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Overview of Issues and Discussions in Regulatory Science and Engineering over the Past Four Years in Global Arena

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Abstract

Regulatory science and engineering (RS and RE) became increasingly needed by extensive people of our society to maintain safety, security, and sustainability of the environment, economy, energy, mineral and other resources of our planet, as science and engineering became increasingly globalized to meet the needs and wants of a variety of people and society in the world. [1]-[4] The current paper firstly discusses the concept of globalization in general, and evolution and globalization of science, engineering, technology and others (SETO) and their impact on our society to better understand globalizing roles of RS and RE. [5], [6] To this end, the author's view of progressively changing SETO, and a systematic description of updated Pillars, Classes, Sub-classes, and Categories for Best Available Science, Metrics for Evaluation of Scientific Claims, and Metrics for Engineering and Technological Claims (BAS, MESC, and MEETC), proposed by Moghissi, are presented to discuss their roles, and steps required in RE and RS practice. [5], [6] Twenty three topics planned for the ASME/VUPRE Conference on Vulnerability, Uncertainty and Probability Quantification in Regulatory Engineering [1]-[4] is also presented to discuss magnitude of the scope of impact RS and RE may give on our society. Presentations and discussion at IMECE2012 Session 5-7-2 Globalization of Regulatory Engineering, [2] and discussion of the author's paper on fatigue and fracture issues of offshore, mechanical, building, and civil engineering structures, and role of regulatory engineering, [3] prepared for the 9th International Conference on Fracture and Strength of Solids (FEOFS2013) in Jeju, South Korea [3] are included in the current paper to illustrate practical issues and applications of RS and RE. The current paper also includes discussion at Organized Session (OS) 7, entitled "Issues and Proposals in Rationalizing Regulations – Toward Quantification of Vulnerability, Uncertainty and Probability in Regulatory Science (RS) and Regulatory Engineering (RE)-" at Safety Engineering Symposium 2015, held by Science Council of Japan (SCJ) on July 2-3 in Tokyo, JSME Annual Meeting held on September 13-16, 2015 at Hokkaido University, and Japanese-French Symposium on Smart Cities held on September 15-16 at SCJ Building in Tokyo, in addition to those included in the IMECE 2013 paper of the author. [4] Prospective impacts of the outcome of the aforementioned discussions on the regulatory agencies, regulated communities, scientists and engineers, and general public in the United States, Latin America, Africa, Europe, Asia and Japan are also discussed.

1. Introduction

With the industrial activities increasingly bound to the global economy, policies, regulations, codes and standards increasingly need to be soundly and effectively applied to situations in the global arena; therefore, RS and RE approaches, based on sound engineering and scientific principles and information, became increasingly important as a basis for the policy development, law making, and regulatory decision making, among others. The author, therefore, would like to discuss on what globalization would mean to people around the world, as a starting point.

1.1. Concept of Globalization in General

The concept of globalization has been extensively discussed by many scholars, journalists and linguists among others. The ultimate and ideal globalization is such that everything on the globe surface is under the same condition, as may be characterized by the fact that every point on the globe surface is under the same distance from the globe center; therefore, it can be said that the substance of 100%, 70% and 30% globality should be air, sea water and land, respectively, on the earth. Oxford dictionaries define that globalization is a process that business and other organizations enhance their international influence or initiate business operations on an international scale. Merriam-Webster Dictionary defines that it is a process of standardization of daily life experiences of all over the world, characterized by popularization of commodities and ideas. Nayef R. F. Al-Rodhan and Gerard Stoudmann, Geneva Centre for Security Policy, define that it

is a process comprising causes, course and consequences of transnational and transcultural integration of human and non-human activities, as a result of reviewing more than 100 definitions of globalization in the world.

Every individual on the globe surface has certain degrees of belief in his or her concepts of globalization, which may be transformed from time to time as they became experienced in their pursuit of life and professional activities.

1.2. Evolution and Globalization of SETO and Its Impact

Figure 1 illustrates the relationship of Science, Engineering, Technology and Others (SETO), which became increasingly complex with the evolution and globalization of our society. For example, many disciplines of engineering and technology increasingly interact with natural science, social science, humanities, and arts, leading to enhanced development of new technology, products and systems in rapidly evolving fields, such as biomedical engineering and technology, smart cities, smart engineering, computer arts, publications technology, economics, and laws, among others.

In Japan, investigation on often, complex, multi-disciplinary issues, such as those of drones, medical operations and ethics, iPS cell type GMO, nuclear power plants, Intelligent Transport Systems, and impact of fluctuation of magnetic fields caused by magnetic levitation transport systems on building and civil structures, i.e. tunnels, buildings, etc., are in progress to establish sound regulations.[5] This type of activities will certainly contribute to maintaining the nation's scientific and technological status and leadership in the global market/arena.

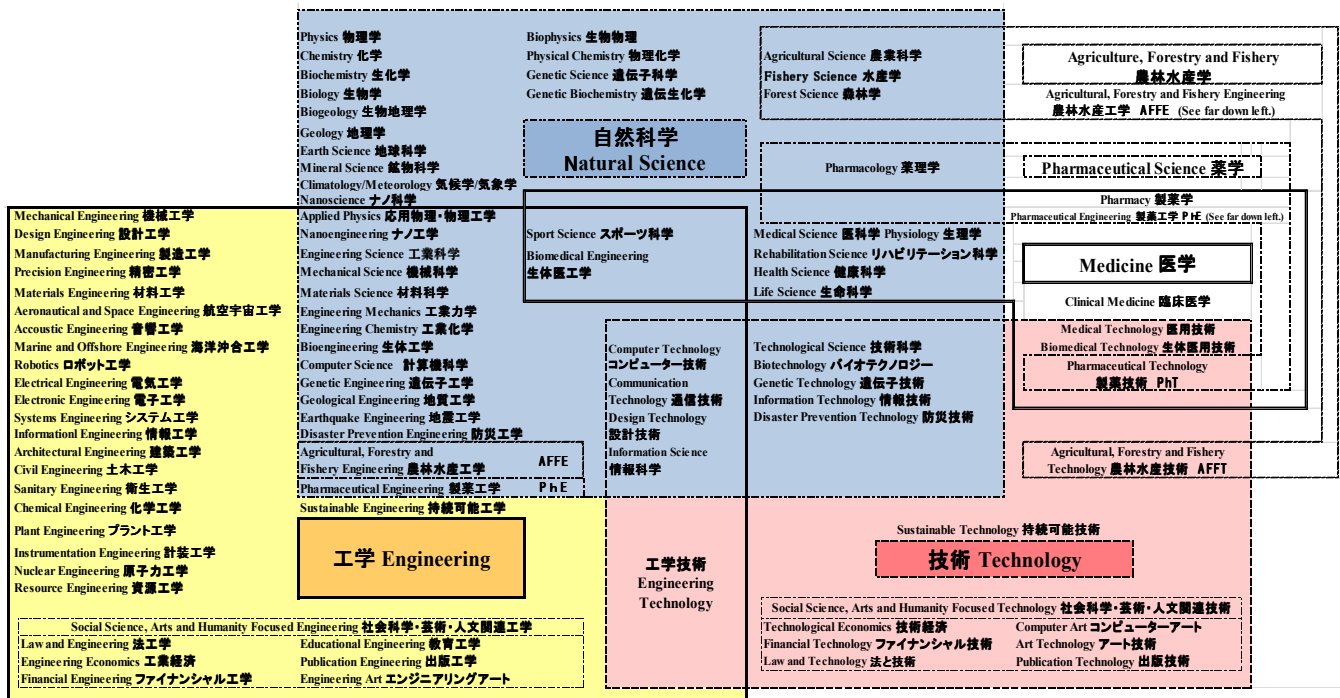


Figure 1. Systematic Relationship of Science, Engineering, Technology, and Others (SETO).

It is also seen that, in treating claims, counterclaims, and information, among others, of science, engineering and technology, each individual should identify whether one is to deal with the issues as the scientific or engineering or technological subjects, depending on nature of the issues one may be dealing with; therefore, it is important to have a better and deeper understanding of the relationship shown in Figure 1.

1.3. Globalizing Roles of RS and RE

During the process of aforementioned evolution of SETO, RS and RE are increasingly employed in disciplines, such as regulatory medical science, regulatory medical processes and products, regulatory nutritional sciences, regulatory climatology, regulatory economics, regulatory hydrology, regulatory smart agriculture, regulatory ecology, regulatory atmospheric sciences, regulatory toxicology, regulatory pharmacology, regulatory offshore oil production engineering, regulatory firing power generation engineering, regulatory mining operation engineering, regulatory engineering for environmental planning for children, regulatory renewable energy engineering, regulatory automobile engineering, regulatory information and communication engineering, regulatory smart city engineering, regulatory manufacturing engineering, regulatory biomedical engineering, regulatory man-machine interface engineering, regulatory waste disposal engineering, regulatory disaster prevention engineering, regulatory water management engineering, regulatory rehabilitation engineering, and regulatory robotics, among others. [7]

In this age of globalization, RS and RE came to draw much attention from a variety of professionals and citizens around the world. In the global arena, various natural disasters such as earthquakes, tsunamis, floods and tornados, societal welfare issues such as those of adverse effects of various chemicals, toxic materials and pharmaceuticals on human bodies and the environment, global energy and environmental issues, and

medical issues became increasingly focused, especially in developing nations.

