or coerced in some manner that could be reasonably construed as an order to complete in the unextended performance period; and
  - ➜ The contractor actually accelerated and thereby incurred additional costs.

5.2.2.3 Cumulative Impact Damages

"Cumulative impact" claims have increased in the last decade in the construction industry. As discussed herein, the cumulative impact claim is one of the most difficult to prove and to calculate relative to the damages incurred by the contractor. The costs claimed must be demonstrated in the proofs of the case. Cumulative impact has been defined as: [499]

> *Cumulative impact costs are costs associated with the impact on the work not directly associated with the event itself and are not readily foreseeable or if foreseeable, are not readily computable as direct impact costs.*

5.2.2.3.1 Change as Defined in General Construction Projects

Webster's Dictionary gives 32 definitions for the word "change."[500] The definitions which come closest to defining *"change"* in the construction industry sense of the word are as follows:

> *10. to become altered or modified …*
> *20. a transformation or modification …*
> *21. a variation or deviation …*
> *22. the substitution of one thing for another …*
> *23. a replacement or substitution …*

Even those definitions, however, fall somewhat short for the construction industry. In construction, "change" is also routinely used to identify an addition or deletion to the contracted scope of work. In common usage in the industry, "change" means any alteration to the contract provisions or scope of work, including modifications, substitutions, additions, deletions, alterations, etc.[501] The effect of a change depends upon the size of the change, the timing of the change, the nature of the change, and the volume of the change.[502]

It is widely accepted within the construction industry that: [503]

> *The single most common cause of compensable delays is the decision of the owner or the architect-engineer to order changes in the contractor's work. The additional cost of the changed work will ordinarily be covered by the changes clause or a similar contractual provision. But implementing a major change, or a large number of minor changes, will also frequently increase the contractor's cost of performing the <u>unchanged</u> work. The contractor may, for instance, find it necessary to disrupt or delay the unchanged work, or may be forced to perform the unchanged work in a different manner or in a different sequence than originally planned.*

The fact that change is the *"single most common cause of compensable delays*" is not surprising given that change in a construction setting takes on an importance that is not readily understood in other industries: [504]

> *In most industries and business transactions, it would be unheard of to allow one of the contracting parties to unilaterally change the terms of the contract without the consent of the other party. In both the public and private sectors of the construction industry, unilateral change orders are widely accepted as part of almost every standard contract form.*

But that unilateral right to change the terms of the contract is restricted to only one of the parties: [505]

> *…the owner is given the right to issue changes within the general scope of the contract, by adding or deleting work, and this right is not dependent on the consent of the contractor to the change.*

Most construction contacts give the owner the right to make changes within the general scope of the contract without invalidating or breaching the contract.[506] The changes may be directed by the owner or its agent or they may be constructive, that is, inferred from or implied by the conduct of the parties. In making such changes the owner also may be responsible for the effect upon the contractor's time and cost of performance.[507] In the event that the owner has the unilateral right to direct changes to the work, this does not mean that the owner is given carte blanche to make changes without accepting the responsibility for the cost of those changes or the cost of the impacts that the introduction of those changes might have on the contractor's time or budget.

A study undertaken and published by The Construction Industry Institute (CII) in the United States succinctly noted that:[508]

> *Owners should not employ fixed-price contracting when they know the project will be subject to numerous changes. If they do, they can expect that excessive management attention will be consumed in change administration and claims.*

As noted by the CII:[509]

> *…owners tend to treat changes as if they were isolated and non-critical events, and are unwilling to accept time extensions since the acceptance of such time extensions means allowances of additional costs …*

Every change has an impact on a project's cost and schedule. Impact, with regard to changes is defined as: [510]

> *<u>Impact:</u> There may be two categories of added cost in any change order. The first is the actual cost of performing the changed work. The second is the effect a change order may have on other work due to sequence changes, etc., or delay to the project. The latter category is labeled variously as 'impact,' 'ripple effect,' …*

5.2.2.3.2 Defining the Impact of Multiple Changes

As noted by Charles A. Leonard in his paper on "The Effects of Change Order Productivity": [511]

> *It is generally accepted that large, untimely, and numerous change orders can disrupt progress of the work and reduce productivity.…*
>
> *And, owners often cannot make up their minds about the requirements of the final product, believing changes can be readily made in the field as construction progresses.…*
>
> *While most owners insist on knowing the impact cost of proposed change orders prior to authorizing their performance, contractors prefer to submit single, all-encompassing impact cost calculations upon completion of the job. Such calculations are usually submitted on the basis that impact costs can be neither isolated for each change order nor calculated accurately in advance due to the interdependency of construction activities. In fact, few contractors maintain adequate job records to allow evaluation of impact costs for each change order. In addition, some contractors do not realize that they have incurred impact costs until the final profit and loss statements indicate a sizeable loss.*

According to the CII the problems associated with predicting the full impact of any specific change on a project is exacerbated in situations where multiple changes are introduced into the project: [512]

> *When there are multiple changes on a project and they act in sequence or concurrently, there is a compounding effect – this is the most damaging consequence for a project and the most difficult to understand and manage. The net effect of the individual changes is much greater than a sum of the individual parts. Not only may there be increases in cost and time required, but the project logic may have to be redone*

Another study by the CII found that: [513]

> *… when a large amount of change occurs on a project there is a compounding and negative effect on total project efficiency. This compounding effect may occur in all phases of a project, but this study focused on the detailed design and construction phases of a project…*

> *This compounding effect of multiple project changes is poorly understood, difficult to measure, and seldom reflected in the estimated cost of individual project changes. It becomes apparent when work cannot be completed on time and labor productivity does measure up to the anticipated level of efficiency.*

Leonard, in his study cited earlier, also noted:[514]

> *In an earlier study reported by Baldwin et al.* [5]*, general contractors ranked design changes as the most important factor influencing progress, behind weather, labour supply and subcontractors….*
>
> *Cumulatively, delays and disruptions to individual work activities caused by change orders were found to bring about gradual deterioration of original schedules….*
>
> *The effect of individual change orders was generally found to depend on the timing of the instruction to proceed in relation to the planned start of the affected activity….*
>
> *On delayed and disrupted projects, productivity losses due to individual change orders cannot be accurately estimated in advance. Productivity losses are best calculated on a global basis, after the fact and, when accurate data on physical progress is available…*
>
> *Since the effect of an individual change order depends upon its timing, all parties should direct their efforts toward identifying, processing and approving change orders as expeditiously as possible to minimize their impact.*

Other experts in the industry share a view similar to Leonard's. The CII published a paper entitled "*Quantitative Effects of Project Change,*" which discussed the cumulative effect of small changes. As noted in the research:[515]

> *One possible explanation is that estimates and pricing for individual changes are produced under time pressure, and the scope definition of the change may not be complete. If each change estimate fails to identify items of work associated with a scope change, multiple changes will compound the difference between the adjusted budget and the actual requirements of the work.…*
>
> *However, many small changes accumulate, the project schedule is not adjusted, and the additional work is executed by means such as short-term hiring, overtime and double or split shifts, which are inherently less productive than normal, well-planned methods.*
>
> *… projects cannot endure numerous changes without suffering a decline in overall project cost performance.*

That research further discussed the impact on schedule and budget recovery:[516]

… project managers often discount the early trends of a project, believing that time remains to recover schedule losses or negative cost trends. Because of this general attitude of optimism, project managers, even on projects that are trending behind schedule or over budget, will allow changes to be introduced, further aggravating the situation.

Part of the reason for this false optimism is that the cumulative effect of multiple changes, especially their effect on schedule, is extremely difficult to monitor or calculate … Most project mangers, when looking at an individual change, are optimistic about the ability to incorporate the change without affecting schedule….

Although the industry acknowledges that the later a change occurs on a project the less efficiently it is implemented, many projects execute significant amounts of changes late in project life cycles. This is especially counter-productive since it can be demonstrated that projects have a significantly reduced ability to recover schedule losses or budget pressures as they approach completion.

As shown by the CII, multiple and late changes have a schedule impact and a cost impact.

Other organizations, such as the Committee on Construction Building Research under the National Research Council, have arrived at similar conclusions:[517]

The cost of contract modifications probably has increased in recent years because of the demise of the so-called "Rice Doctrine," which limited a contractor's cost recovery on changes to the costs directly associated with the change. Now, contractors can claim 'ripple' … damages for the impact of a change on work not directly affected by the change.

The CII summarized the issue of change impacts on projects in a study done in October 2000:[518]

Often, the contractor fails to foresee, and the owner fails to acknowledge, the "synergistic effect" of changes on the work as a whole when pricing individual changes. That is, a change order for one area of the project may likely affect other areas of the project as well as the specific area where the change will actually occur. Consequently, projects that exceed cost or schedule targets are likely to lead to claims. Determining the impacts that changes can have on contract price and time can be arduous due to the interconnected nature of the construction work and the difficulty in isolating factors to quantify them. As a result, it is difficult for owners and contractors to agree on equitable adjustments, especially for cumulative impact.

A common statistic quoted is that a normal project should expect to encounter changes which amount to 5 to 10 percent of the total value of the project. There are two immediate problems with that statistic:

- The absolute value of an individual change may bear no direct relationship to the disruptive impact of the change. For example; a large standby diesel generator may cost many hundreds of thousands of dollars. However, because it is intended to be a stand-alone piece of equipment to be placed outside the primary operating center of the facility with only minimal connections to the primary operating system, it may have no direct disruption impact on the critical project systems. Conversely, a relatively inexpensive change to a control instrument, if made late in the project and in an area already too densely packed to accommodate the instrument change, may have a tremendous disruptive impact on the project.
- Changes are not done in isolation from one another or in isolation from the original fixed scope of work. One must consider such things as the gross number of changes made; the fundamental nature of each change being made (an entire process subsystem or a simple change in wall color); and, the location of the change (in the heart of the process flow or in the parking lot). For example: it is entirely possible in complex facilities to have multiple changes in the same process area that each impact the contractors ability to execute the original fixed scope of work, yet each of the individual changes may have a relatively minor direct cost.

5.2.2.3.3 Cumulative Impact of Multiple Changes

Cumulative impact or disruption is the effect of a series of changes, design clarifications, or owner late responses to Requests for Information (RFIs) on labor productivity and project cost.[519] Extraordinary numbers of change orders, design changes or even the failure to respond to reasonable contractor RFIs are factors that contribute to loss of labor productivity and schedule delays. Unlike the direct impact claim, which can be recognized when a change order is issued, the cumulative impact claim represents a claim for lost productivity on unchanged work that contractors claim is not foreseeable at the time the change order is issued. Specifically, unchanged work refers to the contract work not covered by a specific contract change order.[520] The theory of a "cumulative impact" claim is the contractor, when pricing changes individually and negotiating compensations for the direct changes, fails to consider the synergistic effect of all changes, fails to foresee the so-called cumulative impact costs, and thereby obtains less than full compensation for the change order.[521]

> *The theory of cumulative disruption holds that the issuance of an unreasonable number of change orders creates disruption that exceeds the disruption caused by the individual change orders when viewed independently. The theory of cumulative disruption holds that the issuance of a large number of changes is itself a constructive change wholly separate and distinct from the individual changes themselves.*
>
> *The cumulative impact effect occurs when multiple changes have so disrupted the administrative and field management that the contractor may not control its costs or account for its overruns until the project is completed. The cumulative effect of multiple changes is primarily caused by the owner's failure to provide a complete and final set of design drawings and specifications. Work on an activity is adversely affected by another activity or by the mere nature of the site environment that impose performance, accounting, and control burdens.*
>
> *When there are multiple changes on a project and they act in sequence or concurrently, there is a compounding effect; that is the most damaging consequence for a project and the most difficult to understand and manage, The net effect of the individual changes is much greater than the sum of the individual parts. Not only may there be increases in cost and time required, but the project schedule may have to be redone. The contractor may attempt to recover any excess costs via a claim for the "cumulative impact": of the numerous changes.*

Other definitions used by the courts and boards on cumulative impact include: [522]

> *[The] costs associated with impact on distant work [that] are not readily foreseeable or, if foreseeable, not as readily computable as direct impact costs. The source of such cost is the sheer number of and scope of changes to the contract. The result is an unanticipated loss of efficiency and productivity which increases the contractor's performance costs and usually extends his stay on the job.*

In a matter in the U.S. Court System, the Armed Services Board of Contract Appeals (ASBCA) explained the conceptual framework in greater detail: [523]

> *It is undisputed that the costs of performing changed work include both (a) those costs directly related to the accomplishment of the changed work, called "hardcore costs", and (b) those costs arising from the intertie between the changed work and unchanged work or expended to offset inefficiencies experienced as a result of changes, called "impact". Viewed broadly "impact" embraces:*
>
> *The manhours, labor costs, and material costs that are expended to offset inefficiencies experienced as a result of Government-caused or contractor-caused changes or other departures from the plan. Included is the process by which the above inefficiencies in the performance of contract work are created.*

Among other things, "Impact" includes:

> *Inefficiencies due to overcrowding, or undermanning, skill dilution, extended overtime, shift work, and local and cumulative disruption.*

> *"Local [or direct] disruption" refers to the direct impact that changed work has on other unchanged work going on around it. Conceptually, for purposes of this appeal "cumulative disruption":*

> *Is the disruption which occurs between two or more change orders and basic work and is exclusive of that local disruption that can be ascribed to a specific change. It is the synergistic effect… of change on the unchanged work and on other changes."*

While the courts appear to be struggling to reach a definitional core of cumulative impacts, we observe that "synergistic effect" is at the core of the issue. Synergism is defined as "the simultaneous action of separate agencies, which together, have greater total effect than the sum of their individual effects.[524]

The U.S. *Veteran's Affairs Board of Contract Appeals (*VABCA) also defines cumulative impact with such a definition:[525]

> *Cumulative impact is the unforeseeable disruption of productivity resulting from the "synergistic" effect of an undifferentiated group of changes. Cumulative impact is referred to as the "ripple effect" of changes on unchanged work that causes a decrease in the productivity and is not analyzed in terms of spatial or temporal relationships. This phenomenon arises at the point the ripples caused by an indivisible body on two or more changes on the pond of a construction project sufficiently overlap and disturb the surface such that the entitlement to recover additional costs resulting from the turbulence spontaneously erupts… This result is unforeseeable and indirect.*

5.2.2.3.4 Pricing Cumulative Impact

The compounding effect of multiple project changes is poorly understood, difficult to measure, and seldom reflected in the estimated cost of individual project changes.[526] Arbitration panels and U.S. Courts have consistently held that the number of changes does not establish impact. The cumulative effect becomes apparent when work cannot be completed on time and labor productivity does not measure up to the anticipated level of efficiency. With each change, a contractor will estimate the work-hours required, but due to the inability of project personnel to fully anticipate the consequential effects of multiple changes, the actual work-hours may be much greater than originally anticipated. As the number of changes increases the differential between estimated work-hours and actual work hours widens at an increasing rate ("ripple effect"). As a result, determining if and when the "ripple effect" has occurred is often limited to a post-project analysis. It may be impossible to accurately estimate all hidden costs associated with implementing change orders prior to their implementation. Even after project changes orders are implemented, it is difficult to capture and account for the "ripple effect."[527]

The effect of variations or changes on the remaining or unchanged work may also entitle the contractor to a time extension.[528] It is often difficult to make this determination since it was not one single change or change order that delayed the project, but rather the disruptive effect of numerous change orders.[529] Not all changes affect the contract time and a contractor must prove the time impact of the changes attributable to the owner to recover any additional costs of performance.[530] The principle factor that connects change orders to disruptions and lost efficiency is timing. Late changes can be particularly detrimental. Changes occurring late in the job have a progressively more disruptive impact on productivity.[531]

However, change impact costs typically cannot be quantified and often are not even known until the completion of the project since, by its definition, impact is a ripple effect. Research by the CII found that:[532]

> *… few contractors maintain adequate job-site records to allow evaluation of impact costs for individual change orders. In addition, some contractors do not realize that they have incurred impact costs until final profit and loss statements indicate a sizable loss.*

In a later study, the CII reported on what it identified as the "hidden costs" of changes on a project:[533]

> *Hidden costs are defined as costs not readily apparent or missed when evaluating project change implementation. A major problem with the execution of project change is failure to consider all the costs associated with implementation. Direct costs such as material, equipment and labor or established indirect costs the form of overhead are fairly easy to identify and account for in project change estimates. The more difficult task is estimating or predicting the hidden cost associated with change implementation; i.e., delays, lowered productivity, poor communications or rework.*
>
> *The first research objective was to identify and quantify the hidden cost of change. We quickly discovered that it was impossible to accurately estimate all hidden costs associated with implementing change prior to change*

> *implementation. Even after project change is implemented, it is difficult to capture and account for the "ripple effect" …*

The CII also concluded in another study it performed that the owner's perception of the cost of change was not consistent with the actual cost of change:[534]

> *Pricing methodologies for changed work are often weak. Owners frequently think that contractors make money on changes because their estimates are too high. In reality, contractors often lose money on changes because their estimates are too low.*

Finally, the hard money value of a particular change does not address either the timing of when the change is introduced into the project. It is unfair to require contractors to price changed work on a unit price basis as part of their original bids or to price it using the unit cost of original changed work. Conditions applying at the time of making changes are seldom the same as those prevailing at the time the original work was bid or anticipated to be accomplished.[535]

The attempt to value multiple change orders by the cost of performing changed work is difficult if not impossible. As noted above, the CII study concluded that it was only at the end of the project when all costs are known that the real impact of multiple change orders can be determined. The CII study also indicated that it was essentially impossible to include all the additional performance costs of multiple change orders in any one change order estimate.

5.2.2.3.5 The Importance of "Proof" in the Cumulative Impact Claim

However, despite a general recognition of the legal entitlement, little agreement exists as to how the claim should be characterized and what the contractor must prove in order to prevail on such a claim. In general, a contractor seeking to recover for the impact costs of numerous changes on unchanged work must prove three essential elements: liability, causation, and resultant injury.[536] Of these three elements, causation and resultant injury present the largest obstacles to recovery of damages. Causation and quantum of loss poses a problem because cumulative impacts remain largely an ill-defined concept.[537] As a result, Boards and Courts in the United States have not been able to identify a definite formula to determine whether numerous owner-caused changes are the underlying cause of lost productivity.

The contractor seeking to recover must submit evidence that "the number, timing, and effect of the changes that were issued" impacted its ability to plan and perform the work.[538] Much like the difficulties of demonstrating resultant injury, the biggest problem with proving causation involved separating internally (contractor) caused inefficiencies from externally (government or private owner) caused inefficiencies.

Arbitration panels and U.S. Contract Boards have also found that a contractor's attempts to prove causation can be undermined by the prime contractor's failure to maintain a CPM schedule.[539] When the contractor started the project with a CPM schedule, the schedule must be maintained and the subcontractors must receive copies of the schedule. If the contractor abandons the schedule, the individuals hearing the matter have found it impossible to determine whether the original completion date was possible.

While multiple change orders may have been issued on a project, just showing that there are numerous change orders for which a contractor may claim cumulative impact may not necessarily mean acceptance by the court.[540] In the U.S. matter that was discussed previously, *Wunderlich*, the court held that the 35 change orders amounting to 6% of the contract value did not prove that the government was responsible for all the losses on the contract. The court reasoned that even though the contractor's performance had been lengthier and costlier than anticipated at the time the bid was submitted, it ultimately constructed essentially the same project as agreed upon in the contract. Therefore, the changes neither materially altered the nature of the bargain nor were they so beyond the scope as to constitute a breach of contract, that is, "Cardinal Change".[541] The court also held that there was a critical lack of proof of the cause and effect relationship between the events and the claimed impact in labor productivity and other costs.[542]

To prove a cumulative disruption associated with negotiated change orders, the contractor should show that (1) the changes, although not necessarily constituting a "Cardinal Change", were so numerous or overlapping or both that it obtained less than a full recovery for the individual changes because it was unable to foresee all of the disruption resulting from the individual changes; (2) at the times the contractor negotiated the changes, it had no reason to know it was not fully pricing the changes; 3) a reasonable calculation of damages without duplicating other costs included in its other claims can be produced; (4) the existence of a cumulative impact caused by the excessive and frequent changes can be proved; (5) the cumulative impact of the excessive changes affected the work; (6) the cumulative impact of the excessive changes increased the cost of performance; (7) the impact was not foreseeable when the change orders were priced; and (8) the contracting officer or owner's representative exceeded the permissible limits of discretion under the changes clause when the changes were issued and materially altered the nature of the contractor's original bargain.[543]

5.2.2.3.6 Proofs Required for Cumulative Impact Damages

No matter how the claim is characterized, in presenting claims of cumulative impact, the contractor must prove the essential elements of liability, causation and the resultant injury. A contractor seeking to recover must demonstrate that the impact was not foreseeable, and that when the disruptive effect became known, the contractor documented its occurrence and requested reimbursement. In order to establish the elements, the contractor must rely on a mutually supportive combination of expert and lay testimony, based on the first-hand project experience and on a detailed review of contemporaneous project documentation.[544]

In regard to cumulative impacts claims, the author found that:

- Cumulative impact is simply defined as the effect of a series of changes, design clarifications, or late responses to RFIs on labor productivity and project cost;
- The basis of a cumulative impact claim is that the contractor, when pricing changes individually and negotiating compensation for direct change may not have taken into consideration the synergistic effect of all changes, failed to see the cumulative impact costs and thereby obtained less than full compensation for the change order;
- The effect of a large number of changes may be held as a constructive change wholly separate from the individual changes themselves;
- Cumulative impact costs are those costs associated with the impact on distant work that was not readily foreseeable and if it was foreseeable, was not readily compensated as direct impact costs;
- The result of the cumulative impact is the unanticipated loss of efficiency and productivity which increases the contractor's performance costs and typically extends his planned performance period;
- Arbitrators nor the U.S. Courts have yet to agree on an exact formula for calculating cumulative impact changes and that each case must be analyzed on its own set of facts and in light of its own circumstances, giving just consideration to the magnitude and quality of the changes ordered and their cumulative impact on the project as a whole;

- An excessive number of change orders does not guarantee the contractor the right to a cumulative impact claim;
- In general, the contractor must prove three essential elements: liability, causation, and resultant injury;
- While no specific proofs have yet to be agreed by arbitrators or the U.S. Courts, multiple U.S. case review demonstrates that at a minimum, the contractor must prove:
  - ➔ That the number, timing and effect of the changes issued impacted its ability to plan and perform the work;
  - ➔ That there is a causal connection showing that the contract changes affecting the changed and unchanged contract work resulted in the loss of productivity on that work;
  - ➔ The changes were so numerous or overlapping or both that it obtained less than full recovery for the individual changes because it was unable to foresee all of the disruption resulting from the individual change order;
  - ➔ At the time the contractor was negotiating the changes, it had no reason to know it was not fully pricing the change;
  - ➔ A reasonable calculation of damages without duplicating other costs in the claim can be produced;
  - ➔ The impact was not foreseeable when the individual change orders were priced;
  - ➔ The owner's representative exceeded the permissible limits of discretion under the Changes Clause where the changes were issued and materially altered the contractor's original bargain.

5.2.2.4 Disruption Damages[545]

Schedule delay damages and losses of labor efficiency go hand in hand. A schedule delay analysis and a loss of labor efficiency analysis, however, are not the same. Different methodologies are applied, and the cause and effect relationships are very different. A loss of efficiency means it takes longer to perform a task or more resources, or both. There need not be a work stoppage or time delay to perform a labor efficiency analysis.[546]

Disruption is founded on three principles. First, when a contractor submits a bid, it is entitled to schedule its performance in a series of efficient and economical operations with each stage dependent on or interrelated with other stages consistent with the total scope, interfaces and conditions. Therefore any disruption to the operations of one stage may affect the operations of another stage. Second, when the parties enter into a contract, the parties have mutual obligations to not unreasonably hinder the performance of the other party, again consistent with total scope, interfaces and conditions. When a contractor plans on performing its work in a certain sequence or manner, the owner has a duty not to interfere or interrupt the contractor's performance provided it has met precedent, interface and coordination requirements. Third, the contractor has an obligation that when it plans its work and sequence that it does so reasonably and consistent with total scope, interfaces and conditions. The contractor cannot make unrealistic assumptions about its performance or other parties' performance.[547]

It is not a double recovery to receive both delay and disruption damages.[548] Specifically: [549]

> *Disruption is an activity-specific loss of productivity caused by changes in the working conditions under which that activity was performed. Disruption is a material alteration in the performance conditions that were expected at the time of bid, resulting in increased cost of performance. Lost productivity is a classic result of disruption, because in the end more labor and equipment hours will be required to do the same work.*
>
> *Delay and disruption are different types of damages, Disruption damages can be traced to specific activities; delay damages cannot. Delay damages are caused only by delays either to the overall contract or to project completion; disruption damages are caused by changes in working conditions that can occur regardless of whether the project's completion date changes. The absence of delay does not preclude the finding of disruption, and the absence of delay damage does not preclude the finding disruption damage extended.*

Labor productivity can be defined in a number of ways. However, typically labor productivity is defined as the manhours to execute a unit of work. The parameter is commonly called the unit rate. Using this definition, lower values mean better productivity and higher values worse productivity. Thus, during disrupted periods of time, the focus is on explaining the higher numbers or spikes.[550]

> *An emerging analysis and proof technique for delay and disruption dispute impacts is productivity analysis. Labour and equipment use are the two major performance variables by which a party may manage to achieve timely performance. Much of the impact of timely and efficient performance (or lack thereof) is manifested in labour and equipment performance, of which productivity is the management performance.[551]*

5.2.2.4.1 Pricing Disruption

The problem with disruption and the consequent prolongation of activity durations is that in order to demonstrate that there has been any activity prolongation, it is necessary to be able to show how long the activity would have taken but for the disruption.[552] It is almost impossible to measure the increased costs attributed to particular disruptions.

> *…in a study conducted for the Construction Industry Institute (CII), a team of researchers specifically assigned to measure the costs of a recognized disruption as it occurred concluded that it was practically impossible to determine all the costs associated with a disruption until the disruption had ended; even after a disruption had ended it was difficult to capture and account for the ripple effect until the project was completed. Assignment of responsibility can also be difficult. However, more often than not, responsibility is shared, and disrupted work and contract work occur at the same time.*[553]
>
> *In Luria Bros. & Co. v. United States*[554]*… [the] court acknowledged the differences between the delay and disruption claims and their respective damages. "That loss of productivity in labor resulting from improper delay caused the defendant is an item of damage for which plaintiff is entitled to recover admits of no doubt….nor does the impossibility of proving the amount with exactitude bar recovery from the item."*[555]

The proper measure of the adjustment is the difference between what it would have cost to perform the work without owner-caused disruption and what it actually cost to perform the work with the disruption.[556] The U.S. VABCA summarized the relationship between loss of productivity and impact costs: [557]

> *Impact costs are additional costs occurring as a result of the loss of productivity; loss of productivity is also termed inefficiency. Thus, impact costs are simply increased labor costs that stem from the disruption to labor productivity resulting from a change in working conditions caused by a contract change. Productivity is inversely proportional to the man-hours necessary to produce a given unit of product. As is self-evident, if productivity declines, the number of man-hours of labor to produce a given task will increase. If the number of man-hours increases, labor costs obviously increase.*

Contractors must offer clear proof of damages suffered as the result of the breaching disruption; they can do so through a number of methods such as:[558]

- Total cost method
- Modified total cost method

- Measured Mile Approach
- Industry Standards and Handbook[559]
- Time and Motion studies[560]

While the total cost approach is the most basic approach to calculating damages for loss of productivity, arbitration panels or U.S. Courts seldom allow contractors to rely on the total cost method. However, on occasion they allow this method to be used on the theory that "the very factors that produce loss of productivity can also serve to preclude the accurate and precise record-keeping.[561] But then again, the total cost method is not favored and often is not accepted by arbitration panels or U.S. Courts because it does not eliminate the casual factors for which the owner was not responsible.[562] The total cost method has several weaknesses. First, it does not consider the contractor's own inefficiencies, delays and bid errors. Because the total cost method would allow a contractor to receive all costs, courts and boards typically do not favor or accept this methodology except in an "extraordinary circumstance."[563] The following steps must be proved to sustain a total cost claim:

(1) The bid was reasonable and contained no material errors;
(2) The actual costs were reasonable and accurately recorded to the job;
(3) The contractor was blameless for any of the overrun;
(4) The claim could not be priced under any other method.[564]

The modified total cost method, however, eliminates the dependence on the original estimate and accounts for non-owner related performance factors for which the owner is not responsible. In order to calculate the inefficiency cost, the contractor must begin with the actual cost of performing the project and subtract out (1) costs included due to contractor errors and (2) the bid price for the project.[565] While the modified total cost method is an improvement over the total cost method, it still fails to create the casual link between the impacts suffered and the costs incurred.[566]

While the modified total cost approach is more accepted than a total cost methodology, courts and boards favor the measured mile approach over either of these and above the jury verdict method as well.[567]

The measured mile approach (discussed in more detail below), is an accepted form of impact cost analysis that examines retrospectively what the project should have cost by comparing the productivity achieved by the contractor in an undisrupted period of similar work or comparable work on the same project with the contractor's productivity a period of disrupted similar or comparable work.[568] The greatest obstacle lies in "identifying an unimpacted period in which the work being performed was sufficiently similar to that work performed in the impacted period."[569]

5.2.2.4.2 Recovery of Disruption Costs

To recover lost productivity damages, the claimant bears the fundamental burden of establishing liability, causation and the resulting damage. In proving lost productivity claims, it is necessary to explain the nature of the injury because productivity losses may be perceived as somewhat nebulous. This need involves focused and straightforward evidence of how the disruptions caused the productivity losses, the extent of these losses and the monetary damages associated with the labor productivity losses. The proof usually consists in job cost records, fact witnesses and expert testimony.[570]

Merely comparing the contractor's productivity from past projects or its bid rate of productivity with its actual rate of productivity on a specific project is not sufficient proof of causation to allow recovery of loss of efficiency costs. The mere occurrence of disruption to a contractor's performance does not automatically entitle it to disruption damages.[571] An essential aspect of proving any disruption claim is establishing the casual relationship of the disruption to the damage.[572] Then, identification of specific factors and assessment of responsibility are required. Four types of proofs can help in demonstrating causation and injury in lost productivity cases: expert testimony, trade publications, historical data, and job-specific data.[573]

As with other types of claims, the contractor must prove that it suffered a loss of efficiency and that the owner is responsible for the loss of efficiency costs.[574] Arbitration panels and U.S. Courts have addressed a wide array of disrupting factors which may cause loss of productivity or labor inefficiencies, including factors such as: disruption of the contractor's work sequence, disruptions from numerous contract changes creating delays and acceleration, disruptions causing crowding or stacking of trades, reassignment of manpower, crew size efficiency, learning curve, errors and omissions, site access, fatigue/overtime, season and weather changes, interference of owner, hazardous surroundings, disruptions or accelerations which force the contractor to initiate overtime work, and owner changes to one portion of a project which decrease efficiency or another part of the project.[575],[576]

In claiming or analyzing productivity changes as a delay cause, the estimated or as-planned production rates for work activities which are calculated from the as-planned manhours/manpower and schedule, must be compared with recorded results. As labor performance varies over any period, changes must be measured over a reasonable period of time. But, it is the change that is measured. Differences in production rate always portend a change in time of performance. Higher actual productivity achieved than planned results in a gain during the performance period. Lower than planned productivity always results in delay from as-planned schedule. Productivity is reflected by three primary levels of measurement: (1) Manhours; (2) Manpower; and (3) Cash Flow (labor element thereof). Comparison of as-planned with as-built data must focus on all three, if changes and delay impact are to be identified, quantified and analyzed.[577]

The nearly inviolate rule is that at a minimum the productivity impact and resultant delay claimed must be tied to a number which is verifiable and the veracity of which is easily demonstrated. Since relevant detail must be developed, there are various techniques for “breaking down” or “splitting apart” time and production rates. The productivity data which is broken down or split, however, must be part of a valid and reasonable estimate or of data accurately accounted in books and records normally kept as part of the business or project. If the “developed costs” cannot be tied back-in, they are merely speculative and not acceptable. This is the key to acceptance of proofs.[578]

The primary oversight in most construction delay proofs is the causal link between the event or non-event of entitlement and the damages incurred. Yes, a party may have been disrupted in performance or as an example, was disrupted as a result of having erected a piece of steel that was misfabricated, but was the time of performance increased as a result. Most everyone would say yes, but the difficulty comes in determining how. The causal link between cause and effect <u>must</u> be part of the entitlement proof. If the example of misfabrication is used and the misfabrication was significant, the proof of misfabrication must include not just the design requirement (as shown in the drawings and specifications) and fabrication details (erection and shop detail drawings) and the time/equipment cards for erection crews; but the proof of the idle time caused while the problem was determined; proof of lack of timely response from other parties; proof of need to shift a crew from other work to correct and complete proof of home office engineering time spent in attempting to ferret out the reason the work could not be performed. Each of these items demonstrates and proves disruption. When the proof of delay is required, the delay is the impact of all these elements which constituted the entitlement proof.[579]

The more precise the pricing of the disruption claim, the more credible the proof. To the extent that the contractor is not able to provide actual costs of the extra work, it is still necessary for the contractor to segregate those costs that are not related to the disruption claim.[580] A contractor considers the following points when pricing a disruption claim:[581]

- *Link the specific cause to the effect;*
- *Obtain contemporaneous documentation;*
- *Include all costs of the impacts;*
- *Support the claimed amount with specific evidence;*
- *Be reasonable and;*
- *Keep the presentation simple*

Additional questions that should also be asked when calculating disruption claims should include:[582]

- *Are the labor categories consistent with the affected activities?*
- *Do material charges represent the true excess costs or do they include the original scope of work?*
- *Are the costs incurred in the appropriate time periods?*
- *Are the costs reasonable?*

While theoretical analyses may look as though they may prove the party's case, the trier of fact is only interested what actually happened and how it impacted the project. The nexus of causation is the critical link to proving disruption claims. The principal proofs required include establishing the reasonableness of: [583]

(a) the as-planned programme; and
(b) the impacts on the programmes.