This means that we need to plan, develop, apply, scrutinize, and establish well suited, timely regulations, codes and standards for issues in needs of them, based on the sound engineering and scientific information, with effective communication, discussion and collaboration, between regulatory agencies, regulated communities, scientists and engineers, and the general public, as indicated in Figure 2.

Depending on the subjects, the characteristics of globalization may vary from one to another. In any case, smooth and effective applications of globalizing SETO became increasingly dependent on RS and RE, as a valuable tool to secure availability, safety, security, and sustainability, among others, of globalizing scientific and engineering products, services, professions, etc.

2. Classification of Information and Claims

Table 1 shows a systematic description of updated Pillars, Classes, Sub-classes, and Categories for Best Available Science, Metrics for Evaluation of Scientific Claims, and Metrics for Engineering and Technological Claims (BAS, MESC, and MEETC). Based on this classification, one can group each item of the information and/or claims into corresponding pillars, classes, sub-classes, and categories, utilizing the classification process flow shown in Figure 3, which includes the five principles of BAS and the three pillars of MESC and MEETC. Note that the term science, as used in BAS as well as in MESC, is broad and comprises physical sciences; biomedical sciences; various engineering disciplines; and social sciences. One of the primary applications of BAS/MESC/MEETC is in regulatory science and regulatory engineering.

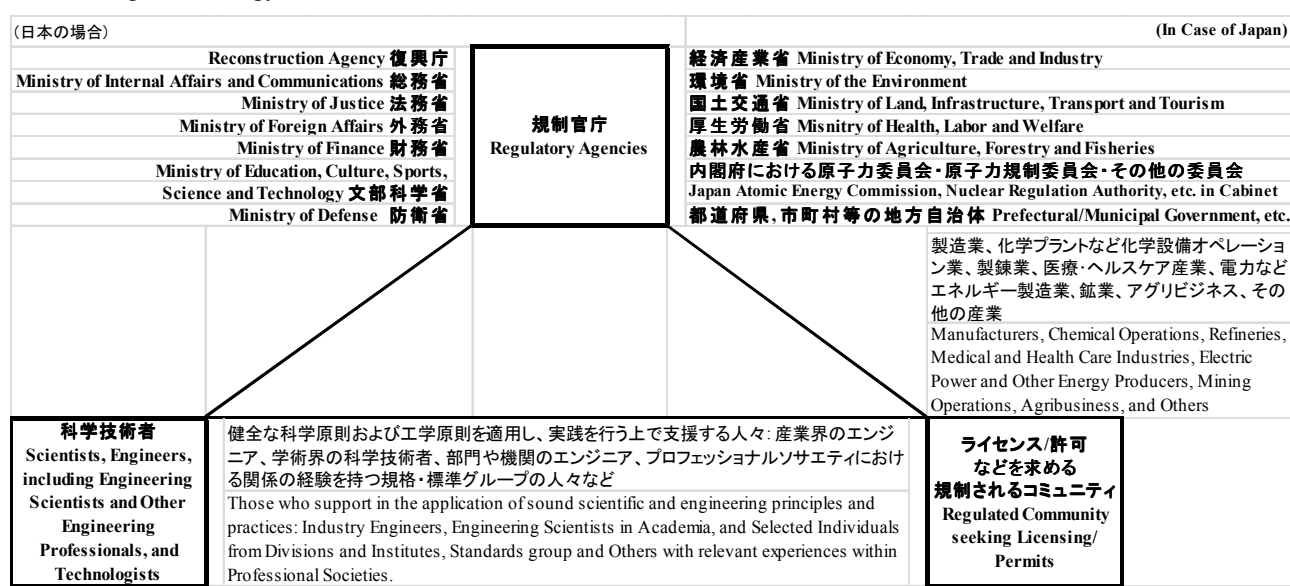


Figure 2. Regulatory Science/Engineering Community Triad in Case of Japan.

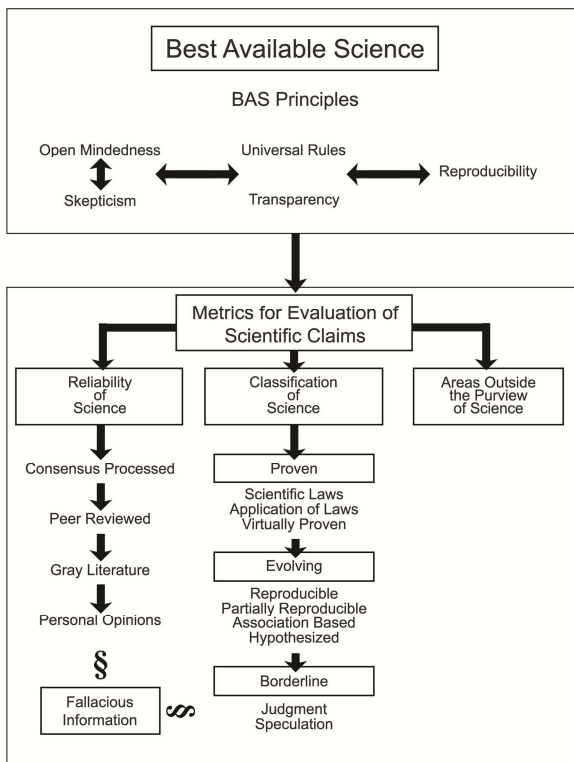


Figure 3. Five Principles of Best Available Science (BAS), Three Pillars of Metrics for Evaluation of Scientific Claims (MESC), and Their Roles and Steps to be considered in Regulatory Science and Engineering Practice Proposed by A. A. Moghissi [6].

3. Planning of the ASME/VUPRE Conference

In February, 2012, tracks were planned for specific fields such as those of energy, medical and renewable energy issues, in addition to those of common interest such as policy, standards, general model development and deployment, optimal immunity conditions of VUP, national preparedness for RE management, historical uncertainties and naturalizations, VUP quantification, RE education, research innovation, computation and affordability. In early June, the topic or track structure for the ASME/VUPRE Conference was expanded, as shown in Table 2, and exhibited on the website, [1] with the best interests of prospective participants taken into consideration.

It is seen from Table 2 that Topics 1 and 2 cover the areas of common interest, i.e. overview of VUP Quantification in RE systems and policy development, RE fundamentals, tools, peer review, communication and standard of practice. [1] Topics 3 to 12 cover issues in specific areas, such as reducing nuclear threats and plant accidents by VUP Quantification, NASA aviation pilots dilemma of dealing with VUP in space vehicles, equipment and systems, military commander's dilemma of dealing with VUP in battlefield operations and logistics, oil and gas well drilling issues, among many others.

Topics 13, 14, 15 and 16 present the ASME/VUPRE panel

discussions on VUP Quantification, the ASME/VUPRE lecture series, the VUPRE/ASME workshop series, and the VUPRE/ASME keynote presentation, respectively.

Topics 17 to 23 cover specific issues in various disciplines, such as development of patient health care systems (PHS) by stochastic modeling, that of integrated public health information statics administration (IP-HISA) from VUP Quantification, VU issues in engineering artificial organs and replacement of body parts, medical doctors experience of dealing with VUP in patient-centered care, among those in other disciplines.

4. Expected Discussions of ASME/VUPRE Conference

In Topic 1, Overview of VUP Quantification in RE System and Policy Development, a project of designing a cheaper, simple and cost efficient model for the determination of equipment performances (availability and utilization) is presented and discussed by Dongbakuro and Kunkyebe, for a case of a mining company in Ghana. [8]

The milling circuit and the crusher plant are the vital major equipment there. As an alternative to software applications for ERP systems, such as Planned Maintenance Management Services (PMMS), Software Application Process (SAP), PRONTO and others, a cheaper and reliable model has been formulated on excel which also produces availability/utilization results, thereby enabling the maintenance section function to the needs of a particular setting.

A catastrophe resulted from the failure to protect Fukushima Daiichi Nuclear Power Plant, under the combined impact of the earthquake (M=9.0) and powerful tsunami, is used as a test-bed, and the nature of various uncertain events is taken into consideration for analysis for the fundamental design of BWR, by Shinozuka. [9] The development of aggressive damage mitigation strategy is proposed, focusing on the critical damage such as core melt of the subject plant, as well as those for other types of low probability but high risk systems.