If the cause and effect are to be proved by reference to the as-built record, then the principal task of the expert in disruption and extended working is to establish by reference to documents or witness statements:

(a) The activities which properly relate to excusable and/or compensable change

(b) The logical relationship between the activities
(c) The effect on the as-built programme but for the excusable events.

5.2.2.4.3 Required Proofs for Disruption Damages

With respect to disruption, the author found that:

- Disruption is an activity specific loss of productivity caused by changes in the working conditions under which that activity was performed;
- Disruption is a material alteration in the performance conditions that were expected at the time of the bid;
- Lost productivity is a classic result of disruption because in the end more labor and equipment hours were required to do the same work;
- Disruption is founded on three principles:
  - ➜ A contractor is entitled to perform its work in a series of efficient and economical operations with each stage dependent or related with other stages;
  - ➜ The owner has a duty not to interfere or interrupt the contractor's performance; and
  - ➜ The contractor has an obligation when it plans it work and sequence that it does so reasonably.
- Pricing disruption damages is difficult and no exact formulas exist that can be uniformity applied to every project;
- The impact costs calculated are the increased labor costs that stem from the disruption to labor productivity resulting from a change in working conditions
- While a number of methods are commonly presented in the calculation of disruption impact costs, the measured mile approach is the most accepted form of impact analysis provided the contractor can identify an unimpacted period in which the work being performed was sufficiently similar to the work performed in the impacted period;
- The mere occurrence of disruption to a contractor's performance does not automatically entitle it to disruption damages; and
- The claimant must establish liability, causation, and the resultant damages by:
  - ➜ Summarizing the relevant events that occurred
  - ➜ Identifying and deducing responsibility for the disruption and extended working period
  - ➜ Identifying the nexus of the element of causation and

- ➜ Tying the productivity loss to numbers that are verifiable and which the veracity is easily demonstrated while concurrently demonstrating that the losses were incurred in the same period as the disruption impact being claimed.

5.2.2.5 Measured Mile Analyses and Disruption/Inefficiency Damages

The measured mile is defined as a continuous period of time when the labor productivity is unaffected.[584] A measured mile analysis compares work performed in one period not impacted by events causing a loss of productivity with the same or comparable work performed in another period that was impacted by productivity affecting events.[585] In its purest form, this method compares the productivity on identical activities during impacted and unimpacted periods of the project to determine the loss of productivity resulting from the impact. An advantage of this method is that it compares only the actual productivity that is achieved during impacted and unimpacted periods. This eliminates any disputes over the validity of original estimates or productivity factors, since the comparison is being made between actual productivities achieved during impacted periods with the actual productivities achieved on the unimpacted period of the project. However, since it is often rare to find identical activities, most measured mile analysis compare productivity on substantially similar activities.[586] The contractor must be careful not to make too broad of a comparison.[587] If the actual performance is compared to the bid performance, then the calculation becomes no more that a total cost methodology and would be subject to the same proofs as discussed above for a total cost claim.[588] The more comparable the project conditions during the two periods (other than the disruption)-the more persuasive the analysis.[589]

5.2.2.5.1 Calculating the Measured Mile

In order to perform a measured mile calculation, the labor productivity is calculated for the area or period of unimpacted performance. When choosing a time period for use as a measured mile, it is important that the work performed be representative of the overall work. When the unimpacted time period is determined, the unit productivity during the time period must be determined. The most common methodology for determining the productivity rate is by taking the actual number of hours and dividing it by the actual quantity of work performed. This provides the productivity during the unimpacted period, which becomes the standard against which the productivity in the impacted period is measured.[590]

The next step is to identify similar work of the same trade during alleged impacted period, and compare those two on an hourly basis based on the productivity during the impacted and unimpacted periods. The one obtains a percentage of lost productivity by determining the ratio of the productivity during the impacted period to the productivity during the unimpacted period.

The next step is to isolate the period of performance that was allegedly impacted. The productivity for the impacted period is calculated in the same manner as for the unimpacted period. The difference between the two productivity factors is the difference in productivity between the impacted and unimpacted periods. The manhours caused by the impact would be calculated as follows:

> *Additional Hours = (Unit Productivity Impacted Period-Unit Productivity Unimpacted period) X Number of Units during the Impacted Period*[591]

There are other forms of productivity measurement for measured mile analysis which, in the author's experience, have also been accepted in legal forums. For instance, on a project that is paid and/or monitored on a percent complete basis, it may be appropriate to compare manhours to percent complete. A sustained rate must be established along the time graph and used as the basis for the measured mile. When applying such approaches, however, it is also important to recognize that the first 10-20 percent and the last 10-20 percent of a project are typically inefficient and thus should not be considered in the measured mile analysis. Thus, when obtaining a sustained rate, the individual performing the measured mile calculation needs to establish a sustained rate somewhere along the 10-90 percent work performed, but ideally between the 20-80 percent of the work performed. While the industry literature does not specifically address this method of establishing a productivity rate, the author has seen and used this method on a number of occasions where it was the more appropriate methodology and has been accepted in legal forums.

Although there are different ways to calculate the measured productivity, the goal of the measured productivity method is to compare productivity during undisrupted periods (or locations) with productivity during disrupted periods (or locations).

Causation is the most difficult element to prove. Without proof of a causal link between the owner-directed changes and the ensuing loss of efficiency, there is no entitlement to recovery.[592]

> *Several challenges have been made to the application of a measured mile productivity method:[593]*
>
> *1. There is a lack of similarity of the work being performed in the compared periods*
> *2. There was no period in which the work was not affected by disruption.*
> *3. Labor productivity was subject to a wide variation within separate periods.*
> *4. Performance during the baseline time period was subject to circumstances that might have improved the labor productivity, and thus it did not represent a true baseline for comparison.*
> *5. Adjustments should be made to the disrupted period to account for other conditions that may have affected productivity.*

Other limitations, adjustments, or problems with the use of the measured productivity method include: [594]

- *The lack of an unimpacted time period or location to develop a measured mile baseline, because disruption occurs throughout the project.*
- *"Learning curve" or worker orientation and familiarization should be taken into account*
- *Time and price adjustments, such as accelerated work, change order work, and time and material compensation, may require special consideration.*
- *Environmental factors, such as temperature, wind, and other weather conditions, may affect the comparison.*
- *The measured mile period or location may not represent a reasonably sustainable level of productivity.*

5.2.2.5.2 Required Proofs for Measured Mile Analysis and Disruption/Inefficiency Damages

Based on the references reviewed and the appropriate case law, it is clear that arbitration panels and the Courts require a reasonable method of calculating damages and a casual connection to actions or inaction of the party against whom the claim is being made. In addition, whenever actual cost data is available and, to the extent available, every effort should be made to determine the actual impacts rather than relying solely on studies.

With respect to the measured mile methodology, the author found that:

- The measured mile is defined as a continuous period of time when labor productivity is relatively unaffected;
- A measured mile analysis compares the work performed in one period not impacted by events causing a loss in productivity, with the same or comparable work performed in another period that was impacted by productivity affecting events;
- The advantage of the measured mile methodology is that it minimizes any disputes over the use of the original bid or estimate and comparisons to the actual productivity achieved during a sustained period to similar work that was impacted;
- When a claimant wishes to use a measured mile methodology, it needs to demonstrate that:
  - ➜ There exists a period where no, or minimal disruption, occurred to the work activities
  - ➜ The undisrupted productivity rate represents an actual performance rate sustained for a period of sufficient duration
  - ➜ The nature of the work being performed in the unimpacted period is comparable to the impacted period of work
  - ➜ There is a cause and effect of the events impacting the productivity and the productivity impact costs being claimed
  - ➜ Any learning curves have been taken into account
  - ➜ That any conditions or context, such as, environmental factors like temperature, wind, and other weather conditions have been considered in the comparisons and any impact from these factors has been deducted from the amounts claimed.

6 ALTERNATIVE DISPUTE RESOLUTION

The author sits as a member of the National Construction Dispute Resolution Committee, a committee of the American Arbitration Association (AAA), whose mission is to collaborate between over 25 associations to develop industry-specific dispute resolution procedures and processes. Working with this committee, the AAA developed a survey to measure, among other things, the use of Alternative Dispute Resolution (ADR) in resolving construction disputes and managing risks inherent in construction projects. More than 150 construction-related professionals-primarily engineers, general contractors, architects, party representatives, arbitrators and lawyers, participate in the study. Close to 90% of the respondents indicated that they had participated in some form of ADR, indicating a clear use of ADR in the construction industry. The most common form of ADR was arbitration followed by mediation. More than 30% indicated that they were involved in dispute avoidance methods such as partnering and dispute resolutions boards. The survey also indicated the desire to find more forms of method to try and both avoid and resolve disputes.[595]

Should conflicts not be resolved easily between the parties, the parties in a construction contract will then need to resort to more “formalized” means of dispute resolution. Typically, there is a hierarchy of how disputes are handled during a project. The methods most commonly used for alternative dispute resolution include:

- Dispute Resolution Boards (previously known as Dispute Review Boards)
- Mediation
- Mini-trials
- Arbitration

A summary of each of these methods is discussed in the sections below.

6.1 Dispute Resolution Boards

The DRB process was first introduced on international projects in 1980 on the El Cajon Hydroelectric Project in Honduras.[596] Since this time, the use of DRBs has increased exponentially. In January 1988, seven DRB projects were completed and 16 recommendations for resolution were issued and accepted with little to no litigation. By February 1991, 21 DRB projects had been completed and 78 recommendations for resolution were issued and accepted without litigation. As of January 1994, 68 DRB projects had been completed and 211 disputes were settled. An additional 98 projects were under construction and 172 more were in the planning stage. At that time construction projects which totaled $19 billion had used or had planned to use the DRB process.[597] By 2002, if one looks at all the DRB projects since 1988, more than 1,000 projects have been completed using DRBs valued at over $79 billion and avoided litigation in 97.9% of all the cases they addressed.[598] By September 2003, more than 1,000 projects have impaneled DRBs which settled 1,200 disputes with less than 30 disputes proceeding to litigation.[599]

DRBs typically consist of a panel of three neutral individuals appointed by the parties that become part of the project team. They attend periodic meetings, review essential project documents and assist in the identification and resolution of issues and potential problems. DRBs are usually, although not always, established in the contract documents. The process is that when a dispute arises on a project, the dispute is presented to the DRB at a hearing and the DRB deliberates and makes a recommendation to the parties. While non-binding upon the parties, they are typically admissible in future proceedings-such as arbitration or litigation-if the issue is not resolved at the DRB level.

The Dispute Resolution Board Foundation cites nine elements that contribute to the DRB success:[600]

(1) All three members of the DRB are neutral and subject to the approval of both parties
(2) All members sign a three-party agreement obligating them to serve all parties equally and fairly
(3) The DRB's fees and expenses are shared among the parties. Costs vary depending on how often the DRB is asked to resolve disputes.
(4) The DRB is organized at project initiation before any disputes have arisen.
(5) The DRB keeps abreast of job developments by means of periodic review of relevant documents and regular site visits
(6) Any party can refer a dispute to the DRB
(7) An informal but comprehensive hearing is convened promptly
(8) The written recommendations or decisions of the DRB are not binding on either party unless mandated by the contract, but they are generally admissible as evidence, to the extent permitted by law, in subsequent arbitration or litigation.
(9) DRB members are absolved from any personal or professional liability arising from their DRB activities.

6.2 Mediation

Mediation is the process by which the parties select an independent individual to "hear" the disputes and issues presented by each of the parties and for that individual to then facilitate discussion among the parties in order to arrive at a settlement. The mediator participates impartially in the negotiations, guiding and consulting the parties involved.

The goal of mediation is to arrive at an agreement that all the parties find mutually acceptable. The mediator does not impose the settlement but rather guides the parties towards achieving their own resolution of the dispute. Settling disputes through mediation generally saves time and money and perhaps the most important aspect-saves the business relationship of the parties.[601]

Typically the process for mediation involves the parties selecting a third party neutral whom both parties trust and agree can hear the parties' disputes and allegations and then work with the parties to attempt to find common ground and resolution. Once the individual is identified, the next step is to schedule a time for the parties and the mediator to meet to hear the disputes. The mediator usually requires each party to prepare a mediation statement that outlines briefly the allegations and reasons for relief. Most mediators limit the number of pages that are to be submitted to the mediator and to the parties involved in the mediation to somewhere between seven-twenty pages. The limitation is to force the parties to isolate on the key issues in dispute and the key reasons for entitlement as well as the damages for which the respective parties believe that they are entitled. While the information is probably not "new" to either of the parties, it does provide a framework for the mediator to give him/her an understanding of the issues and monetary amounts being claimed which in turn will assist the mediator in his/her discussions with the respective parties.

Mediations typically range from 1 day to 3 days depending on the size of the dispute and the number of parties involved. Most mediations are 2 days in duration. The first half of the first day or the full day (again depending on the size of the dispute and the number of parties involved) will be for the parties to make a brief presentation of their alleged issues, reasons for entitlement, and the amount of money being claimed. While the presentation is good for the mediator to hear and to understand for the assistance that will be provided for negotiation, the primary reason for the presentations is for the respective parties to present their version of what happened to the other party (ies) raising the key points that would be pursued in further litigation should the matter not be resolved.

The parties are free to bring whoever they desire to the mediation, but mediation is most effective when someone who can bind the company in a decision is present. If no one of authority is present at the mediation, the probability of the mediation being successful is very low and the mediation provides little value other than determining what the other party may continue in a litigation venue. In addition to the principal, the party will most likely have their legal counsel present who often makes the presentation on behalf of the party citing legal precedent or legal reasons upon which he/she believes his/her client is entitled. In larger disputes, the party may also bring an expert witness who will attend to assist counsel in talking with the mediator, or who may make a presentation on the expert findings, whether that be technical issues, delay and/or damages. Thus, depending on how many individuals make presentations will also determine the length of time that will be required to make the initial presentations in front of all parties and the mediator at the same time. One of the most important aspects of mediation, world over, is that anything that is said and/or presented in the mediation is not recorded, not handed to the other side, nor can be used in any future legal proceeding. The mediation is not binding and only serves as a vehicle to bring the parties together in a forum where they can actively negotiate with the assistance of a qualified and experienced facilitator whose sole responsibility is to assist the parties in determining the soundness of their respective claims, the probabilities of going forward and to bring the parties closer together, hopefully in a resolution for which the parties can agree and then put forth the agreement in writing for execution upon completion of the mediation or some reasonable time thereafter.

Once the initial presentations are made, then the normal practice is for the parties to move to separate rooms. The mediator then roams from party to party in order to discuss merits of the claims and reasonableness of the monies being claimed. The mediator, unless told otherwise, holds what he/she is told in confidence and uses his/her negotiation skills in their respective discussions with the parties. Discussions continue throughout the day or days until there is either a resolution that can be drafted between the parties at which point the dispute has resolved itself and no further litigation action should be taken, or the negotiation breaks down, the parties remain too far apart and the matter continues under what ever form of dispute resolution is defined in the contract.

The entire purpose of mediation is of course to attempt to allow the parties to resolve their differences in a non-confrontational manner and confidential manner while still preserving their relationship with each other. Mediation further avoids what could be a very costly task of resolving the dispute through formal dispute resolution processes.

6.3 Mini-Trials

A mini-trial is where the parties each nominate a decision maker that has not been involved in the project to serve on a panel with a neutral party to serve as the Chairperson. Attorneys and experts from both parties make presentations to the panel relative to their respective issues and disputes. After the presentations, the panel meets and decides whether a resolution can be arrived at for which the two party representatives can then bind both parties to the settlement-or resolution. Should the two party members, with the assistance of the neutral, not be able to resolve the disputes, typically the neutral then serves as a mediator assisting the parties in seeking a resolution.

6.4 Arbitration

Should the parties not be able to resolve their difference during the project, or through a DRB or through mediation, the most common means of resolving disputes post project completion on international construction projects is through means of arbitration. Generally, any decisions by an arbitration panel are binding on the parties as outlined in the contract. Arbitration is a less formal alternative to litigation and is an efficient means of resolving disputes. It is faster and less expensive than judicial resolution and has the added advantage of presenting the dispute to a panel of industry experts knowledgeable in construction contracting and more often than not, in the particular type of construction in dispute. Also, arbitration is private and not subject to public disclosure, as is true in most litigation.

Typically arbitration clauses are written into the contract and the consulting engineer should be fully aware of these clauses before commencement of the works. The clauses will typically define the language of the arbitration as well as the venue for the arbitration should it be necessary. There are multiple arbitration centers throughout the world with specific rules and procedures on how the arbitration will be conducted. The more common are the International Chamber of Commerce (ICC) rules of arbitration, UNICITRAL and the ICDR, a unit of the AAA. The arbitration center is usually defined in the contract, however, some contracts identify arbitration but remain silent as to the arbitration rules to be followed resulting in the parties having to define this at a later date. However, once a dispute has arisen on a project, it is not advisable to have one additional issue that the parties may not agree and thus the author recommends that the dispute resolution process be fully defined in the contract prior to the parties entering into the agreement. While ICC, UNICITRAL and ICDR are the more common centers, arbitration centers exist throughout the world and the parties developing the contract should be familiar with the precise rules and procedures of the centers and determine which center will provide the most appropriate means of resolving the dispute post the project completion.

6.5 Summary

While the various methods of dispute resolution have been briefly defined and discussed herein, the AAA has developed a simple diagram outlining the various means of dispute resolution and defining the methods as more collaborative or more adversarial in nature. This diagram provides a very comprehensive look at the different alternative dispute resolution methods. In today's litigious world where disputes are a reality and a norm in today's construction practice, it is necessary for the consulting engineer to become familiar with the different forms of resolution and to be prepared to give careful consideration make recommendations as to which alternative methods should be selected in order to best meet the needs of the stakeholders and the project at the time.[602]

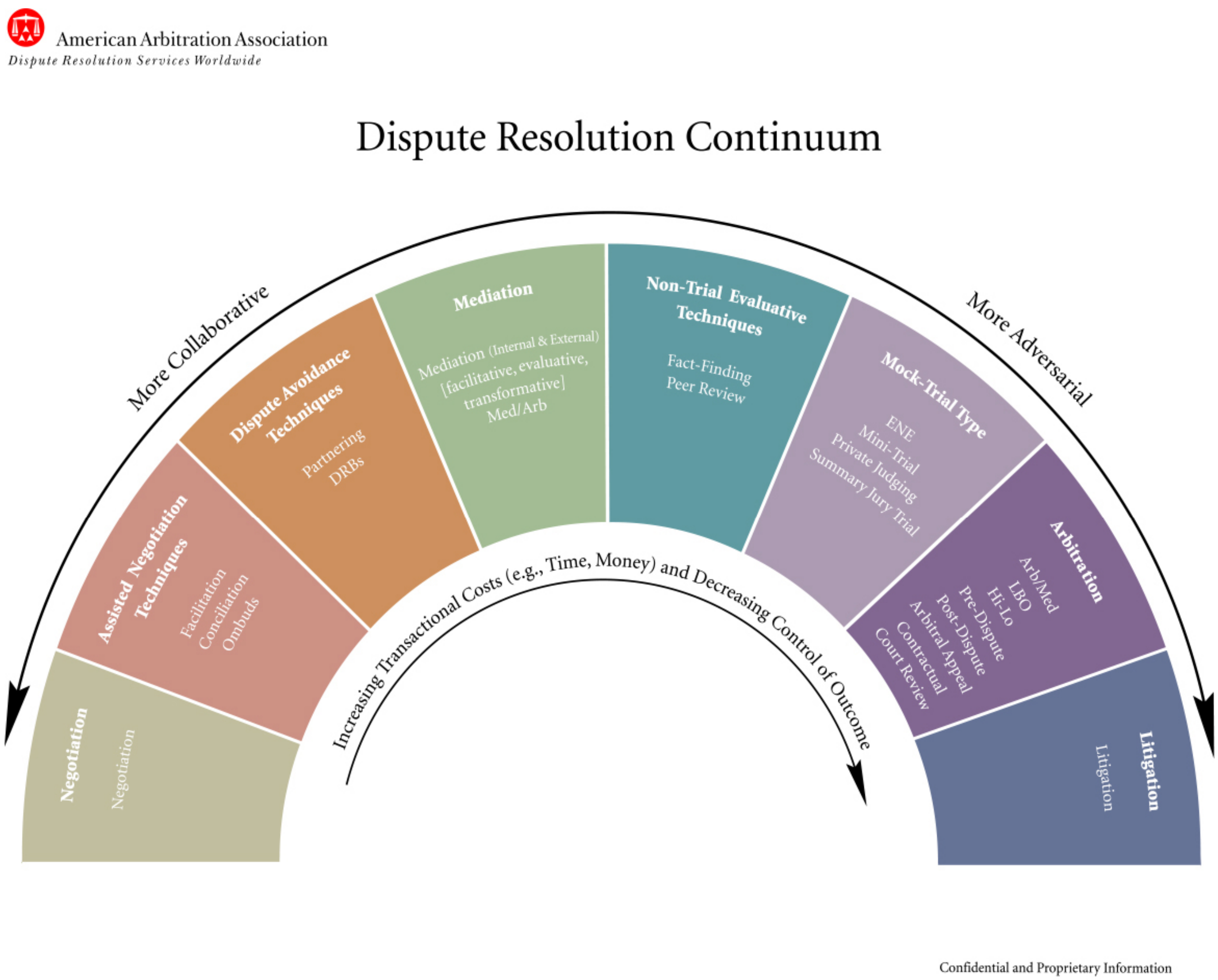

FIGURE XII-1

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XIII. THE PROPOSED MASTERS DEGREE

1 INTRODUCTION

In the Mejii Era, Japan absorbed many of its ideas from western civilization. However, as noted by Past JSCE President, Yoshiaki Iwasa, Japan did not look at what was learned from a "total system". Ideas were merely incorporated on an individual basis.[603] Today, one can also make the same comparison to engineering education reform. While Japan, as other nations, including the U.S., are recognizing the needs for professional skills and the need for courses in the educational system in order to acquire these skills, the work that has been done to date in moving towards this goal has been on a "piecemeal" basis and has not looked at the "total system" with respect to what is needed in engineering education reform to fully develop the 21st Century Engineer. This chapter explores those individual ideas that have been thought of by engineering schools in many parts of the world and then goes further to recommend a proposed masters degree program that can provide the project management and professional skills that are now required for engineers to be competitive and to succeed in the 21st Century.

In 1946, Cornell University in the United States, took a bold step in presenting a 5-year engineering degree. However, the 5-year degree only created "more time" that a student had to take to become an engineer whereas other schools were offering an engineering degree in only 4-years. Thus, in 1965, Cornell took another bold step and presented a new engineering degree program. It was a 5-year professional degree program that consisted of the 4-year undergraduate degree, but with the fifth year as the "professional degree" with an emphasis in the fifth year on professional subjects and liberal arts. The Cornell Professional Masters Degree required 30 credit hours of study.[604] However, it was not until almost 30 years later, in 2004 that ASCE released its book on the Civil Engineering Body of Knowledge (BOK) and the need for an additional 30 credit hours of study beyond the bachelor's degree in the professional skill areas.

Why is it just now that the instruction of professional skills is taking on the situation of a crisis? Because many of the young people today perceive engineering as a less attractive profession. There are increased choices in this global society and companies are becoming increasingly concerned that after a few years, the engineering technology learned today will become obsolete tomorrow. If the engineer does not have the necessary training to move them into positions that while using their engineering skills will allow them to use additional skills in communicating with various respective stakeholders, the engineer will soon face the fate of not only becoming a technician, but will lose any competitive advantage, either domestically or internationally. Companies will look to other professions to lead the team, communicate with the stakeholders while leaving the "technical matters" to the engineers. The need has come to prepare engineers to be flexible, versatile and entrepreneurial in order to survive in this global knowledge based society.[605]

The most dramatic change facing the consulting engineer is the globalization of the engineering and construction industry. While globalization on large international projects has been around for decades, globalization will soon start to affect domestic construction. The change is evitable driven by factors such as (1) inexpensive instantaneous communications through the internet and e-mail, (2) consolidation of English as the global business language, and (3) rapidly improvement of undergraduate engineering education in India, China, countries of Eastern Europe.[606] Further, the highest value added lies at the upper management end of the continuum and not at the lower design end. The skills at the higher end deal with project management. Globalization calls for skills in project management, economics, foreign language, and courses that simply cannot be fully communicated in a four-year degree. Engineers of today will not be competitive in the future unless they adapt to a higher-value-added role as managers of collaborative teams, and thus their education must include relevant courses to prepare them for the 21st Century.[607]

Engineering education has captured the attention of many over the last decade. Numerous articles have been written on the need for engineering education reform. Emphasis has been placed on the need for "professional skills". Engineering organizations such as ASCE have been discussing the situation for years and only in the last two years has a proposed solution been offered. However, despite the multiple articles and books and lectures, the reform will not happen unless the universities take an active part to make the proposed reform happen. Universities must now consider the increasing demand in non-engineering sectors of the economy for engineers and that engineering is a preferred preparation for many jobs and many professions. As noted earlier in this dissertation, today's requirements suggest that a successful engineer will have an exquisite command of the current state of the profession with astute interpersonal skills. This includes team building, global experience, effective communication skills, and the ability to predict the needs of the workforce-the Engineer of the 21st Century will be akin to a Renaissance Engineer.[608]

However, despite the recognized need for engineering education reform from all parts of the world, the author's research of universities has determined that not one school is yet offering the proposed master's degree which focuses on all the respective professional skills that are now required in today's global and knowledge based society-those necessary to produce a "Renaissance Engineer". Several universities do offer some courses within its respective programs and are taking steps to recognize this critical need for today's engineers, but it is at a piecemeal level and the full picture has not yet been captured. The courses that are identified in the following section may have been part of the undergraduate program, or may have been included within the masters program-some within the engineering school and others within the construction management school. The author has attempted to recognize those schools which are moving in the direction so proposed, or may have courses that could be used as models in the recommended course descriptions. To the extent that the author has developed her own descriptions or combined the course descriptions from multiple universities, citations are so noted.

2 CURRENT UNIVERSITY CURRICULUMS WITH 21ST CENTURY ENGINEERING REQUIREMENTS

The author's initial focus will be on programs that are being offered in parts of the world other than the United States. Universities in India recognized a few years ago that in order to play in the higher levels of the world market, they were going to have to educate their engineers in a much broader context. India made a conscious effort to fully capitalize on the competitive resources of the country and to focus its engineering education in such a way so as to optimize the commercialization of technical know-how. Of specific importance were the areas of finance, organization, management, and marketing. India also recognized that companies themselves are becoming more global and those engineers of the future need to be ready to operate in the global, knowledge based society. The reward for the government and universities moving in this new direction is that many Indian engineering graduates are now in senior positions in other fields-business, consulting and finance.[609]

The French are also actively looking to reform their educational system for the 21st Century. The French are looking to change their higher education to combine the formal training of technology with the transmission of cultural appreciation (literature, philosophy, and humanities) and general knowledge. They are further looking towards emphasizing the global perspective and encouraging integration with the European Community's education system. The French recognize this will result in a major reform of the current curricula.[610]

The Helsinki University of Technology in Finland offers a degree in Construction Economics and Management which is noted to deal with the "*managerial, organizational, administrative economic, and legal issues inherent in the construction industry as a whole…as well as, in particular, in the contracting, design, production, and steering of construction investments."* The courses offered include:[611]

- Seminar on Construction Economics and Management
- Construction Contracting
- Advanced Construction Project Management
- Management of Construction Contractors
- Postgraduate Course in Management of Constructors and Internationalization
- Finnish Cases in International Construction Business
- Strategies in International Construction

The Nanyang School of Civil and Environmental Engineering in Singapore offers a graduate diploma in Construction Management. Those who successfully graduate can apply for a Master's of Science in International Construction Management. Some of the courses offered include:[612]

- Project Financing
- International Construction & Marketing
- Construction Management
- Techniques of Project Planning and Control
- Value Engineering and Managing Quality

Temple University in Japan offers a 2-day course in Practical Project Management. The two-day course is actually a fourth module in a series of an open enrollment Global Management Program course. Temple University notes that those individuals who complete eight or more modules will be eligible to receive a "Certificate in International Business Management" from Temple University, Japan.

Temple also offers some courses in the professional skills area including:[613]

- Civil Engineering-Construction Administration
- Engineering Project Management
- Construction Financial Management
- Construction Industry Business
- Strategic Corporate Management in Engineering Construction

The University of Newcastle in Australia offers a Masters of Engineering Management. As noted by the University:[614] *Engineering Management-the art and science of planning, organizing, allocating resources, and directing and controlling activities which have a technical component-is rapidly becoming recognized as a professional discipline. Engineering managers are distinguished from other managers by the fact that they possess both the ability to apply engineering principles and skills in organizing and leading people with technical and non-technical priorities. The Master of Engineering Management program is designed to:*

- *Assist in the transition to a softer spectrum of skills offering courses covering theories and applications of motivational needs, management styles, interpersonal skills, and systems approach;*
- *Develop leadership and communication potential; and*
- *Strengthen engineering skills by offering unique and cutting edge engineering courses covering a range of areas of interest including mechanical, civil, chemical, electrical, and software engineering.*

Courses which are offered which are similar to those being proposed include:[615]

- Engineering and Project Management
- Total Quality Management
- Teamwork and Leadership
- Political Management and Decision-Making
- Accounting and Financial Management
- Management and Organizational Behavior
- Risk Management
- Sustainability for Engineers and Scientists

A course entitled “Society and the Engineer” about teaching ethics to engineers is taught at the Kanazawa Institute of Technology in Japan. The course focuses on three cases in nuclear energy development (1) Monju fire in 1995, (2) Bituminization Demonstration facility fire and explosion in 1997 and (3) Criticality accident at JCO, a subsidiary of Sumitomo Metal Mining Co, in 1999. These three incidents are widely known in Japan and thus the reason for the choice of these projects.[616]

Tokyo Institute of Technology has developed a graduate program in the Department of International Development Engineering which can either be taken in Japanese or in English. The department was established in 1999 to support human welfare in technical aspects. The studies are done in conjunction with the Japan International Cooperation Agency in order to solve problems in the international development, especially concentrated on underdeveloped countries. It is noted that its purpose is to: *our purpose in education is that the students become engineers who have the ability, courage, and leadership, and can solve problems.* Many of the courses offered at TIT are similar in nature to the proposed course in the proposed degree and include courses in:[617]

- Principles of International Development Project
- Exercises on International Development Project
- Engineering/Science and Society: Environmental Impacts and Global Responses
- Engineering/Science and Society: Writing and Analytical Skills
- Sustainable Development and Integrated Management Approach
- Principles of International Co-existence

The Hong Kong University of Science and Technology offers several Masters Degree programs on campus, on-line and combinations thereof. They offer a Masters Certification in Public Policy and Management in conjunction with the University of York.[618] Some of the courses offered at the Hong Kong University of Science and Technology that are similar to those being proposed include:

- Construction Practice and Communication
- Construction Financial Management
- Construction Project Delivery
- Engineering Risk, Reliability and Decision

In addition to those universities in Europe and Asia, several universities in the United States have begun to shape their competitive literature in attracting both undergraduate and graduate engineers into their program through the recognition that professional skills are now a requirement for the 21st Century Engineer. For instance, Tulane University in Louisiana, notes the goals in support of the civil and environmental engineering department to include:[619]

- *To educate our students to a level of competence insuring the requisite skills for proper conception, planning, design, construction and operation of those public and private infrastructure projects that directly benefit the public welfare*
- *To develop in our graduates the ability to use critical thinking and creativity in insuring sustainable development for society*
- *To provide a total experience to our students leading to their moral, ethical, legal and professional commitment to society as a whole*
- *To develop leadership skills for our graduates enabling them to work cooperatively with persons in other engineering disciplines and fields of endeavor for the common goal of society*

With respect to the civil engineering program objectives, many of the objectives include the professional skills including:

- Functioning as a contributing member of a multidisciplinary team
- Demonstration of an appreciation of the roles and responsibilities of civil engineers and the issues they face in professional practice
- Writing effectively
- Speaking effectively
- Demonstration of contemporary issues
- And pursuit of continued intellectual and professional growth.