In Topic 2, fundamentals of RE, such as principles serving as basis for the concept of best available science, metrics for evaluation of scientific and regulatory engineering claims, and classification of scientific and technical information are discussed. These are the first step knowledge and basis for the RS and RE education, which contributes to understanding of the global economy and globalizing industry from political, regulatory and communities' perspectives. [10]

The TRANSPARENT framework is also presented and discussed by Fewell. [11] It is based on lessons learned from performance assessments of the Department of Energy's Waste Isolation Pilot Plant and the formerly proposed high level nuclear waste repository in Yucca Mountain, Nevada. The regulatory environment for these performance assessments imposed traceability, reproducibility, and transparency requirements, and because these attributes were implemented ad hoc, these assessments were expensive and

lengthy to perform and refine. The TRANSPARENT framework was developed so that assessments conducted with it automatically inherit traceability, reproducibility, and transparency. Moreover, tasks common to all analyses such as unit conversion, configuration management, model

component data sharing (input/output linkage), system model construction and execution, and results display and analysis, are built into TRANSPARENT, generically. Its additional features are also introduced and discussed.

Table 1. Pillars IA, IB, II & III, Classes I, II & III for Pillars IA & IB, Pillar IA Sub-Classes and Pillar II Categories I, II, III & IV for Best Available Science/Metrics for Evaluation of Scientific Claims/Metrics for Evaluation of Engineering & Technological Claims (BAS/MESC/MEETC) [5].

Pillars	Classes/Categories	Sub-Classes/Categories and Explanation
Pillar IA Classification of Science (& Engineering)(SE) and Scientific & Engineering Information (SEI) Note: It is connoted that Engineering in Pillar IA is rather meant to be Engineering Science.	Class I Proven Science and Engineering (PS/PE) & SEI PS is equivalent to scientific laws in the classical “hypothesis-theory-law” (HTL). PS/PE comprise scientific laws, sometimes called scientific principles, and their application, which are in compliance with <i>Reproducibility Principle (RP)</i> .	IA Confirmed Science: Scientific laws and all other information that have been unequivocally confirmed and generally accepted IB Applied Science: This class comprises application of scientific laws to various branches of commerce and industry. The only prerequisite for information to be placed into this class is the correct interpretation of scientific laws. Many of the engineering disciplines and a large segment of other applied sciences fall into this class. IC Virtually Proven Science: This class comprises information whose reliability has been uncontested, yet there is insufficient proof to be placed in the proven science class. (Requisite: 1. Reliable observation does not contradict the information in this class, and 2. No alternative system describes the observed phenomena.)
	Class II Evolving Science (ES) & SEI This class does not have a counterpart in the classical HTL process, and significantly deviates from theory. Scientific advances in all disciplines represent evolving science.	IIA Reproducible ES: Reliable information dealing with a subject, not completely understood, constitutes core of this class. The observation of this class may not necessarily have general applicability; however, they are clearly and unambiguously reproducible. An example is provided by much of medical science. IIB Rationalized Science: The scientific foundation for the information is derived from proven or reproducible evolving science; however, it uses assumptions and extrapolations to derive results and conclusions, thus not meeting the RP requirements. IIC Hypothesized Science: This class comprises organized responses to observation, idea, or any other thought initiating processes.
	Class III Borderline Science (BS) & SEI This class is not necessarily science. The closest part in the classical HTL process is hypothesis.	IIIA Scientific or Engineering Judgment: The methodology for expert judgement is reasonably well developed and comprises asking a number of presumably knowledgeable individuals to give answers to specific questions and statistically assess the results, resulting often in educated guess. (BS is based on the notion that a decision maker must make decisions without information covered in Classes I & II.) IIIB: Speculation: This class comprises information that cannot meet standards described in any of the above classes, which is often based on the intuition of a person, who wants to stimulate a discussion or initiate a research project.
Pillar IB Classification of Engineering and Technology (ET) and Their Information (ETI)	Class II Evolving Engineering and Technology (EET) & EETI	Reproducible EETI: Reliable and reproducible information, not completely understood, must comply with RP and may not violate Universal ET Principle (UETP). Partially Reproducible EETI: Foundation of information placed in this class is derived from Proven or Reproducible SETOI.
	Class III Borderline Engineering and Technology (BET) & BETI	Association-Based EETI: Often based on attempts to correlate an effect to a cause. Hypothesized EETI: Consists of an organized response to an observation, idea, etc. Engineering or Technological Judgment: This comprises asking a number of presumably knowledgeable individuals to give answers to specific questions and statistically assess the results. The information in this class is often, at best, educated guess.
	Fallacious Information	Speculation: This comprises information that cannot meet standards above. Often called “pseudo-science” or “junk science” or “politically processed science” made to exaggerate an issue to move the population to accomplish a notable goal.
Pillar II Assessment of Reliability of Scientific, Engineering, Technological and Other Information (SETOI)	Category I Personal Opinion (PO)	Personal Opinion consists of expression of views by individuals, regardless of their training, experience, and social agenda.
	Category II Gray Literature (GL)	GL consists of written information prepared by government agencies, advocacy groups and others, not subjected to peer-review.
	Category III Peer-Reviewed Scientific, Engineering, Technological and Other Information (PRSETOI)	The value of peer review and similar processes in assessing the validity of SETO assertions has been known for at least two centuries. Prerequisite for the acceptability of an SETO claim (independent peer review without conflicts of interest) is required.
Pillar III Areas outside of the Purview of Science, Engineering, and Technology	Category IV Consensus-Processed Science, Engineering, Technology and Other Information (CPSETOI)	This Category comprises information resulting from a process used to resolve disputes, particularly those in contested areas of SETOI. CPSETOI is particularly useful in RS and RE, as in many cases the information includes assumptions, judgements, default data and other areas, and it attempts to address contradictory SETOI (similar to the process for Category III)
	One of the most complex and often misused or abused areas of RS and RE is the intrusion of societal goals, ideology, and numerous non-SET subjects in RE and RS decisions. Their intrusion in RS and RE processes inherently jeopardizes the objectivity and consequently the acceptability of SETI. Such an approach, as desirable as they might be, must be addressed after the SET issues have been resolved. The role of scientists, engineers and technologists is to provide SET options that underly a potential regulatory decision. Although various nations such as US, Japan, Germany, France, India, Brazil, Israel and Saudi Arabia may have different societal and cultural traditions, SET foundations of their regulatory decisions should be identical.	

The application of guidelines (GLs), subordinate to official Codes and Standards in general, to masonry bridges is discussed by Baratta and Corbi. [12] Masonry bridges are inscribed in the frame of existing buildings, and standards include special prescriptions for existing buildings; however, masonry bridges, quite differently from buildings, are neither frequented nor daily observed by inhabitants even though masonry arcades in bridges may be loaded in an eccentric way. Therefore, they need a special surveillance, as tools for seismic analysis are not clearly established. Some basic statements about GL elaboration will also be exposed in relation to Italian national codes. [12]

In Topic 6, an overview of reliability assessment in structural health monitoring is presented and discussed by Noori, [13] covering non-linear model-based approaches, which may be better suited for reliable health monitoring and damage detection, in addition to traditional model-based techniques to identify parametric changes in a linear dynamic model. In particular, the application of a novel intelligent parameter varying (IPV) modeling and system identification technique, developed by Noori, to detect damage in base-excited structures is presented and discussed in this Topic.

In Topic 7, the improved sample size choice for confidence interval based inferences (and extensions) is presented and discussed by Jiroutek. [14] The sample size required to conduct a study must be large enough to have sufficient statistical power, while at the same time not be too large, to avoid wasting resources or unnecessarily introducing ethical concerns. In comparison to sample size methods for hypothesis testing, fewer methods have been developed for choosing an optimal sample size for confidence interval construction. By neglecting the notions of Validity and Rejection, these methods often provide a sample size with a low probability of achieving other desired goals. By incorporating concern for Validity and Rejection, as well as

Width, in choosing a sample size for constructing confidence intervals, a higher probability of success can be achieved. The smallest sample size is recommended such that, given Validity, both Rejection and Width occur with at least a certain specified probability.

Theoretical results, which generalize the concept of Power, are derived in the framework of the General Linear Multivariate Model with Gaussian errors. Extensions to investigate the effect of using a variance estimate in place of a population parameter and truncation of the error variance density are also briefly presented. Truncation results from target studies performed conditionally on achieving a desired result in a screening study. These results lead to concluding that bias in both directions can occur if truncation is ignored. [14]

A study of the effects of existing heavy tail phenomena in the risk based design of large scale and complex engineering systems is also presented by Golbayani, et al. [15] in Topic 7. Current methodologies for calculating reliability and probability of failure rely mostly on the moments of the outputs' distribution. However, in case of catastrophic failures and rare events, these moments do not exist because of heaviness of the tail. The authors focus on studying the existence of heavy tail phenomena and the relationship between the dynamic of the system and behavior of the tail. The existing methodologies in measuring the heaviness of the tail, tail index, have been reviewed extensively. In the early stage of the design, the complexity of the system prevents the designer to have enough realization of the outputs by using Monte Carlo simulation. Therefore, instead of having enough data for tail analysis, the extreme case of small sample size is considered for this study. The methods are applied to a complex system with a small desired probability of failure. The sensitivity and robustness of the current methodologies have been compared.