Carnegie Mellon in the United States, within its Mechanical Engineering School recognized several years ago the need to explore options of how best to train future engineers. The discussions coalesced on an agreement of the following principles:[620]

- Engineering requires critical thinking
- Integrated subjects within and across engineering, and a cross-disciplinary focus provide a better engineering education,

- Effective engineering design and analysis increasingly fall between the traditional disciplines
- Accommodation to the diversity of student talents and interests promotes enthusiasm and student success.

Carnegie Mellon also recognized the need for an understanding of social sensibilities, teamwork and leadership as well as the need to have links with industry and engineering practice. Professional societies, industry roundtables, advisory boards and industry panels provide useful and necessary feedback. By involving industry, partnerships can in co-educating engineers of tomorrow has shown to be very successful. The changes that Carnegie Mellon has made to its engineering program in their mind have allowed them to move from the traditional engineering education to a spatial and practical intelligence to the interpersonal and intrapersonal skills which are essential for the renaissance engineer and a leader.[621]

The Civil and Environmental Engineering Department at Berkeley in California offers a graduate degree in Engineering and Project Management. As noted in the program:[622]

> *The objective of the engineering and project management program is to educate professionals for leadership in corporate and project management, research, and teaching associated with the lifecycle of civil engineered systems. Teaching and research are organized around seven areas of emphasis: business management and leadership, human and organizational considerations, quality and reliability assessments, lifecycle engineering and management processes, construction engineering, engineering and the environment, and implementation processes and strategies.*

The University of Southern California (USC) at its USC Viterbi School of Engineering's Distance Education Network (DEN) offers on-line courses and degrees specifically tailored to the engineering professional. The admission requirements and curriculum for DEN students and on-campus graduate students is exactly the same. Two of its degrees, Master of Science in Engineering Management and a Master in Construction Management contain many of the professional skill set courses that are being proposed by the author. However, the courses are spread over the two degrees and thus one degree does not yet capture the idea by the author. There is still a need for a Professional Engineering Management Degree. Courses that are offered amongst the DEN learning in the graduate engineering school include:[623]

- Oral Communication in Business

- Business Communication Management
- Negotiation and Persuasion
- Management Consulting
- Construction Accounting and Finance
- Accounting Concepts and Financial Reporting
- Project Cost Estimating, Control, Planning and Scheduling
- Finance Fundamentals
- Construction Law
- General Construction Estimating
- International Construction and Engineering
- Quality Management for Engineers
- Management of Engineering Teams
- The Political Process in Systems Architecture Design
- Communicating in the Working World-Managing Diversity and Conflict
- International Business Communication
- Management for Engineers

The University of Washington in Seattle, Washington offers a degree in architecture and urban planning construction management which has several courses which are similar to those being proposed including:[624]

- Introduction to the Construction Industry
- Construction Accounting
- Construction Contract Documents
- Construction Estimating I and II
- Project Planning and Control
- Competitive Business Presentations
- Project Management I and II
- Construction Law
- Construction Firm Management I and II
- Managing International Projects

The University of Washington in St. Louis in the United States offers a Masters of Construction Management and Construction Engineering which has a number of courses that are applicable to the proposed program including:[625]

- Construction Cost Engineering
- Construction Cost Estimating
- Legal Aspects of Construction
- Construction Risk Management
- Construction Management of Public Projects
- Construction Project Planning and Scheduling
- Quality Processes in Construction Management
- Construction Claims

The Ohio State University in the United States has a construction management program which offers courses in some areas reflected in the proposed master degree. These courses include:[626]

- Construction Forensics in Construction
- Construction Network Analysis
- Deterministic Construction Estimating and Pricing
- Construction Contracts and Claims
- Construction Project Administration
- Construction Risk and Decision Analysis
- Management Accounting

The University of Madison at Wisconsin offers a Masters of Engineering in Professional Practice (MEPP) which is closely aligned to both the proposed master's degree as well as the proposed method of education.[627] The MEPP degree is on on-line degree that is designed to allow the practitioner to advance his/her career as an engineering leader by partaking in the advanced education program while still actively practicing. As noted on the university's website:

> *"The Master of Engineering in Professional Practice (MEPP) degree targets the engineering, communication, management and computer skills most needed in today's and tomorrow's work place. A proven engineering graduate program, MEPP has a better than 98% course completion rate. A cross disciplinary degree, MEPP provides an alternative to an MBA for mid-career engineers*

> *seeking to advance in project and engineering management. Courses in this engineering master's degree are problem-based and provide opportunities to integrate learning with current job responsibilities. The MEPP curriculum will improve your ability to: Lead engineering projects and teams to (1) Effectively manage engineering projects, (2) improve products, services, and workplace practices, (3) lead networked global projects and teams.* [The MEPP curriculum] *will improve your ability to communicate effectively as a leader with many audiences and (1) use better strategies to achieve results, (2) use better practices in al forms of communication, (3) overcome barriers to effectively working across cultures, and* [the MEPP curriculum will] *improve your abilities to make better engineering and business decisions to (1) understand the big picture-how your decisions affect the business performance of your organization, (2) use the latest computer-based tools for better analysis and project management, (3) apply statistics to problems and identify opportunities for improvement and (4) conduct research that supports better decision making."*

The on-line course allows an engineer to complete the distance education in two years without interruption to an individuals work or career. The degree consists of 26 graduate credits obtained by taking ten courses plus two summers on site at the university in a week-long residency. The courses which most closely align with that proposed by the author include:

- Engineering Economic Analysis and Management
- Technical Project Management
- Communicating Technical Information
- International Engineering Strategies and Operations
- Quality Engineering and Quality Management

The George Washington University in Washington, DC offers a distance mode Masters of Science in Project Management which has several similar qualities to the proposed degree including the integration of distance mode learning and on-campus residency week. Students are required to attend a one-day orientation session in Washington DC on the campus to provide an opportunity to meet the faculty and set forth the patterns of how the distance learning mode will be facilitated and how the student interacts with the school. The class communication is mediated through web-based course management software. Blackboard, a private web shell, facilitates the course interaction, allowing instructors to publish course content and administrative information conveniently. Blackboard also provides virtual classrooms, e-mail, chat rooms, and discussion groups. The CD-Rom replaces the classroom lectures with a transition to internet delivery as soon as high-speed access becomes more common. A one-week residency on the campus is also required prior to completion of the degree.[628] The Program is also laid out in that courses must precede advanced courses. Some of the courses that are offered as part of this Master's Degree include (those that are considered advanced courses are indicated by an asterisk):

- Introduction to Project and Program Management
- Risk Management*
- Planning and Scheduling*
- Project Estimation and Cost Management*
- Project Management Applications*
- Organization, Management, and Leadership
- Conflict Management
- Executive Decision Making
- Financial Accounting
- Financial Management

Villanova University in the United States offers a Masters Certificate in Project Management Practices. Villanova has indicated the reason for an advanced program in project management is needed because: *The increased globalization of the workplace, coupled with the ever increasing influx of change has caused a significant shift in the way business is conducted, projects are managed, and success is determined. Project management has come into the forefront of the skill sets necessary for success in this environment.* [629]

The courses offered in the Certificate program include:

- Understanding Project Management Practices
- Project Management Performance Management
- Issues in Project Risk Management
- Communication, Motivation and Leadership
- Issues in Project Quality Management
- Intercultural Communication and Understanding
- Project Plan Development
- The Project Management Process
- Elective Courses

In review of the above mentioned universities and the courses that are now being offered which are becoming more closely aligned to the needed courses for the 21st Century professional engineer, there are several common themes (1) the need for communication, (2) the need for project management, (3) the need for leadership skills, (4) the need to understand the role of the engineer in society and the importance of ethics and (5) the recognition that in today's workplace, that these courses are generally needed post the bachelor's degree and that in order to attract more engineers to the prospect of gaining these skills, the degree has to be flexible enough to allow an engineer to continue to work while at the same time working towards acquiring the necessary skills to remain competitive. It was observed that numerous universities now offer degrees on line and allow engineers to take most if not all courses through distance learning with the one week to two week on campus sessions. Distance learning is the wave of the future. If universities are to be successful in attracting the working professional to returning to school and if the engineering profession is to continue to live as a profession, it will be necessary for the universities in collaboration with industry and the engineering professions to make significant reforms to the way advanced engineering education is now delivered.

3 THE PROPOSED COURSE REQUIREMENTS AND DESCRIPTIONS

3.1 Overall Description of the Proposed Master's Degree

The proposed Master's Degree Program suggested by the author assumes a 30-hour degree (graduate credits) program with a written thesis that is agreed upon between the university advisor and the consulting engineer. It is envisioned that the degree could be accomplished in a minimum of two years, but could be extended to three years, allowing flexibility to an individual's own personal life and work situation. The degree received would be a Masters Degree in Professional Engineering Management (PEM), reflecting upon the requirements for professional skills necessary to manage and lead engineering teams and projects. Each of the proposed courses encompass the subjects that have been discussed in previous chapters and which upon completion would allow an engineer to have the ability to communicate with the public, non-engineering stakeholders and to gain the ability to negotiate and resolve disputes should they arise.

The author has reviewed hundreds of course descriptions similar to the subjects that have been discussed in this dissertation as being required for the Engineer of the 21st Century. In simplest of terms, engineering either falls in the category of professional services or manufacturing. The professional skills are required no matter what category of engineering is being pursued. However, the focus of the courses and the course descriptions would likely be different if the course was more focused on manufacturing than for professional services. Thus, for purposes of this dissertation, the proposed Master's Degree and its proposed courses have focused on the Consulting industry and specifically the consulting engineer that would be involved in the Construction Industry. While the courses that are proposed have this particular focus, the courses could easily be modified to adapt to other industries.

The proposed Master's Degree also focuses on the fact that most of the immediate students are those that are already in practice and are specifically interested in increasing their professional skills to be more competitive both domestically and internationally. Thus, the degree proposed assumes a combination of short-focused on-campus seminars with the majority of the work being accomplished through distance learning. It is also assumed that specific companies will take a keen interest in the proposed degree and thus some of the courses proposed can be specifically tailored to meet the company's specific needs while at the same time meeting the minimum requirements of what is needed to fulfill the knowledge required for a particular subject. The author believes that this latter recommendation is an excellent means of bringing industry support for the programs, encouraging more engineers to take part in the program, and enhancing the courses through a combination of academia and practical industry experience. Those courses which the author believes can be specifically tailored to a particular company and can be taught within the company's premises are so noted.

3.2 The Proposed Master's Degree Courses

The intent of the Professional Engineering Management degree program is to provide the consulting engineer with the necessary skills to be competitive and effective in the 21st Century. The details of the specific topics have been covered in detail in the preceding chapters. The author recommends that in order to deliver an effective degree program, that the majority of the subject matter presented in the preceding chapters be incorporated into the actual course curriculum for each of the proposed courses. However, the course descriptions that follow are only a guide and are tailored to meet a university's course description catalog to provide the prospective student and/or employer with an overall understanding of the topics to be covered in the course and the minimum knowledge that will be acquired upon course completion. Thus, relative to specific aspects of the proposed courses, the reader is encouraged to refer back to the preceding chapters for any particular subject. The courses have been divided in those courses which the author personally believes are more suitable for on-campus study versus on-line study as well as those courses that could be specifically tailored to meet a particular company's needs and requirements. The program envisions that the student will make an initial visit to campus to meet with faculty and other students and to gain an understanding of how the course program will be conducted, especially in regard to on-line studies. It is further envisioned that the student will need to spend two one-week intensive on-campus stays with respect to subjects that are best presented by a combination of academia and industry practitioners. As the program is directed at achieving international competitiveness, it is recommended that all course work as well as the written thesis be conducted in English.

3.2.1 On-Campus Course Work

<u>PEM Network Skills for Distance Learners</u>

> This course will be the introduction course on Campus which will allow the student to meet the faculty as well as provide the opportunity to use, explore, and gain confidence in all of the learning and collaboration tools needed to complete the distance learning courses on-line. The course will offer practical tips for efficient distance learning and provide opportunities to work through software/hardware/network configuration problems. The course also addresses the challenges of time management and balancing employer expectations, personal and family needs, and course responsibilities. Course topics include: (1) Software setup and becoming familiar with course communications, backup and trouble shooting and security considerations at home, work and traveling away from work, (2) information management including e-mail effectiveness, using online document management, introducing instant messaging, professional web searching, and file management, (3) learning at a distance including learning in a online discussion forums and effective web conferencing, (4) file management skills including understanding file types and file formats, sharing data between applications, and mastering word processing templates and styles (1 credit) .[630]

PEM Legal Aspects of Construction

This course will be covered in a one-week intensive lecture series held on campus. Most topics will be covered by expert practitioners in the field who will be able to share their own personal experience as well as internationally known legal advisors who deal exclusively with international construction projects and international arbitration. This course deals with the numerous ways in which the legal system affects or controls the construction process. The first half of the course will address the construction process from the initial contract through execution. Topics include basic legal doctrines, the consultant/client relationship, contractor selection, the construction process, professional practice problems, and claim resolution.[631] The course will focus on different approaches to contracting, project delivery systems, contract law, and the relationships between the parties to the construction process. The various principal contract relationships and responsibilities (Owner-Contractor, Contractor-Subcontractor, Owner-Architect/Engineer, and Owner-Engineer-Constructor) will be explored as well as the problems and disputes that typically arise out of these relationships.[632] Additional course topics include legal aspects of contract documents, drawings and specifications; bids and contract performance; labor laws; governmental administrative; regulatory agencies;[633] legal issues arising from design and construction services; and liability awareness. The course also examines the advanced project development process-business planning and pre-project planning for engineering, procurement and construction (EPC).[634]

The second half of the course will address construction claims designed to present the basic foundations of the construction claims process starting with an understanding of the contractual basis for construction claims trough final resolutions of claims. These include a detailed survey of the various standard contracts used in the construction industry including FIDIC, ENAA, AIA, etc., and the specific clauses that form the basis for claims; recognition of claims; the contract notice requirements, communicating the basis for claims, pricing of claims and methods for resolving claims including settlement and alternative dispute resolution. This will include presentation of the technical and the legal and business requirements for processing claims in the construction industry.[635] Case studies of the most frequent causes of claims (delay, disruption, acceleration, soil conditions, and changes) are discussed along with the way international arbitration panels determine proofs for causation, entitlement and damages. The role of the expert witness is also briefly introduced.[636] (3 credits)

PEM Construction Risk Management

This course will be conducted through an intensive one-week lecture series held on-campus using a combination of university professors and internationally known experts in risk management. The practitioners will focus on specific case studies where risk management was employed and the savings and claims minimization evident as a direct result of risk management identification, assessment and monitoring. The course identifies the various types of risk encountered in the construction industry and explores the basic principles of risk management practices. The course explores risk from different points of view (project team, client, etc) focusing on the development of risk mitigation procedures and execution.[637] Risk identification techniques will be introduced as well as methods for quantifying risk and risk allocation methods. The steps in developing a risk management plan including identifying analyzing, mitigating and monitoring project risks will be discussed.[638] Both simplistic matrix types of risk identification and probabilistic methods will be explored including reliability based probabilistic risk analyses, Monte Carlo simulation, Fault and Event Tree Models, and At Risk Software modeling. Fundamentals of integrated risk assessment and risk-based decision analysis are emphasized. Through case studies and discussions, the student will develop and understanding of the basic principles of risk identification and management. Practical examples will be used extensively to demonstrate the application of these risk identification and risk assessment methods.[639] (3 credits)

3.2.2 Industry-Based Courses

The following courses can either be offered in an on-line situation or as a company-tailored course to specifically address the specific techniques and methods used by a particular company, thus further enhancing the ability of the engineer to be more effective and efficient in their own organization once completing these courses. Specific company case studies can be utilized as specific training tools. The course can either be offered via university professors coming to the company location and/or video conferencing technology with engineers from the company participating at a specific company location and then working with the university professors through a webinar or video conference.

PEM Project Management

The course provides an overview of the construction industry and practice, and of the planning, design and construction phases of civil engineering projects. The course includes an introduction to the organizational structure and its functions including Organizational Breakdown Structure (OBS), Work Breakdown Structure (WBS), matrix organization and task assignment, setting up of the project team management and administrative functions[640] including the respective duties of professional construction managers. The essentials of Construction Management practices and methods are discussed including[641] the basis of construction contracting, employment practices, and labor relations, organizational financing and accounting, safety practices, risk management, and industrial insurance.[642] The course provides an introduction to project planning, scheduling, cost estimating, budgeting, cost accounting and cost controls as well as an introduction to procurement, value engineering, and quality control/assurance. The course discusses specific aspects critical to project management including the understanding of change orders, project acceleration, coordination, communication, project documentation and record keeping,[643] partnering, safety and health in construction,[644] and ensuring the effective completion of the project on time, within budget and meeting the contract specification. (3 credits)[645]

PEM Construction Cost Engineering

The course examines cost engineering principles. Fundamentals will be reviewed which focus on principles and techniques to problems of cost estimating, cost control, business planning and management science, profitability analysis, project management, and planning and scheduling.[646] Formalized procedures, tools and techniques used in developing the project estimate during the planning stages and in updating the estimate throughout the project life, tools and techniques used in monitoring, managing and controlling the cost of the project will be introduced[647] including the fundamentals of estimating, review of the details of costs associated with material, labor, equipment, overhead and profit.[648] The course will also focus on principles of interpreting financial information and performing engineering-related economic analyses. Course topics include (1) financial principles including implications of basic accounting and cost system to engineering and interpretation of financial data, budgets and accounting summaries, (2) costing systems and management control including activity-based costing, pricing strategies and decision making, life-cycle cost analysis and models, and budgeting and risk analysis.[649] (2 credits)

PEM Construction Project Planning and Scheduling

This course is designed to provide an understanding of the construction scheduling process: (1) fundamentals of planning and scheduling information systems; (2) identification of project activities, activity duration estimation and activity logic and sequence; (3) manpower and cost resource allocation; (4) activity constraints and (5) identification of potential project milestones. The course will provide for an understanding of the critical path method (CPM) theory, legal implications, and practice. CPM network based scheduling methodologies including arrow-on-arrow, precedence and PERT will be presented.[650] Introduction in commercial project management and scheduling software will be provided including its application to a variety of construction problems and projects.[651] Different techniques for analyzing delay on a project will be introduced. Concentration will be on resolving delay disputes as they arise during the project, but after the fact delay analyses will also be explored along with different methods and their acceptance to international arbitration panels. (2 credits)

PEM Quality Management

This course will introduce the various theories of quality and tools to apply various quality practices/principles to the construction management process.[652] The course focuses on modern quality concepts, tools and techniques to develop, implement and maintain systems for improving quality and productivity. Exploration of the use of quality management and planning tools will assist in defining quality problems and opportunities, implement measurable solutions and foster team-based strategies for continuous improvement. The course topics include (1) Kaizen/Total Quality Management, concepts and principles, basis problem solving techniques and tools, defining good process improvement projects and group processes, (2) quality management systems (QMS) international quality standards (ISO 9000, QS-9000, etc), QMS documentation requirements and structures and (3) quality assurance. The course addresses standardization of improved methods through proper documentation using ISO 9000 and QS 9000 standards, basic auditing techniques, and synergy and links between QMS and Strategic Quality Planning. (2 credits)

3.2.3 On-line Courses

These courses are courses that can be tailored specifically to be taught through various on-line teaching methods, depending on the requirements of the university.

PEM Communicating Technical Information

This course focuses on communication skills for engineers. Both oral and written communication abilities will be addressed including oral reporting, oral presentations, project team meetings, management briefings, listening techniques, interviewing skills, conference and committee leadership, and methods of written communication including daily, weekly, and monthly reports, proposals and letter writing.[653] The course includes a series of workshops and practical exercises in construction presentation skills, teamwork and leadership. The course will focus on the ability to communicate effectively, the ability to deal with various audiences and strategies to successfully use technical information. This course incorporates weekly web conferences, forums on communication topics, recommended readings from books on communication. The weekly web conferences will be seminar discussions including presentations and occasional guest lectures. Course topics will also cover practical skills for advanced leadership including: (1) audience analyses-strategies for technical, non-technical, and mixed audiences; (2) teamwork; (3) business communication such as e-mail, memos, letters, style, tone, diplomacy, political correctiveness; (4) major communication projects including reports, proposals, project management, teleconferences; (5) technical presentations online and live; and (6) research such as traditional, library, database, web resources, lifelong learning. Applications to research papers, biographical sketches, engineering reports, and correspondence are emphasized.[654] Beside a written report or proposals, one of the course requirements is to deliver an oral technical presentation, videotape it and submit it as part of the work for the course. Facilitation of a web conference (usually 15 minutes) will also be required. (3 credits)[655]

PEM The Engineer's Responsibility to Society and Professional Issues

This course examines the business issues which constitute the framework within which practitioners apply technology. The course provides an introduction to the profession of civil engineering and its practice including social obligations and ethical challenges.[656] Topics covered include professionalism and ethics, and professional liability insurance.[657] The course focuses on the: (1) influence of quality of engineering and construction works; (2) cover ups and delays in informing others of accidents; (3) work not performed to specification; (4) importance of professional work to society; (5) learning from past experiences and transfer of information from older more experienced engineers; (6) incompetent and inexperienced behavior by engineers; (7) careless design; (8) negligence in watching and observing construction; (8) responsibility of oversight and engineering managers; (9) poor management and management ethics; (10) trust and communication; and (11) the engineer's responsibility when observing unethical or life threatening matters even when not in charge.[658] The course includes actual case studies of ethical and non-ethical behavior and the results and/or consequences and the lessons to be learned. (2 credits)

PEM Teamwork and Leadership

This course will provide a series of tools addressing organizational communications, motivation, team building, and leadership. Coaching and team building exercises will be introduced. Change management, power and influence will be investigated.[659] Integrative approaches to organization concepts, management principles, philosophy, and the differences in theory in public and private organizations will be discussed. Concepts and methods for making complex decisions, identifying criteria and alternatives, setting priorities, allocating resources, strategic planning, resolving conflict and making group decisions will be explored.[660] The course will include aspects of leadership of individuals, groups and organizations including concepts of motivation, conflict and negotiation, and empowerment. Group dynamics and team building exercises will be key aspects of this course[661] including group decision-making, motivation, leadership, infrastructure requirements, performance measurement, team diversity, conflict and integration. [662] (2 credits)

PEM Public Policy Analysis and Decision Making

This course explores the intimate interaction between the political process and the engineering design and processes.[663] The importance of understanding how public policy is developed and implemented will be explored as well as the engineer's role in contributing to this the public policy process. Methods and techniques of analyzing, developing and evaluating public policies and programs will be discussed with emphasis given to benefit-cost and cost-effectiveness analysis and concepts of economic, efficiency, equity and distribution. Methods include problem solving, decision making and case studies. Discussion of the engineer in the political process will also be explored including the importance of engineers communicating with politicians and the consideration of engineers in the political arena.[664] (2 credits)

PEM Managing International Projects

The course focuses on the management of international construction projects. The actual state and problems of international co-existence between Japan and foreign countries-especially south-eastern countries are lectured. These lectures are focused on culture, climate, and law as well as technological aspects. This course focuses on the civil infrastructure development process outside of Japan. Emphasis is placed on examining common problems associated with managing construction projects outside the engineer's own country, identifying risks involved, and discussing possible solutions.[665] Areas of concentration include participant organization and culture, project delivery methods, multinational teams, and unique operational and management activities essential to the international market.[666] The course provides techniques in order to work better globally through a comparative examination and analysis of global trends and regional variations of engineering concepts, standards and practices. Using case studies, lectures and discussions, the course offers a perspective on how cultural differences among countries affect interpersonal and business relationships and actions. This course will describe and analyze multinational and national engineering operations, summarizing best practices. Comparative regional and national engineering professional practice procedures and methods will be explored from different regions of the world. Working across cultures will be explored including: (1) national and regional cultures; (2) business and corporate cultures; (3) languages including verbal and non-verbal; and (4), special concerns including economic and legal, social and political and strategies, structures and people.[667] The course will also present an understanding of the international engineering and construction markets, how to enter those markets, financial resources available, international financial assistance entities, basic legal considerations, and risks involved in international projects. The course also explores the importance of sustainability in all international projects including policy and planning for sustainable development while critically examining the concept of sustainability as a process of social, organizational, and political development.[668] (3 credits)[669]

PEM Understanding Intercultural Communication and Diversity

As project management becomes more and more globalized engineers have the opportunity to interact with business associates from many different countries and cultures and the differences in backgrounds can cause potential communication challenges. This course provides an awareness and understanding of cultural differences as defined by ethnic religious, gender, abilities, and national differences. The course will explore the intentional and unintentional effects of non-verbal communication and the potential damage it can cause to business relationships. The course identifies sources of stereo types and recognizes the impact of stereotypes on the job as well as learning strategies for adapting to different communication styles.[670] Institutional barriers to diversity: race, gender, sexual orientation, age, physical disabilities, culture will be discussed as well as[671] communication strategies to manage workplace diversity and conflict. The course will also focus on the critical importance of a diverse workforce and the challenges the engineering profession faces in attracting women to the profession as well as retaining them in the profession. Recommended techniques and methods for increasing women in the engineering profession and in construction related companies will be presented. (2 credits)

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XIV CONCLUSIONS AND RECOMMENDATIONS

The most dramatic change facing the Japanese Consulting Engineer is the globalization of the engineering and construction industry. While globalization on large international projects has been around for decades, globalization will soon start to affect Japanese domestic construction. The change is evitable driven by factors such as (1) inexpensive instantaneous communications through the internet and e-mail, (2) consolidation of English as the global business language, and (3) rapidly improvement of undergraduate engineering education in India, China, countries of Eastern Europe. Further, the highest value added lies at the upper management end of the continuum and not at the lower design end. The skills at the higher end deal with project management. Globalization calls for skills in project management, economics, foreign language, and courses that simply cannot be fully communicated in a four-year engineering degree. Engineers of today will not be competitive in the future unless they adapt to a higher-value-added role as managers of collaborative teams, and thus their education must include relevant courses to prepare them for the 21st Century.

The "global" international consulting engineer is well respected and well versed in project management, dispute resolution, communication skills and leadership skills. Japanese industries such as car manufacturing, electronics and Information Technology (IT), made significant strides in understanding how to compete globally and have established themselves as formable competitiveness industries all around the world. However, the Japanese Construction Industry did not recognize the changes needed to move into the 21st Century and thus, Japanese Consulting Engineers are no longer equipped with the necessary skill sets to compete in the global marketplace. The current Japanese Consulting Engineer simply does not possess many of the needed skills in order to compete internationally or to move the domestic construction market ahead in Japan. As a result, the image of the consulting engineer in Japan has declined over the years to the extent that few Japanese Consulting Engineers hold prominent government positions, leadership positions, or even have the ability to stamp drawings in the name of the engineer versus the prefecture.

Reasons for reform center on the problems that Japanese Consulting Engineers face in today's global economy including:

- Japanese Consulting Engineers are strong on technology but weak at comprehensive powers and project management capability. They are not good at managing power which is inevitable for international business, especially the ability to handle claims.
- Japanese Consulting Engineers are not good at expressing themselves. It is not just a lack of completing understanding the English language, but also a lack of understanding the social and industrial background differences. This is especially critical when it comes to communication and making timely positive presentations and speeches, areas where the Japanese Consulting Engineer lacks ability.

There is an urgent need to change the image of the consulting engineer in Japan based on the following current situations:

(1) Japan is currently undergoing a major period of social change and reform which has been triggered by the end of the economic growth, the destruction of the post-war political system, and the requirement for Japan to open its market to foreign competition.
(2) Lack of the public's trust for the "public system" due to scandals in the early 1990s, the public's questioning of the effectiveness of public works projects as a result of the 1995 Great Hanshin earthquake, recent accidents with the nuclear power plants and recent issues regarding bid rigging in the Construction Industry.
(3) The increasing difficulty in adjusting to the various trends in the Japanese society such as aging, diversification, the information technology age, globalization, and environmental problems.
(4) Conceptual reforms that engineers have yet to undergo in their mind set, despite advances in construction production systems.

The primary reason that Japanese Consulting Engineers have a low capability of project management is because they do not have the chance to obtain the appropriate education regarding project management and other professional skill sets that are now required to compete in an international marketplace. So why doesn't an education program of project management for Japanese Consulting Engineers currently exist in Japan? Based on the author's research of the consulting engineers history and current work in Japan, the author's experience with Japanese Consulting Engineers, the survey that she performed of Japanese Consulting Engineers and her work with MLIT, the primary reason is based on the fact that up to this point in time, the method of contracting and method of designing and constructing a domestic infrastructure project in Japan has never required a systematic approach or education of project management. The construction industry has simply not required the need for project management skills based on its unique philosophy of contracting as compared to other countries.

There is another reason why Japanese Consulting Engineers have a low capability of project management. Contractually they are not required to be in a position to handle project management. Unlike the consulting engineers in the U.S. and Europe, Japanese Consulting Engineers in Japan have primarily served in supporting roles and have not been involved with giving their opinions with respect to judgment of business, estimates of the works, and selection of contractors. Accordingly, Japanese Consulting Engineers have not been performing such works as offering advice on accountability, qualification examination of contractors, examination of adequacy of estimation and bidding price, management of progress payment, payment to contractors, all which have traditionally been roles of consulting engineering in the U.S. and Europe. Japanese Consulting Engineers domestically are not in a position to draft up construction contracts and instead use what the client creates or use the standard form of contract as developed by the government. As such, the Japanese Consulting Engineer has little concept of contracts, contract clauses and/or the importance of a contract in management of the works. This is a major disadvantage in the Japanese Consulting Engineer's knowledge for international work.

The primary difference in the way Japan operates in its domestic construction industry as compared to the rest of the world is the basis of the two-party structure and the basis of "mutual trust." The understanding of the concept of "mutual trust" and "mutual mistrust" is critical to the success of the Japanese Consulting Engineer. To be successful in an environment of "mutual mistrust" requires the Japanese Consulting Engineer to be trained in project management and especially a culture of contract management.