Table 2. List of Validated Topics and Tracks for the ASME/VUPRE Conference 2012 on the Conference Website as of June 6, 2012 [1].

No	Topics (Note: Twenty three topics below correspond to twenty three track titles with minor edits for some of them.)
1.	General Presentations on Overview of VUP Quantification in Regulatory Engineering Systems and Policy Development
2.	Regulatory Engineering Fundamentals, Tools, Peer Review, Ethics, Communication and Standard of Practice
3.	Reducing Nuclear Threats and Nuclear Plant Accidents by VUP Quantification
4.	NASA Aviation Pilots Dilemma of Dealing with Vulnerabilities and Uncertainties (VU) in Space Vehicles, Equipment and Systems
5.	Military Commanders Dilemma of Dealing with Vulnerabilities, Uncertainties and Probabilities in Battlefield Operations and Logistics
6.	Sustainable Reliability Index for Oil and Gas Well-Drilling, Fracking, Casing and Maintenance, and Violations Analysis
7.	The Role of Extreme Value Statistics and Distributions in Sustainable Infrastructures and Materials
8.	Salvage Experience of Dealing with VU in Emergency Readiness Systems and Bollard Pull Calculation Guidance
9.	Framing Highest Imaginable Standards and Codes for Renewable Energy Production from Imprecise Probabilities
10.	Vulnerability, Uncertainty and Probability (VUP) Quantification in Aerospace Design, Systems and Vehicles
11.	Developing Standards and Codes for Medical Devices, Surgical Instrumentation and Robots by VUP Quantification
12.	Regulatory Engineering Workforce Development, Accreditations and Imprecise Human Factor Probabilities
13.	ASME/VUPRE Panel Discussions on VUP Quantification in the World Vital Commodities and Planet Sustainability
14.	ASME/VUPRE Lecture Series on World's and America's Oil and Shale Gas Development, Production Outlook and Uncertainties
15.	VUPRE/ASME Workshop Series on Creating Balanced International Trade and Regulatory Engineering Collaboration by VUP Quantification
16.	VUPRE/ASME Keynote Presentation on Lessons Learned, Managing Vulnerabilities and Crisis under Imprecise Information Probabilities
17.	Developing Patient Healthcare Systems (PHS) by Stochastic Modeling of Medical State Uncertainties
18.	Developing Integrated Public Health Information Statistics Administration (IP-HISA) from VUP Quantification
19.	Overcoming Vulnerabilities and Uncertainties (VU) in Engineering Artificial Organs and Replacement of Body Parts
20.	Medical Doctors Experience of Dealing with Vulnerabilities, Uncertainties and Probabilities (VUP) in Patient-Centered Care
21.	Developing Sustainable Manufacturing and Consumer Safety Index by VUP Quantification
22.	Enhancing Safety and Reliability of Mining and Petroleum Production by VUP Quantification
23.	Creating a Sustainable Value from Intellectual Property, and Reduction of Vulnerabilities and Uncertainties (VU)

In Topic 9, the changing mode of energy mix and role of regulatory engineering is presented and discussed. [16] In nations such as Japan, as was the case with the United States, plans for the energy mix have been significantly changed after the nuclear power plant disasters in Fukushima and Three Mile Island, respectively. Nations such as Germany and Japan are clearly moving toward development, demonstration and commercialization of new renewable energy systems, such as combined systems of wind power, solar, ocean and geothermal energy, while developing economies such as People's Republic of China, India and Vietnam are becoming increasingly dependent on nuclear energy, as has been the case with France. Possibilities of the development and application of the RE models and approaches to these energy issues will be discussed.

In Topic 10, systems-of-systems (SoS) or collections of highly complex, heterogeneous systems, typically seen in air transportation systems (ATS), are discussed, referring to the relevance of public policies in ATS to SoS engineering, by Boling, Lim, Kirby and Mavris. [17] The case for treating public policy within the ATS is presented as one of the system-of-policy-systems (SoPS) with inherent "deep" uncertainty, resulting from limitations in their ability to use the formalism of statistical decision theory to quantify uncertainty. Because of these limitations, it is recommended that public policy making is recommended to be pursued with an exploratory rationale as a philosophical underpinning, and the philosophy behind exploratory modeling and analyses is also discussed.

A way of dealing with uncertainty in the wind tunnel loading of an automobile is presented and discussed by Mohammed. [18] Formula One regulations by Federation Internationale de l'Automobile (FIA) have made all aspects of testing and simulation very stringent, and the Formula One racing companies wish to make the best use of wind tunnel testing time; however, due to deflections in the tires, the loading point (Moment Center) on the force transducer is not fixed, giving rise to uncertainty in loads and interactions. The moment is essential in dealing with the uncertainty of the load and its location at any given instant. A force transducer has been designed to deal with this problem, and simulated, using FEA to check for interactions; thereafter, the FEA results are compared to the calibration results of the transducer.

For damage and failure prediction in polymer composites due to mechanical loading, a method of coupling atomistic, mesoscale and macroscopic scale modeling simulations is developed and discussed by Koslowski, Pipes and Strachan in Topic 10. [19] In this model, the onset of failure occurs in the polymeric phase and it is determined, using atomistic simulations, by the ability of the polymeric material to reach a critical dilatational and distortional strain. Phase field based mesoscale models are used to determine damage propagation and compared to experiments of failure in polymeric materials. Finally, a model that incorporates the effect of uncertainty in the microstructure of composite systems in the failure analysis is used to determine the range of failure angles in an open hole

off-axis specimen and the uncertainty in the critical effective shear-strain in the matrix phase at failure. A Bayesian methodology is used for model validation and the Bayes factor metric is used to quantify the confidence in the model prediction.

The concept of probabilistic-design-for-reliability (PDFR) and its applicability to aerospace electronics is discussed by Suhir in Topic 10. [20] The use and role of mean-time-to-failure (MTTF), prognosis and health monitoring (PHM), technical prognosis, predictive modeling techniques based on applied probability, probabilistic risk assessment (PRA) and management (PRM), failure-oriented-accelerated testing (FOAT), highly-accelerated-life-testing (HALT), development of adequate QT specifications, methodologies, etc., and methods for understanding the human factor in product's overall performance are illustrated by practical examples.

Estimating likelihood and uncertainty for intelligence issues using belief/plausibility, fuzzy sets, and approximate reasoning is discussed by Darby and Biringer in Topic 10. [21] Issues of national security of concern to the intelligence community require consideration of highly subjective information. Much of the information available is qualitative instead of quantitative. The intelligence community has established an Estimate Language to express Likelihood and Confidence to answers of questions of concern such as: "What is the probability that an event was of type A?" The uncertainty associated with evaluating such information is highly epistemic (state of knowledge) rather than aleatory (stochastic). Qualitative information is linguistic (words) instead of numbers, and the linguistics can be considered as fuzzy sets. Linguistic variables can be combined using an approximate reasoning rule base for the constituent fuzzy sets. The custom Java software, Linguistic Belief, has been developed to evaluate problems that are qualitative and that involve considerable epistemic uncertainty. The software implements the belief/plausibility measure of uncertainty on linguistic variables whose outcomes are fuzzy sets; variables are combined using an approximate reasoning rule base. The techniques have been applied to issues of national security. The Likelihood results in the Estimate Language as the midpoint of a belief to plausibility interval, and the Confidence results in the estimative language as the size of the belief to plausibility interval.

In Topic 11, Hyeng and Krivoshapko [22] provides information on the sixteen umbrella-type surfaces and two umbrella surfaces from the identical parts of translational surface in architecture of spatial structures, formed by a generating circle of constant radius, using methods of differential geometry and computer design. The parametrical equations of the surfaces are presented and the influence of constant parameters containing in the equations of these surfaces on their form is studied in detail, with the aid of computer graphics. Other presentations and discussions are also expected for these and the other Topics of this VUPRE 2012 Conference.

5. Issues of Disaster Prevention & Management and Role of Regulatory Engineering

As the issues associated with disasters are one of the primary items of discussion at the subject VUPRE Conference, they are briefly described here. These issues have also been extensively discussed at various meetings of Science Council of Japan among others, after disasters of Fukushima Daiichi Nuclear Power Plants and those of the other areas in East Japan occurred on March 11, 2011 and thereafter, stemming from the great earthquake and subsequent tsunami. The author has attended these meetings, joining discussions, which may be summarized as follows:

Forecast of Earthquakes: Estimation of occurrence of the earthquakes within thirty years and longer periods in certain areas can be reasonably made, based on the data of the past earthquakes, as well as those with less accuracy of centuries ago, if they are appropriately treated for forecast purposes. On the other hand, it is reported impossible, however, to foretell the occurrence of earthquakes within a short time period before their happening, as strain levels of active faults are hardly estimated, especially for those at the sea bottom. The comprehensive RE model to quantify uncertainty and probability to this end from short to decade long periods are yet to be developed, with promising approaches, innovative instruments, etc. in hand. However, once magnitudes and the other data of the earthquakes become available, consequent tsunamis can be reasonably simulated, with the use of high-performance supercomputers.

Guiding People in Case of Emergency: Everyday training and education for risk communication is very important for the general public, pupils of kindergartens and elementary schools, and students of junior high schools, high schools and colleges, to cope with disasters. People in Tohoku have a mentality that only oneself should not evacuate, but they should help little children and elderly people first. On the other hand, Katada [23] stressed children the importance of themselves evacuating first and running to the highest possible point in case of tsunami, so that everybody else can naturally and consequently follow them. This teaching and associated training have resulted in the 99.8% survival of the elementary school pupils and junior high school students in Kamaishi City during the 3/11 disaster. He also strongly said to the pupils and students, “Don’t trust hazard maps, but run up to the highest point possible.” This means that hazard maps may not be useful in case of disasters of unexpected levels, and it should be kept in mind that they are constructed based on presumptions, and thus are not all mighty.

The hazard maps, i.e. scientific and engineering information, must be interpreted in a way that will conform to situations and relevant factors of each event, which may be of either expected or unexpected levels. Therefore, the information made known in public, based on RE and RS models, should incorporate human mind and behavior (in case of extraordinary events and/or emergency) into its regulations,

guidelines and education, when addressing disasters. The education and training to this end should also nurture the people with their own initiative and proactive mind, without merely relying on shallowly understood knowledge.

Building and Facility Collapses, Fire, and Other Disasters: The tsunami of unexpected levels has brought about collapse of buildings, failure of tanks, etc., subsequently resulting in fire and explosion of oil and gas tanks among others. The Codes and Standards certainly have to be updated to sustain the level of stresses and forces, corresponding to the maximal level of the events that actually occurred. There will be no way, however, to sustain the events that exceed certain levels of magnitude; in such a case, the best countermeasures are to plan and construct the infrastructure with least and/or less vulnerability to the extent possible. These points should be kept in mind when RS and RE approaches are applied in planning of the areas, likely subject to disasters of those levels.

Nuclear Power Plant Issues: It is reported by media and a representative of Science Council of Japan that the Fukushima Daiichi disaster is primarily a human-caused disaster from the planning stage to the operation and maintenance of the subject plants. Both the emergency diesel engine power generators and distributors were located at a level that could be immersed in water in case of tsunami with the wave height of over certain levels. This, as well as loss of connection to the external power sources, were causes for loss of power sources for the plant at the time of the 3/11 event, resulting in the stoppage of the circulation pumps for cooling water to the reactor. Damage to the piping also resulted in loss of coolant, leading to lowering of the water level in the reactor. Consequently, the reactor core meltdown occurred, leading to shell melt-through, and hydrogen gas and vapor generated went up to the upper part of the reactor container, leading to pressure increase, gas leakage to the housing, and an explosion at two units. The vent was done to lower pressure inside of the container, and radioactive substances were spread to surrounding prefectures.

The adoption of filtered containment venting system shall be made to the nuclear power plants in Japan, as this will enable the plant operators to conduct early vent, with very low level radioactive substances, thus saving both reactors and the environment of the surrounding areas and prefectures.

It was also pointed out that the subject nuclear power plants were not of adequate fail-safe structures, which should be improved for future operations. Human errors were also made; however, it would be almost impossible to perfectly manage and control human errors in case of critical conditions. These kinds of situations are often caused by a lack of availability of necessary information, the network system of which should particularly be improved in the near future. Nuclear power industry community tended to be closed within those that are involved; however, it became opened up after this event in this nation.

The density of radioactive substances, spread via atmosphere, river, and ocean, was also measured for human beings, cattle, dairy products, vegetable plants among many other food and materials in order to secure and improve safety level of the human life. The RE and RS approaches can play a

significant role in establishing standards, codes and regulations regarding its radioactivity, its distribution in the concerned areas, and its influence on human beings, society, food, and the environment among others.

Increase of aging nuclear power plants is becoming an issue in Japan, as four nuclear reactors out of the fifty-four reactors in operation (as of March 31, 2011) have surpassed 40 years of age as of July 2012, and fourteen more reactors will reach forty years of age by Year 2020 in this nation. It is obvious that more appropriate, thorough regulations, matching reality of their operation, will be increasingly required to cope with the aging issues such as embrittlement of the reactor and other materials. Regulatory agencies will need more staffs with experiences of working in operating plants, and the quantification of VUP in RE will continue to be important, as has been to date, to safely extend the lives of nuclear power plants.

Debris (Gareki): Thousands of tons of debris are yet to be treated and buried underground, and how this is to be done is an issue, as the volume of the debris in East Japan area amounts to a gigantic level, and those composed of radioactive substances are of special concern. Increasing numbers of prefectures and the metropolitan government are accepting the debris generated in these areas for treatment to bury them. The RE approaches can play a certain role, especially in treating unfamiliar debris, which may be harmful to human kind and the environment.

Mental Care of People: Many of the children, the younger and the elderly, lost their parents and other family members such as grandparents, brothers and sisters. Mental care and psychiatric treatment are needed for a majority of them to recuperate from their dreadful and sad experiences. Group activities by the youth, such as college students, are organized by the Association for Children's Environment [24] to help the victims in daily life among others, and to create the better environment for the children in a longer run. The RE approaches can play a meaningful role in restoring the environment for the children, thereby realizing better planning for the better future.

Future Planning: It is empirically known that there is no way to prevent the community from disasters, if earthquakes of over certain magnitudes occur in nations such as Japan, an island nation with many active magmas, surrounded by the Pacific Ocean and the Sea of Japan, among others. The issues are, therefore, both how we can prevent our society from disasters caused by the events of under certain levels of magnitudes, and how we can implement counter measures, with the RS and RE approaches, to realize the society with less vulnerability for the events we cannot prevent us from disasters.

Many of Tohoku areas lost seas, mountains and rivers where children used to play around before the disaster, and the best efforts are made to restore them and to make the environment even better for children than before. This may be essential to raise global human capitals/engineers for the future. Those who have experienced a variety of new environment after evacuation, due to these disasters, have a good chance of becoming globally successful persons, given the past records that many of those successful people in the global arena also overcame similarly

tough situations. An application of RE can help standards, codes, regulations, and policies become extensively applicable and adoptable to realization of the aforementioned, improved environment, among others.

6. Energy Mix Planning for the Nation

All nuclear power plants in Japan stopped as of May, 2012, and this has compelled the nation to use more fossil fuels, thus leading to price hikes of these fuels, and consequent price increase of electric power, before shale oil and shale gas became available. As a 15% shortage of electric power supply to its demand was expected to occur in August, 2012 in Kansai area, the national and local governments have restarted the operation of Ohi Nuclear Power Plants in Fukui Prefecture to supply electric power to Osaka, Kyoto and Shiga Prefectures, beginning July, 2012. These issues have given a significant impact on the national economy, giving rise to a loss of competitiveness of heavily power-consuming industry. However, Sendai Nuclear Power Plant in Kagoshima, Kyushu is still the only operating nuclear power plant as of December 2015 in Japan.

On May 28, 2012, Ministry of Economy, Trade and Industry made a decision on the share of nuclear power in the electric power mix to be decreased to the levels of 0% or 15% or 20~25% by Year 2030 from the original target of 57%, which had been planned before the March 11 event in 2011, to suppress emission of global warming gas, or mainly CO₂. RE will certainly play important roles in determining the share of nuclear power as well as the other energy, given a situation that much higher safety level is required against disasters such as those stemming from great earthquakes and subsequent tsunamis, while maintaining economic strength and the environmental health of the nation and globe at the same time.

7. Role of Renewable Energy

In almost all developed economies, renewable energy has come to draw much greater attention from policy makers, engineering professionals and general public, among others. After then Prime Minister Naoto Kan declared a policy change to realize a nation without depending on nuclear power in summer 2011, a variety of professionals have been promoting the research, development and demonstration of innovative renewable energy technologies such as solar thermal, photovoltaic, wind, geothermal and ocean energy among others.

The research, development and demonstration of floating platforms, simultaneously utilizing solar energy, wind, tidal, wave, (and possibly ocean thermal) energy conversion are promoted by Kyoizuka, et al. [25] Offshore structures are usually designed for a life of twenty years; however, lives of such platforms may be extended by decades, given the development and availability of innovative technology and RE suitable for such applications. New Energy and Industrial Technology Development Organization (NEDO), Japan, conducted a feasibility study of ocean energy, and declared a target share of the ocean energy to be 10% of the primary

energy mix of the nation by Year 2050. This indicates that RE can help utilize this and other energy technologies effectively and efficiently.

8. IMECE 2012 Session 5-7-2 “Globalization of Regulatory Engineering” on November 13, 2012

1) *NSF Funded MSOE-NFTDC Collaborative Research [26]*: Professor Kumpaty and Mr. Kamara of Milwaukee School of Engineering took four undergraduate students to Non-Ferrous Materials Technology Development Centre (NFTDC), Hyderabad, India each summer for a six-week global research experience of interdisciplinary nature.