The two-party system in Japan in basic terms is a one-page contract between the owner (primarily the government) and the contractor. Especially in heavy civil public projects, the designer and consulting engineer are not separate contracting entities nor autonomous in the process. For instance, in most countries, when an infrastructure is conceived, a contract is entered into between the owner and the consulting engineer whereby the consulting engineer prepares the design, stamps the drawings with the consulting engineer's initials and company name and these plans and specifications are then issued to the contractor for tender. Once the tenders are received and a contract awarded, the contractor signs a contract with terms within that include specific requirements for schedule preparation, progress monitoring and reporting and payment applications which are based on progress achieved. Progress as well as conformance to design is carried out by the consulting engineer. The consulting engineer plays an integral role in the construction process and the monitoring of the project and execution thereof is performed via a three-party system. In some instances, an owner may employ a construction manager, (who would also employ consulting engineers) who would strictly be responsible for the project execution and monitoring while the design consultant would be responsible for answering Requests for Information (RFIs) and design questions as well as potentially inspecting the construction in a QA/QC role for compliance to the plans and specifications.

However, under the Japanese system, the designer is not typically recognized and the drawings are merely stamped with the prefecture stamp with no identification of who the actual designer or company was that prepared the drawings. The government basically takes over and the consulting engineer has little to no role in the actual project execution. Under the Japanese form of Contract, there is no practice of having a consulting engineer as so defined in the FIDIC Book who acts as the owner's agent during execution of the project as well as adjudicator of the disputes between the owner and the contractor. Further, the contract which is signed between the government and the contractor has little more than a total dollar amount and a due date for completion. Given the fact that a large prepayment is made with no further monies being paid to the contractor until completion, little incentive remains for either party to monitor cost or schedule, especially knowing past trends have been to resolve any "issue" that arise on a project with a single change order at the project completion which is resolved by "mutual consultation." Thus, under this situation and two-party system, there has been little reason for the Japanese Consulting Engineer to have an identity or to have any reason to acquire project management skills.

British and FIDIC construction contracts traditionally provide for "the Engineer" for engineering works among whose responsibilities is to also resolve disputes as they arise on a contract. Most international construction contracting concepts are based on the concept that the consulting engineer has a dual role; *i.e.* he acts as an agent of the owner and, at the same time, as an independent certifier. Under both the British ICE and FIDIC Conditions, the consulting engineer is vested with a special role to act as a "pre-arbitrator". The consulting engineer reviews and gives "decisions," upon request of either the owner or the contractor, on issues in dispute.

Unlike British standard forms of construction contract or the FIDIC contract, the Japanese contracts do not provide for the consulting engineer. Instead, the owner assigns its staff member, or sometimes may employ a third party, as a site representative of the owner or an agent acting on the owner's behalf. He supervises and certifies the Works and assesses any adjustment to the contract price or the extension of time for completion.

It is also becoming increasingly important for Japanese Consulting Engineers to have knowledge of public policy, not only for the consultants, but for the entire project team. Most of the public works are for the public good and the role of the engineer is to protect the public health, safety and welfare of the public. As the Public Involvement (PI) process increases for public works projects in Japan, it is essential that the Japanese Consulting Engineer play a vital role in this process. Japanese Consulting Engineers can efficiently and effectively contribute to the study and review of projects from the beginning stages to the final stage and satisfy the public policy makers. The Japanese Consulting Engineer is ideally suited for this role; especially since the consulting engineer can be in an independent position and take a neutral viewpoint which is important in the public policy decision process.

While the current domestic contracting system in Japan may appear internally “to work,” the current system has a very short shelf life in the face of WTO requirements and the shrinking infrastructure construction market. Public works are the main source of the civil engineering construction business. The MLIT is the typical and the largest customer procuring public works contracts. However its procurement system consists of two distinguishing features: the Designated Competitive Tendering System and the Ceiling Price.

The MLIT selects a certain number of bidders for a particular project and even designates the combination of members for joint ventures. While it is said that this system has served well for purposes of fair distribution of contract awards among contractors, it is not clear to the public how the MLIT has selected bidders or joint venture members in reference to other contractors who obviously are capable of performing the project. There is no transparency and this is not a system of fair competition in which any contractor within the eligible classification may participate in the bidding. Further, recent indictments regarding bid rigging in certain sectors of the Japanese Construction Industry has led to further public mistrust.

The estimate made by the MLIT's officers becomes the budget and hence the Ceiling Price for purpose of the award of contract in accordance with the law of government's accounting system. This Ceiling Price is not made public. Construction contracts are procured as lump sum contracts, and a tender submission is nothing more than a piece of paper in which a lump sum contract bid price is written. If there is no tender who is below the Ceiling Price, the submittal of prices is repeated up to three times without any changing of the tender conditions announced by the owner side, after which a new set of tenderers is selected by the MLIT. It is almost always the case that some tenderer goes below the Ceiling Price and is awarded the contract on the first round of the bidding. The procurement system of other public authorities is similar to that of the MLIT.

These two features of the public works procurement system have been recently criticized, as they tend to create bad business practices, in fact, such as unlawful trusts ("Dango"). Transparency is being called for by the public to avoid any further corruption in order to learn the Ceiling Prices in advance is sometimes reported in the press. The Japanese Civil Works Infrastructure Construction Industry is not prepared and cannot survive in a market that is open to competition, yet continues to operate and function as it has for so many years. The government walks a thin line in committing the country to a period of structural change and dealing with the massive debt the country has accumulated. This change is being accomplished at the same time Japan is also dealing with demographic changes. The government at the highest levels has committed Japan to change. While the changes must be made, the government has left the domestic civil works infrastructure construction Industry in an unenviable position. It has to open the domestic market to those contractors that are accustomed to the global civil works infrastructure construction market.

If Japan is to sustain a healthy and sustainable construction industry and become competitive on the open market, the system has to change. Japan has changed dramatically in the last two decades as evidenced by the strong competitive advances in other industries such as IT, electronics and the automotive industry. The younger generation is recognizing the need to learn about ethics and professionalism. Japan will continue to change over the coming years. The MLIT has begun to make some strides in this area. The author has worked with the MLIT on researching public contracting methods and concepts as well as procurement concepts for both Japanese Consulting Engineers and Japanese Contractors in other parts of the world. The MLIT is taking steps to procure outside consulting engineering services, has taken some steps in allowing in some cases for consulting engineers to be recognized in the construction documents and has even started some “pilot projects” where a construction manager has been retained. The slow but steady changes in Japan's construction industry are due to the following three major reasons:

1. Outside pressure, *e.g.,* the Japan-U.S. Structural Impediment Initiative, to open Japan's construction market and assure fair competition

2. Public demand for fair competition

3. The natural tendency of the construction industry itself to demand a truly open market amid persistent economic recession

However, this evolution of methods and forms towards "international ways" should not be seen as some form of abandonment by Japan and its people of their culture. It best can be understood as an economic occurrence. Japan's economy progressively increases its linkage with the economic of other nations; Japan's trading surpluses bring increasing pressures for the opening of Japan's domestic market to competition from outside Japan; with increasing exposure of Japan's people to more open and more competitive practices in other societies; Japan's people increasingly press for introduction of truly competitive procurement practice to be used in Japan. Just as many other Japanese practices, whose roots lie in pre-Meiji restoration eras have gradually altered since Japan's "opening" of itself to the rest of the world, so may we expect many of the construction industry's past practices to be replaced by practices more conducive to true competition. Such change doubtless will include the adoption of various contract forms, concepts, and methods which other nations have developed in fostering greater competition within their markets. As construction is a major industry in Japan, it is to be expected that that industry will among the Japanese industries most affected by such change. If the Japanese construction market is to survive and the Japanese Consulting Engineer competitive and effective both on the domestic as well as the global market, immediate changes have to be made in both education and practice of project management.

As the MLIT begins to make steps towards opening its market and changing its public contracting processes, it will need to continue to also hasten the number its learning of project management and its application to public works projects. While it has started internal projects in having its own engineers becoming Project Management Professionals (PMPs), the only way to assure a complete and effective method towards bringing consulting engineers to the forefront and to bring Japan back to its world competitive market, is to increase the education of project management and professional skills necessary to compete both domestically and in the global marketplace.

This will be best accomplished by the reform of the engineering education system and the introduction of a Master's Degree level program in Professional Engineering Management which will cover the project management and professional skills that are now required of a 21st Century consulting engineer, including:

1) An understanding of globalization;
2) The importance of ethics and professionalism;
3) An understanding of diversity throughout engineering and the multi-disciplinary team;
4) Effective oral and written communications;
5) An understanding of leadership principles and attitudes;
6) An understanding of public policy;
7) Project management skills;
8) Risk management skills; and
9) An understanding of dispute resolution skills.

It will be these fundamental capacities that will allow the Japanese Consulting Engineers to develop into independent professional engineers capable of working both domestically and globally, respected by the public and regarded by the government as professionals whose services are to be based on qualifications and not price.

By using this program, Japan and the Japanese Government will be able to educate the engineers of governmental organizations as well as private consulting firms and private owner companies. It is essential that Japan revise its standard conditions of contract and move from a two-party system to a three-party system together with reforming its engineering education for increasing the Japanese Consulting Engineers' capabilities.

Thus, the author recommends that with the new freedom experienced by Japanese universities with their separation from the Government, that university Presidents take note of the proposed Master's Degree program suggested by the author and consider programs similar to that proposed which will include university and industry partnerships and will allow practicing engineers to reenter the education system while still working at their respective companies. In this way, Japan has the opportunity to regain its competitive edge on the world stage in consulting engineering.

The proposed Master's Degree Program suggested by the author assumes a 30-hour degree (graduate credits) program with a written thesis that is agreed upon between the university advisor and the consulting engineer. It is envisioned that the degree could be accomplished in a minimum of two years, but could be extended to three years, allowing flexibility to an individual's own personal life and work situation. The degree received would be a Masters Degree in Professional Engineering Management (PEM), reflecting upon the requirements for professional skills necessary to manage and lead engineering teams and projects. Each of the proposed courses encompass the subjects which upon completion would allow an engineer to have the ability to communicate with the public, non-engineering stakeholders and to gain the ability to negotiate and resolve disputes should they arise.

The proposed Master's Degree also focuses on the fact that most of the immediate students are those that are already in practice and are specifically interested in increasing their professional skills to be more competitive both domestically and internationally. Thus, the degree proposed assumes a combination of short-focused on-campus seminars with the majority of the work being accomplished through distance learning. It is also assumed that specific companies will take a keen interest in the proposed degree and thus some of the courses proposed can be specifically tailored to meet the company's specific needs while at the same time meeting the minimum requirements of what is needed to fulfill the knowledge required for a particular subject. The author believes that this latter recommendation is an excellent means of bringing industry support for the programs, encouraging more engineers to take part in the program, and enhancing the courses through a combination of academia and practical industry experience.

The author also recognizes that the suggested Master's Degree may not be able to be immediately implemented in Japan as so proposed due to limitations on faculty experience and expertise to teach the proposed courses and/or administrative issues relative to designing and implementing such a program. Thus, as an interim step, the author recommends that universities take steps to prepare “modules” and/or certificates that can be issued for groupings of courses such as those in the project management area. The author also proposes that industry practitioners, in partnership agreements with universities be engaged to teach courses in cases where a particular institution may not yet have faculty well versed in particular areas. Similar program designs to Master’s of Business Administration (MBA) Executive Programs in the U.S. could be designed where courses are taught on Saturdays and thus both students and practitioners have more available time to attend and teach classes.

Another question that must be addressed is what happens if the Japanese domestic Construction Industry does not change, what value is added by adopting the proposed education reform? The answer is simple-given no change, if consulting engineering firms and construction companies adopted the proposed program, their respective companies would become more profitable as the means and methods for doing business would be more efficient and effective. This is the key to success even under the 2-party system as it exists today. It will be important for top management to participate in the proposed program as well in order to not only effectuate change within their own organizations, but to be part of the process of increasing profitability.

Relative to the government, issues of transparency are continuing to impact the Japanese domestic Construction Industry. It is necessary for government engineers to learn the social sciences (public policy) in order to improve the policy making process. In this way, Japan will also integrate its engineers within all sectors working together to arrive at a total solution to an existing problem and new value added is then defined as to its benefits to the Construction Industry.

Author’s Comments: Based on the author’s extensive research over the last two years, the author has learned the importance of studying other cultures and business operations before one can make recommendations as to change. This research is helpful to foreigners wanting to study the Japanese marketplace and what skills are required to become world engineering leaders. While the research was focused on the Japanese Consulting Engineer, the author learned through the research that the topic of engineering education reform is not isolated to Japan and that other countries, especially those in Asia could benefit from review of the research that has been performed. The author also believes that the proposed Masters Program could be implemented in most countries and with the struggles that most countries are facing in this regard, the research proves timely and provides a guideline from which education institutions can use in their own curriculum design for engineering education reform. With respect to Japan, the author learned that Japanese Consulting Engineers excel in technical abilities; however, they lack the ability to push forward as a result of their lack of understanding and appreciation of project management and the management process. I have learned in general that engineers have not had an opportunity to learn "soft" skills in their traditional engineering education or their work environment, but with the opportunity to do so, they can inspire to become leaders and influential in the policy making process. I believe that young engineers should aspire to learn the skills that I have discussed as the research demonstrated that those possessing these skills will indeed position themselves into top management and leadership positions. The same is true for companies, in that by employing the recommendations proposed, the companies can become more profitable by incorporating diverse opinions and project management concepts resulting in more efficient and effective operations. I have discovered that Japan is rapidly changing on many fronts and now has an opportunity with the proposed recommendations herein, to once become a world leader and competitive player in the construction industry in the international marketplace provided it takes immediate action to implement actions along the lines of the recommendations proposed. Otherwise, based on my research, it would appear that Japan will continue to experience difficulties in the construction industry in the international marketplace and may take a step backwards, serving more in the role as a subcontractor to other world players who have begun to recognize the importance of project management, such as the Koreans. The research also demonstrates that employing such recommendations will make an individual company more profitable and thus the proposed recommendations are applicable to those Japanese firms and consulting engineers who will remain working solely in Japan. The research has confirmed my own passion for the engineering profession. I believe that given concerted efforts by both industry and universities to work together in implementing the proposed solutions, that the engineering profession can indeed raise its image, produce world leaders, increase the confidence level with the public and demonstrate that engineers do indeed improve the quality of life for society and can do so while at the same time as increasing firm profitability.

APPENDIX A

SURVEY OF JAPANESE CONSULTING ENGINEERS

Survey of Consulting Engineering in Japan

The following questions are being asked as part of the research being performed by Patricia D. Galloway for her Doctorial Research as a PhD Candidate at Kochi University of Technology under the direction of Professor Kusayanagi. The research paper will be for “The Mission of the Consulting Engineer in Contributing to the Realization of a Better World”. Comparisons are being made as to how Consulting Engineering is being performed currently in Japan, what role the Japanese Consulting Engineers performs outside of Japan, what the role of the non-Japanese Consulting Engineer is on international contracts, and what recommendation can be made as to how the different systems can be combined for the betterment of the Japanese Construction and Consulting Engineer industry. Your participation in this survey is very important and will go to assisting in bettering the profession in Japan. You may type your answers directly into this document or print it out, write your answers and fax or mail to me. Your comments can be made confidentially, however, if you can provide your name, organization and contact information, this will allow the researcher the opportunity to contact you for either an interview on your answers and/or to seek additional information. All contributors will be credited in the doctorial research as having provided information.

1. How would you define the Construction Industry in Japan? What entities would you include that have a major role?

2. How is the Consulting Engineer viewed in Japan?

3. Do you believe that this view has changed over the years and if so, when and how?

4. Who is typically the Client of the Consulting Engineer-in Japan? In Projects outside of Japan?

5. What do you consider to be the roles and responsibilities of the Consulting Engineer?

6. How is the Consulting Engineer selected for work in Japan?

7. Is the concept of Quality Based Selection well understood in Japan and do you believe it is important? Why?

8. Does the Consulting Engineer write/develop the construction contract in Japan? If not, what entity writes and develops the contract?

9. Do you believe this differs on contracts outside of Japan? How does the role of a Japanese Consulting Engineer differ from domestic Japanese projects versus projects outside of Japan?

10. What skills do you believe the Consulting Engineer should possess?

11. How does a Consulting Engineer acquire these skills?

12. Which of these skills do you believe are not adequately taught in Japan and why?

13. How do you foresee change occurring in Japan to meet these needs?

14. Do you believe Japanese Consulting Engineers are well prepared to work on international projects? Why or why not?

15. What differences do you see in the qualifications/skills of a Japanese Consulting Engineer on an international project versus a Consulting Engineer from the US, Australia or Europe?