An electrical engineering major, Jisun Yoo researched on *Comparative Analysis of Heat Treatment Methods for Direct Metal Laser Sintered 17-4 Precipitate Hardened Steel* and a biomedical engineering student, Brandon Tomlin worked on the *Analysis of Grain Structure and Surface Roughness in Heat-treated EOS GPI Stainless Steel Parts*. The Kumpaty team collaborated with Greatbatch Medical to receive the EOS GPI samples for characterization studies at NFTDC. The following finding summarizes the work:

The annealing heat treatment recommended by EOS did not relieve the stress of the part as stated, in fact it acted as a precipitation hardening treatment having the opposite effect. As a result, the treatment used by Greatbatch over-aged the parts, causing them to have too much precipitation to have the ideal properties. Our recommendation is that for the best precipitation hardened properties, Greatbatch stress relieves the parts as EOS recommends, however have no further heat treatments done to the parts.

A mechanical engineering student, Brett Steffan researched on the *Mechanical Properties of Titanium Alloys Manufactured with Additive Processes for Use in Medical Applications*. A biomedical engineering student, Jennifer Anderson addressed the topic, “*Analyzing the Surface Finish and Grain Structure of Additive Manufactured Porous Titanium Alloy for Applications in Biomedical Implantation*” using the sample samples. The summary of their work is as follows:

Several additive manufacturing processes have been in practice for a reasonable amount of time, but selective laser melting (SLM) and electron beam melting (EBM) are relatively new processes for creating unique parts from a variety of different metal powders. This technology may be particularly useful in the field of biomedical implants, in which customization of components is key to a compatibility with the body. In addition to customization, controlled porosity may be achieved by the EBM and SLM processes, yielding greater strength to weight ratios and higher biocompatibility than their solid counterparts. The purpose of this research was to investigate and compare the material’s strength and hardness amongst several variables such as different manufacturing processes, structure, and annealing processes. The samples were also compared to both the industry standard forged and annealed Ti 64. The results of

this research showed that an annealing-age hardening heat treatment is unnecessary, if not harmful for both EBM and SLM processes. Also shown was the superiority of SLM to EBM in regards to strength among others. If higher strength properties are necessary than the initial properties, the precipitate would need to be identified in each case to develop an alternate heat treatment process from the standard. Regulatory engineering is therefore considered to play a meaningful role in these areas.

For two students, this global research experience motivated them to apply for a graduate school while the other two have already decided on pursuing graduate school. The students liked interactions with people both at work and outside. They consider it a lifetime opportunity and a memorable experience with the people of India. All the four participants also presented their individual research results at the *Biomedical Engineering Society Conference* in Atlanta, GA, during October 25-27, 2012.

2) *Lead from Behind: Estimating Partnership to Bring Clean Water to Caliche, Honduras [27]*: Cliché is an impoverished village of approximately 350 people in central Honduras, which had had access to a mountain spring as a source of water until a 2009 earthquake, did not have a clean source of drinking water, utilizing collected rainwater and surface water ponds for all of their water needs. A community-scale bios and filtration system with requisite delivery structures was proposed, accepted, and brought to design fruition, after a survey of the geography, the resources of the local people, and partner institutions.

The innovation in this project was the “lead from the behind” approach in the context of a best practice called asset-based community development.

Dayton Service Engineering Collaborative (DSEC), Ohio, U. S. A., provided technical leadership and project oversight, ensuring that not only were the technical obstacles overcome, but that the community and local authorities were empowered to tackle future development projects with independent vision.

3) *Global Occupational Hazard: Silica Dust [28]*: Workers worldwide exposed to silica dust span a variety of industries from construction, mining, sandblasting, to masonry, and machinery. Exposure to crystalline silica can lead to lung cancer, tuberculosis, and other chronic airway diseases. Cooper examines the health effects of silica dust on the worker, discussing exposure paths, work groups affected, occupational safety measures, worker health policies, and compare these among the developed and developing world. A comparison of the successes and limitations of several worker safety programs from around the world, including wearing Personal Protective Equipment (PPE), health monitoring and developing exposure limits, shows that the strong national occupational safety programs can reduce the mortality and illness rates of silicosis due to the silica dust exposure. It is concluded that, in order to meet the objective set by WHO of eliminating silicosis by 2030, governments and organizations must come together, collaborate on research, and share best practices. By collaboratively standardizing engineering

controls, workers can be protected from a variety of lung diseases brought on by working with silica dust.

4) *Stakeholder-Driven Design Evolution of the Leveraged Freedom Chair* [29]: Winter, et al., of MIT designed the Leveraged Freedom Chair (LFC) to be a low-cost, all-terrain, variable mechanical advantage, lever-propelled wheelchair designed for use in developing countries. In this design, the user effectively changes gear by shifting his hands along the levers; grasping near the ends increases torque delivered to the drive train, while grasping near the pivots enables a larger angular displacement with every stroke, which increases angular velocity in the drive train and makes the chair go faster. The authors presented the design evolution of the LFC through three user trials in East Africa, Guatemala, and India. Feedback from test subjects was used to refine the chair between trials, resulting in a lighter, narrower, and with a center of gravity 5 inches lower than the first iteration. Increases in performance were possible after successive iterations. Quantitative biomechanical performance data were also measured during the Guatemala and India trials, which showed the LFC to be faster and more efficient during a common daily commute and able to produce higher peak propulsion force compared to conventional, push rim-propelled wheelchairs.

Pinnacle Industries, the production partner in India, was creating the tooling to produce 500 LFCs/month. The main message of the authors was that when creating technology for developing countries and emerging markets, engineers must recognize stakeholders as collaborators and give them the opportunity to articulate problems and solutions. The project

itself included many global partners from conception to completion.

There will be a need for this kind of wheel chairs, useful for nations with many unpaved roads; therefore, regulatory engineering will play a significant role in setting international codes and standards for these products, and consequently regulations and policies among others, for those nations.

9. Fatigue and Fracture Issues Addressed at FEOFS 2013

9.1. Fatigue and Ultimate Strength Design Issues of Jack-Up Oil Drilling Rigs

A research on the strength of racks for jack-up units was conducted by Honda, et al. [30], [31], [32] three decades ago, and role of regulatory engineering in these issues is described in the author's paper, [3] as follows:

1) *Ultimate and Fatigue Design of Racks for Jack-Up Units:*

(1) Jack-Up Rig Model [30]

The rack and pinion type jack-up units can be classified into the float and fixed type units. Figure 4 shows a manner of the leg response and each type jack-up unit, respectively. Figure 5 and 6 show a plane figure of the platform, used for a computational model in this investigation, and a jack-up rig under construction, respectively. The legs for this investigation are of triangle truss structure, consisting of three chords, and a jack-up unit is installed for each chord, as shown in Figure 5.

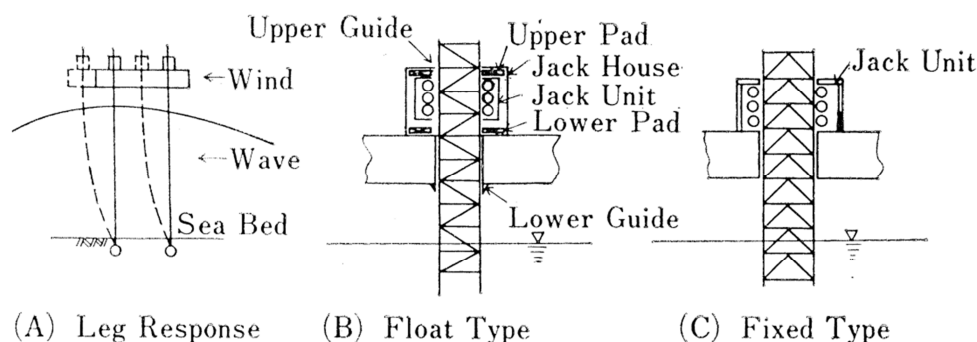


Figure 4. Float Type and Fixed Type Jack-Up Units and the Leg Response of a Jack-Up Rig to Wave and Wind.

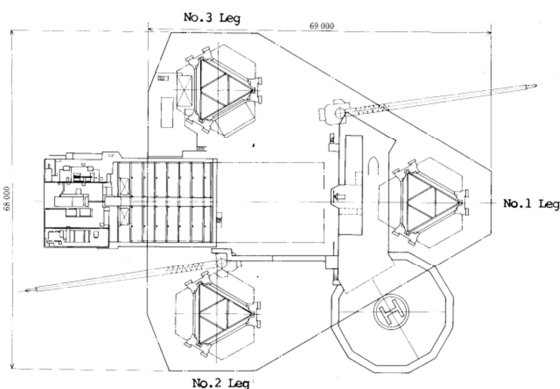


Figure 5. Plane Figure of the Jack-Up Rig Model [30].

(2) Evaluation of Jack Load for Design Storm Condition

Table 3 shows the design condition of this rig for a storm of 100-year return period. The wave and wind directions were assumed to be perpendicular to the line connecting No. 1 and No. 2 legs and approaching from the side without No. 3 leg to the side with No. 3 leg. As this direction was considered the most critical for the leg, the analysis was conducted for this case.

(3) Computational Method and Results

The method of wave load computation, the wind load computation, and the structural analysis are summarized elsewhere. [30] Figure 7 shows results of the jack load computation.

(4) Experimental Results of Rack Fracture Test

Figure 8 shows relation between the stroke displacement and

the jack load per two pinions (the sum of the jack loads for Rack Teeth A and B). The numbers in this figure indicate the measurement numbers which represent the stop positions of the loading head for strain and displacement measurement, and photography for the rack teeth, as shown in Figures 9 and 10.



Figure 6. Jack-Up Rig under Construction (Photographed in May, 1983, Tamano City, Okayama, Japan).

It is seen that the maximum jack load for this test is approximately 1322 tonf (12.96 MN) in the vicinity of Measurement 23. It is also seen that the stroke displacement at the maximum load is approximately 100 mm; therefore, the rack tooth is highly deformable. At Measurement 23, the jacking load becomes maximal and decreases thereafter. After Measurement 25, the rack and pinion teeth began to squeak due to friction. At Measurement 29, a crack is observed on the

compressive surface of Side B.

Table 3. Assumed Conditions in Design of Jack-Up Oil Drilling Rig.

Water Depth	91.4 m
Wave Height	18.6 m
Wave Period	15 seconds
Wind Velocity	44.8 m/sec
Air Gap	13.7 m
Penetration	4.57 m
Footing Support	Pin Support

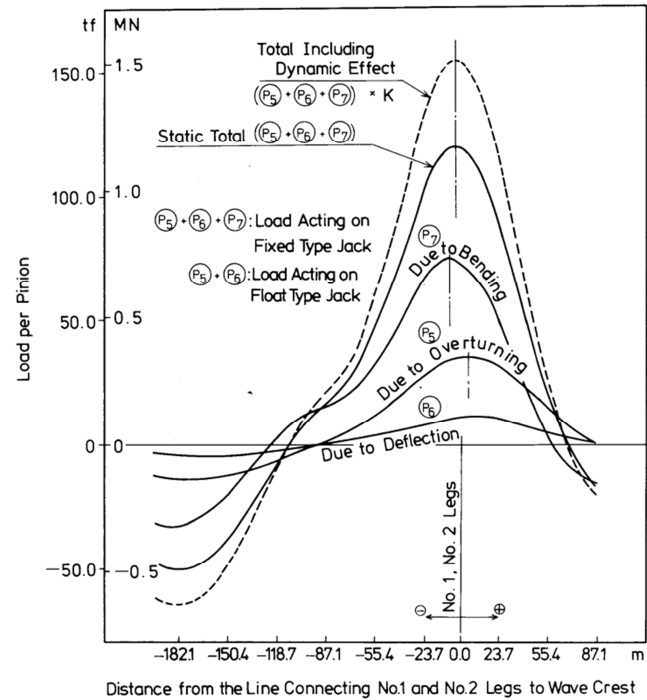


Figure 7. Relation between Jack Load per Pinion for No. 3 Leg and Wave Crest Location.

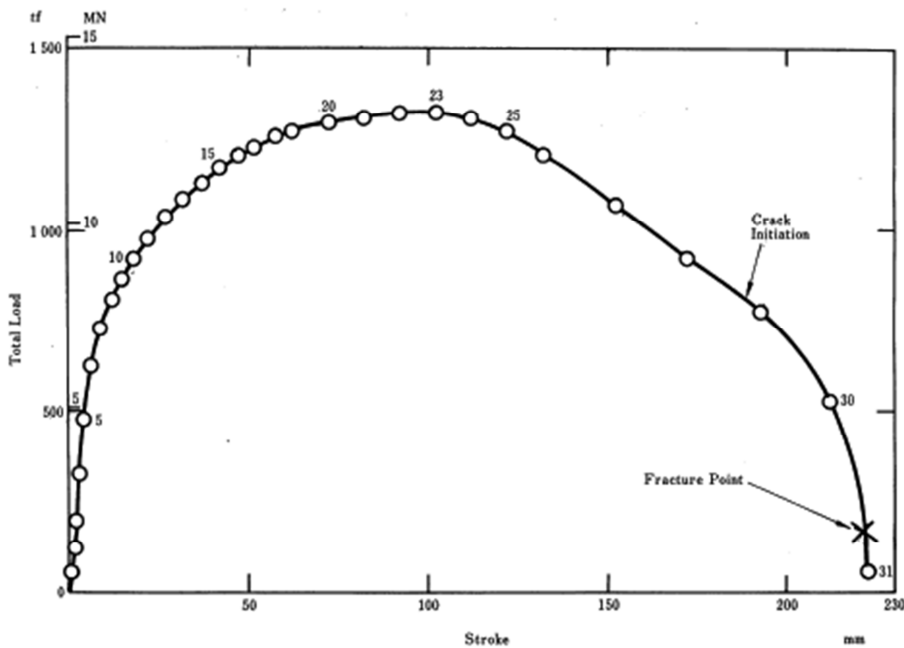


Figure 8. Relation between Jack Load per Two Pinions and Stroke Displacement.

(5) Ultimate Strength Design of the Racks: [30]

The length of legs of the jack-up rig discussed is over 100 m; consequently, the number of the rack teeth for one side of the chord is over 393 since the pitch of the rack is 254 mm. The rack tooth which was once in mesh with pinions has a low probability of being in mesh with the pinion tooth again, since a jack-up rig moves from one place to another at a location of various water depth; consequently, it is considered that the allowable load for the rack tooth can be set higher than those for other members of the jack-up rig in conducting the ultimate strength and fatigue design.[30], [31] In addition, it must be noted that the neighboring tooth of the rack or the rack teeth in mesh with other pinions share the load in the case of a failure of one rack tooth; therefore, the rig is of a fail-safe-structure.

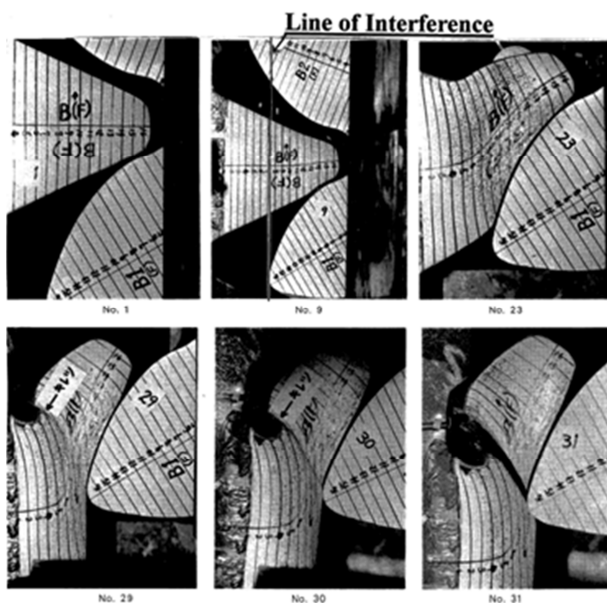


Figure 9. Deformation and Fracture Pattern of Rack Tooth B.

The design method of the rack tooth has been discussed, based on a premise of a single meshing with a pinion, which is usually designed stronger than the rack. The conventional

design method is, therefore, on the conservative side. The scale factor for the ultimate strength is considered negligibly small. [32] Since the evaluated maximum jack load is 429 ton (4.21 MN) per pinion and the endurable maximum jack load is 6.48MN per pinion, the factor of safety for the rack is found to be 1.54 by neglecting contact ratio. Therefore, the rack design is on the safe side from engineering viewpoint.

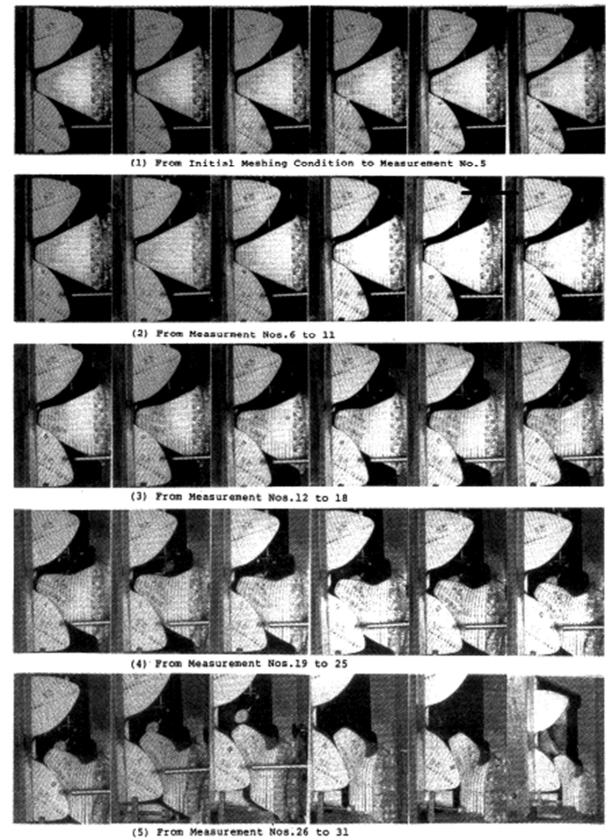


Figure 10. Deformation and Fracture Pattern of Rack Tooth A Photographed from Side (F) [33].