16. Do you believe it is important for the Consulting Engineer to have knowledge about public policy or to be involved in the public policy process? If so, why? Do you believe the Japanese Consulting Engineer has this knowledge?

17. How many Engineers currently hold public office at the National Level in Japan?

18. Should the Engineer hold public office and hold Cabinet and Minister positions? If yes, what steps do you think Consulting Engineers must take to rise to this level?

19. Do you believe that Diversity is important for the Project Team? Why? What steps is Japan taking to encourage young women to enter the profession?

20. Do you think it is important for the Consulting Engineer to be a licensed professional? Why or why not? What is typical of a Japanese Consulting Engineer?

21. Do you believe the concept of engineering and/or consulting engineering is taught in the Japanese schools system (lower school system)? Do you believe it is beneficial to do so and why? Does Japanese television have programs that promote engineering or consulting engineering? Do you believe that such programs would be helpful for young children in understanding engineering?

22. Do you believe it is important for the Consulting Engineer to understand globalization? Why or why not? What is typical of most Japanese practice in this area?

23. What is the Consulting Engineer's role in the development of public contracting? (The Contract, prequalification of bidders, the bid (tender) package, selection of bidders, monitoring/managing the contract during project execution) in Japan?

24. What changes do you believe are necessary to the public contracting system for Japan for which the Consulting Engineer can assist and why is it important?

25. What training do Japanese Consulting Engineers have with respect to cost and schedule control?

26. Do you use CPM schedules? Why do you believe this is important? Do you belie CPM scheduling assists in progressing the project and makes for a more timely completion of the project? If so, why and if not, why not?

27. Do you use electronic scheduling and it so, what software do you use? What entity performs the CPM scheduling for the Japanese Consulting Engineer-in Japan? On International Projects?

28. How can the Consulting Engineer contribute to Society?

29. What Changes would you make to the Japanese Construction Industry if you could change anything and why would you change it?

30. How important is the English language to the Japanese Consulting Engineer? Does the Japanese Consulting Engineer need to read, write and speak English? Do you believe that this make the Consulting Engineer more competitive in a global world?

31. Do you use risk management and why do you believe it is important? Is it well explained and/or taught in Japan and what recommendations would you give to change this?

32. Is there anything else you wish to add or comment on?

33. What is your name and title (position within your firm)?

34. Are you a licensed professional engineer? If so, where?

35. What company do you work for?

36. What is your address and contact information including your e-mail address?

37. Do you primarily work in Japan or outside of Japan?

38. Are there any articles or papers that you recommend that the researcher review? If so, can you either provide copies of the paper and/or provide information as to where these articles/papers and/or books can be obtained?

Thank you very much for you assistance in this research. Please send your responses either via e-mail, fax or mail delivery to:

Patricia D. Galloway, P.E., PMP. MRICS
Chief Executive Officer
The Nielsen-Wurster Group
719 Second Avenue, Suite 700
Seattle, WA 98104
USA
Ph: +1-206-386-5250
Fax: +1-206-386-5252
E-mail: patnwg@aol.com

APPENDIX B

INDUSTRY VIEW ON CPM SCHEDULING SURVEY

Critical Path Method - Industry Questionnaire

Exit this questionnaire >>

General Information

*** 1. Organization Name:**

*** 2. What is your position within your organization?**

- Project Manager
- Department Head
- Staff Position
- Executive Officer
- Other (please specify)

*** 3. What is your average annual construction budget or revenues?**

- Under $1 Million
- $1 - $10 Million
- $10 - $50 Million
- $50 - $100 Million
- $100 - $500 Million
- Greater than $500 Million

4. Where is the majority of your work performed? (Check all that apply)

- US - Nationwide
- US - West
- US - East
- US - Midwest
- US - south
- Europe - Western and Eastern
- Europe - Western
- Europe - East
- Europe - UK solely
- Asia - throughout
- Asia - China
- Asia - Japan
- Asia - Australia
- Middle East
- Africa
- Latin/South/Central America
- Other (please specify)

5. How large is your organization?

- Under 50
- 50 - 100
- 100 - 500
- 500 - 1000
- 1000 - 5000
- over 5000

6. What is your primary industry? (check all that apply)

- Transportation
- Process
- Building
- Power
- Oil and gas
- Aerospace
- Other (please specify)

*** 7. What type of organization do you represent? (Note: Contractors will be forwarded to a separate page specific to contractors; Owners, construction managers, engineers, and government respondents will answer questions related to project owners.)**

- Private Owner
- Contractor
- Government
- Engineer
- Construction Manager
- Other (please specify)

Next >>

Critical Path Method - Industry Questionnaire

Exit this questionnaire >>

Use of CPM Scheduling - Owner/owner's representative

1. Do you use Critical Path Scheduling on your construction projects?

- Yes, always
- On 75% or more of projects
- On over 50% of projects
- 25 - 50% of time
- Less than 25%
- No

2. If you answered "Never", please explain why:

3. Do you require a CPM baseline schedule in your contracts?

- Yes, Always
- Only on projects greater than $5M
- Only on projects greater than $10M
- Only on projects greater than $20M
- Only on projects greater than $50M
- Only on projects greater than $100M
- No, Never
- Other (please specify)

4. Do you use a CPM specification in your contract?

- Yes
- No

5. Is the specification a standard CPM specification or is it customized for each project?

- standard
- customized

6. Do you distinguish between an update and revision?

- Yes
- No
- Don't know

7. Do you require updates?

- Yes
- No

8. How often do you require updates?

- Weekly
- Monthly
- Quarterly
- Other (please specify)

9. Do you require revisions?

- Yes
- No

10. If revisions are required, why are they required? (check all that apply)

- Critical path changes
- Project behind schedule
- Change orders
- Other (please specify)

11. Do you limit the activity durations?

- Yes
- No
- Don't know

12. Do you require activity coding?

- Yes
- No
- Don't know

13. Do you require resource loading?

- Yes
- No
- Don't know

14. If resource loading is required, do the requirements include:

- Manpower level
- Trade breakdown
- Dollar per activity
- Other (please specify)

15. Do you require electronic file copies of the schedule to be submitted?

- Yes
- No
- Don't know

16. What computer software do you specify?

- Primavera
- MS Project
- SureTrak
- Artemis
- Left up to contractor
- Or equal
- Other (please specify)

17. Do you require a risk assessment to be performed on the schedules?

- Yes
- No
- Don't know

18. In what format is the CPM required?

- Arrow Diagramming Method
- Precedence Diagramming Method
- PERT
- GERT
- Critical Chain

- Don't Know
- No Requirement
- Other (please specify)

19. What are the Advantages and Disadvantages of the format you use:

20. Do you use any other scheduling techniques? (Check all that apply)

- Program Evaluation and Review Techniques
- 4D Planning
- Line of Balance (LOB)
- Linear Balance Charts (Vertical Production Methods)
- Free Hand Bar Chart (Not based on logic diagram)
- Other (please specify and explain)

21. What are the Advantages and Disadvantages of the method you use:

<< Prev **Next >>**

Critical Path Method - Industry Questionnaire

Exit this questionnaire >>

Use of CPM Scheduling - Owner/owner's representative

1. Do you use Critical Path Scheduling on your construction projects?

- Yes, always
- On 75% or more of projects
- On over 50% of projects
- 25 - 50% of time
- Less than 25%
- No

2. If you answered "Never", please explain why:

3. Do you require a CPM baseline schedule in your contracts?

- Yes, Always
- Only on projects greater than $5M
- Only on projects greater than $10M
- Only on projects greater than $20M
- Only on projects greater than $50M
- Only on projects greater than $100M
- No, Never
- Other (please specify)

4. Do you use a CPM specification in your contract?

- Yes
- No

5. Is the specification a standard CPM specification or is it customized for each project?

- standard
- customized

Critical Path Method - Industry Questionnaire

Exit this questionnaire >>

Use of CPM Scheduling - Contractors

1. Do you find that the contracts now contain a specification requiring CPM scheduling?

- Yes, always
- Yes, most of the time
- Yes, Always
- Only on projects greater than $5M
- Only on projects greater than $10M
- Only on projects greater than $20M
- Only on projects greater than $50M
- Only on projects greater than $100M
- No, Never
- Rarely
- Never
- Other (please specify)

2. If not required, do you still prepare a CPM on your project?

- Yes, Always
- Only on projects greater than $5M
- Only on projects greater than $10M
- Only on projects greater than $20M
- Only on projects greater than $50M
- Only on projects greater than $100M
- No, Never
- Other (please specify)

3. What are the major areas of CPM application in your organization?

- Design Development (Conceptualization, feasibility, etc.)
- Estimating and Bidding
- Detailed planning of work PRIOR to start of construction
- Periodic control of work after start of construction
- Operation and Maintenance of projects
- Change management and claims analysis
- Other (please specify)

4. If you use CPM for periodic control of the work during construction, for what tasks do you use CPM?

- Coordination of own trades
- Tracking shop drawings and submittals
- Tracking costs
- Schedule impact analysis and trackign changes
- Calculating payment requests for work performed
- Developing a look ahead schedule
- Coordination of Subcontractors
- Other (please specify)

5. How often do you make decisions based on CPM information?

- Frequently
- Moderate Frequency
- Infrequently
- Never
- Comments

6. Do you maintain a separate schedule to maintain the work in addition to the contract specified schedule?

- Yes
- No
- Depends on situation (explain)

7. What software do you prefer and use if given an option?

- Primavera
- SureTrak
- MS Project
- Artemis
- Other (please specify)

8. Do you find manpower loading useful and do you use it for CPM?

- Yes
- No
- Don't know
- Depends (please specify)

9. Do you find cost loading useful and do you use it for CPM?

- Yes
- No
- Don't know
- Depends (please specify)

10. What are the benefits obtained from using CPM? (Choose all that apply)

- Improved scheduling
- Improved estimating/bidding
- Reduces delays
- Time savings
- Helpls train future project managers
- Minimizes disputes between contractor and owner
- Positive psychological effect on employees
- Increase control over risk and uncertainty
- Faster response to problems
- Improved communication among the workforce
- Cost savings
- Improved understanding of the project
- Improved project control after work starts
- Improved planning before work starts
- Other (please specify)

11. What are the disadvantages of CPM? (Choose all that apply).

- Not responsive to the needs of top management
- Logic abuses
- Requires excessive work to implement
- Not responsive to the needs of field personnel
- No major disadvantages
- Costs too much

- Requires too much dependancy on specialists
- Other (please specify)

12. On average, what is the cost of CPM application as a percentage of total project (construction) cost?

- 0 - 0.25%
- 0.26 - 0.50%
- 0.51 - 0.75%
- 0.76 - 1.00%
- Over 1%
- Other (please specify)

13. Do you believe there is an economic benefit to using CPM (that the benefits outweight the costs)?

- Yes
- No

14. What has been your degree of success in achieving the benefits of CPM?

- Very Successful
- Moderately Successful
- Unsuccessful
- Undecided
- Comments

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Critical Path Method - Industry Questionnaire

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Personnel

1. Does your organization have an overall manager of planning and scheduling?

- Yes
- No

2. Do you have a dedicated person responsible for planning and scheduling on each project?

- Yes
- No

3. What is the background of personnel performing planning and scheduling?

- Engineer
- Technician
- Project Management
- Site Engineer
- Dedicated Scheduler
- Contractor Foreman
- Other (please specify)

4. What credentials do you require of someone performing planning and scheduling?

- Undergraduate University Degree
- Undergraduate University degree in Construction Mgt
- Graduate University Degree
- Graduate Degree in Construction Management
- Other Scheduling Training/Coursework
- On-job training
- no training/credentials required
- Other (please specify)

5. With respect to your specific project personnel responsible for CPM scheduling do they:

- Sole duty is CPM scheduling including periodic updating
- Does multiple tasks in addition to the CPM schedule

6. Is your CPM scheduling performed by:

- In-house personnel
- Outside consultant
- Combination of in-house and consultants

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Critical Path Method - Industry Questionnaire

Exit this questionnaire >>

CPM Standards

1. For which reasons do you use CPM (check all that apply):

- It is a beneficial planning tool that makes projects more efficient and cost effective
- Contract Requirement
- Change Management
- Claims, after the fact
- Other (please specify)

2. With regard to the primary uses of CPM Scheduling (check all that apply):

- Projects where CPM is used cost less
- Projects where effective CPM has been used regularly have reduced claims
- CPM schedule aids assessment of risk
- CPM scheduling costs too much and is a burden on staff
- CPM scheudling is only performed to meet a contract requirement
- CPM schedules are only helpful in a claim presentation
- Other (please specify)

3. Does Senior Management (above project level) review and use the informaiton provided in the CPM schedule?

- Yes
- No
- Don't Know

4. Are you familiar with the Project Management Institute (PMI) Body of Knowledge (PMBOK)?

- Yes
- No

5. Are you familiar with the Time Management Guildelines within PMBOK?

- Yes
- No

6. Do you train personnel in your firm to be familiar with PMBOK time management guidelines?

- Yes
- No

7. Do you attempt to assure that your CPM schedule and process conforms to the PMBOK time management guidelines?

- Yes
- No

8. Are you familiar with PMI's College of Scheduling?

- Yes
- No

9. Are you familiar with AACE's National Committee on Planning and Scheduling?

- Yes
- No

10. Do you believe standards should be defined for the area of CPM scheduling?

- Yes
- No

11. What entity should evelop these standards?

- ANSI
- AACE
- PMI
- Government
- Don't Know
- Other (please specify)

12. Do you believe that people performing CPM scheduling should be certified?

- Yes
- No

13. Do you believe certification would improve the industry?

- Yes
- No

14. Do you believe Best Practices guidelines should be developed that could be made available to owners/contractors?

- Yes
- No

15. Do you believe University Curriculum should use the PMBOK as a guide to what should be taught regarding CPM scheduling?

- Yes
- No

16. Have you ever reviewed University Curriculum to see what is being taught regarding CPM scheduling?

- Yes
- No
- Which Institution?

17. Do you believe that it is important that CPM scheduling is consistent in the curriculum across universities?

- Yes
- No

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Critical Path Method - Industry Questionnaire

Exit this questionnaire >>

➔ Claims Avoidance and Usage of CPM

1. Does the use of CPM schedule minimize claims in your projects?

- Yes
- No

2. Do you use CPM scheduling in claims resolution?

- Yes
- No

3. Do you use existing CPM schedules that were used during the project or do you redevelop a schedule for the claim?

- Existing
- New Development for Claims

4. What methods of CPM Scheduling Analysis do you use in claims (check all that apply):

- As-Built
- As-Impacted
- Contemporaneous
- Window Analysis
- Collapsed As-Built
- Time Impact Analysis
- Other (please specify)

5. Do you believe the usage of CPM is essential in delay claims?

- Yes
- No

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Critical Path Method - Industry Questionnaire

Exit this questionnaire >>

Risk Management

1. Do you have a company-wide risk management program?

- Yes
- No

2. Do you have a Risk Management Officer?

- Yes
- No

3. Do you have a Project Risk Management Program?

- Yes
- No

4. Do you perform project risk management assessments?

- Yes
- No

5. Do you believe that risk management assessments save money in overall project__?

- yes
- No

6. How much money do you believe is saved on a project when risk assessments are performed?

- 0%
- 1 - 2%
- 3 - 5%
- 6 - 10%
- 11 - 15%
- 16 - 20%
- over 20%

7. How are risk assessments performed?

- In-house project team personnel
- In-house project team and other company personnel
- Outside consultants
- In-house personnel and outside consultant team
- Other (please specify)

8. Do you use simulation in risk assessment

- Yes
- No

9. Do you perform periodic risk assessment updates throughout the project?

- Yes
- No

10. How often are the periodic risk assessments?

- Monthly
- Bi-monthly
- Quarterly
- Other (please specify)

11. Additional Comments on Risk Management:

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Critical Path Method - Industry Questionnaire

Exit this questionnaire >>

Thank You and Final Comments

1. Thank you very much for taking the time out of your busy schedule to help with this research.

If you would like to learn the results of this research, please leave your contact information in the box below. You may also use this box to share any thoughts or comments on CPM scheduling that were not covered within the survey.

<< Prev **Done >>**