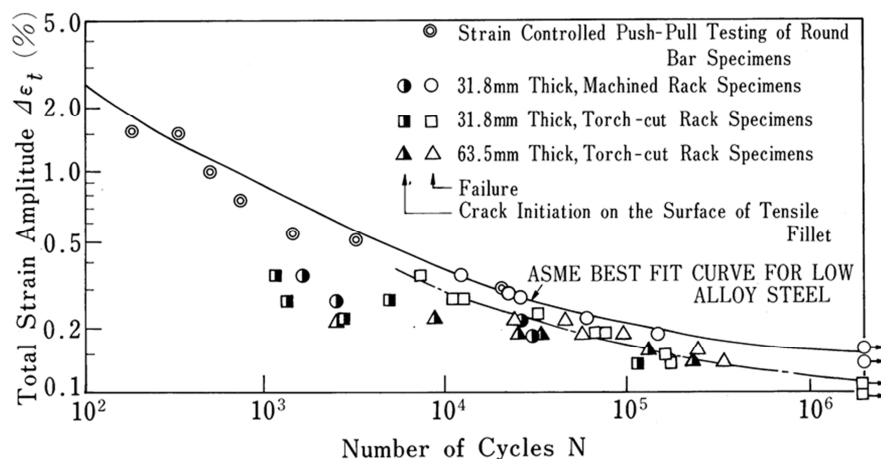


Figure 11. S-N Curve for both Machined and Torch-Cut Racks.

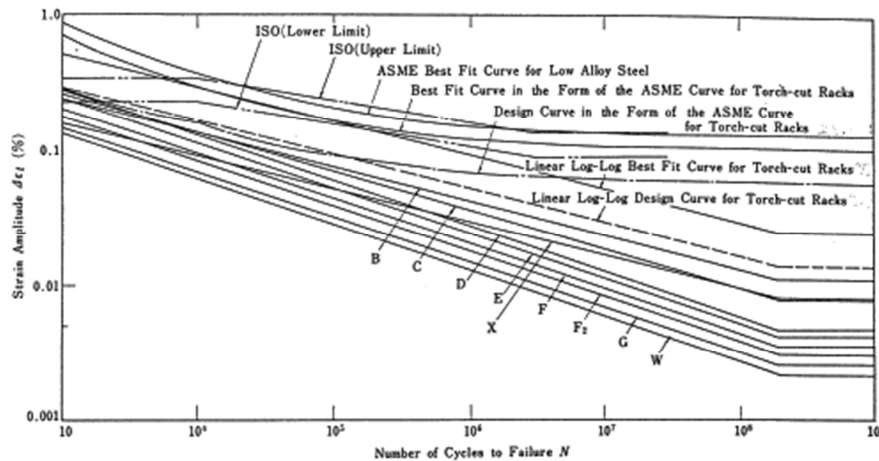


Figure 12. Comparative Design S-N Curves.

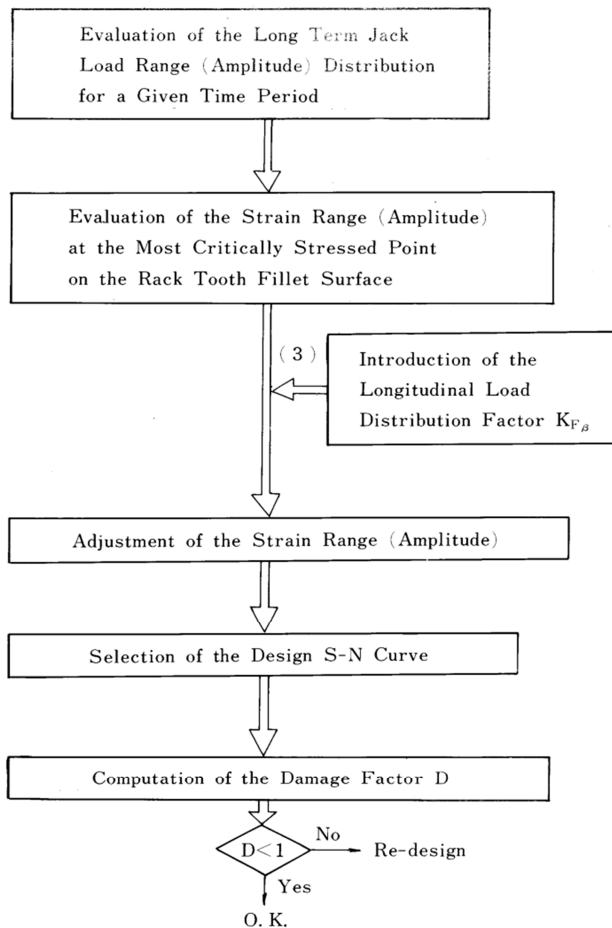


Figure 13. Proposed Fatigue Design Steps for the Rack Tooth.

For a single meshing at the rack tooth tip, which is considered the most critical in this research, the deformability of a rack tooth is considered to be large enough to let other teeth share the load with overload acting on one tooth according to the reason stated by Honda [30] and Figure 9. It was reported by Honda, et al. [32] that the endurable jack load of the rack is considered to be well expressed in terms of the shear strength of the cross section of this material determined

by Line of Interference, shown in Figure 9; consequently, the endurable shear stress for the rack made from HT80 steel is 410MPa, which is approximately 57% of the tensile strength of this material. This percentage matches the ratio of pure shear to tensile yield stress 57.7% determined by the criterion of von Mises.

(6) Fatigue Design of the Racks: [31]

Figures 11, 12 and 13 respectively show the fatigue test results of both torch-cut and machined racks, comparative design S-N curves of HT80 Steel and other low alloy steels, and a proposed fatigue design steps for the rack tooth. The design S-N Curves identified with Classes B through X are those of DNV for the failure probability of 2.28%.

It is seen that fatigue strength of torch-cut racks have lower values than ASME Best Fit Curve for low alloy steels, and the former varied considerably due to defects produced by torch-cutting. The design S-N Curves in the form of DNV and ASME were obtained from the results of fatigue tests on torch-cut racks, with the former being considered to be more appropriate than the latter for fatigue design of the torch-cut racks. The Linear Log-Log Design Curve of a dotted line, close to Class B Curve, is therefore adopted for the subject design purposes.

2) RE Issues regarding Ultimate Strength and Fatigue Design of Racks

It is important to assess reliability of the scientific and technical information to utilize them as a sound basis for establishment of regulations, codes and standards, by quantifying vulnerability, uncertainty and probability (VUP) of the subject issues. There are many issues to be resolved by utilizing RE approaches, in which regulatory agencies, regulated communities, and engineers and scientists work together in a triad structure, as shown in Figure 2, to improve the jack-up unit design issues, such as the following:

(1) Evaluation of Design Storm Conditions such as Wind Speed, Wave Speed, Wave Height, and Tide Condition

A storm of one hundred year return period was adopted as the design condition for the jack-up rig studied in this paper; however, those of 10,000 year return period have been employed by an oil company such as Shell for design conditions for offshore rigs. This is considered to be a political

decision to mitigate criticism and claims against prospective accidents and/or disaster, which may lead to environmental deterioration in offshore areas. Further studies are commended in this field.

(2) Evaluation of Jack Load and Its Fluctuating Load

The deterministic approach is adopted by Classification Notes of DNV to avoid complex calculation for a benefit of busy engineering practitioners; however, methods such as those utilizing probabilistic finite element analyses may replace deterministic methods to minimize overly underestimation or overestimation of a total jack load acting on all the jack-up units.

(3) Meshing Condition of the Rack and Pinion for Jack-Up Units

As strength of the subject rack teeth depends on meshing conditions of the rack and pinion, a probabilistic approach may be utilized to estimate the total strength of all the rack teeth in mesh with pinions. This means that, as contact points of the rack teeth vary from one time to another, their elastic and plastic deformation behavior may also vary, leading to change or variation of their total strength.

(4) Stress and Strain Evaluation of the Racks

Due to manufacturing errors associated with torch-cutting, the computed stress and strain values for designed dimensions may deviate from those for racks in service. A sound probabilistic approach may be effective in this area of issues and research.

(5) Fracture Mode of Structural Members

It was found that the subject rack teeth are subject to a shearing mode fracture, contrary to an opening mode fracture, which was believed to be the case, in assessing ultimate strength of the rack teeth.[30], [32] It was also shown that

fatigue cracks could be first initiated on the compressive side of the rack teeth and then on its tensile side. [31] These findings have given important clues to sound maintenance and other guidelines for jack-up rigs. Further research of this kind is commended for different types of offshore structures, such as those for renewable electric power generation under development. [25]

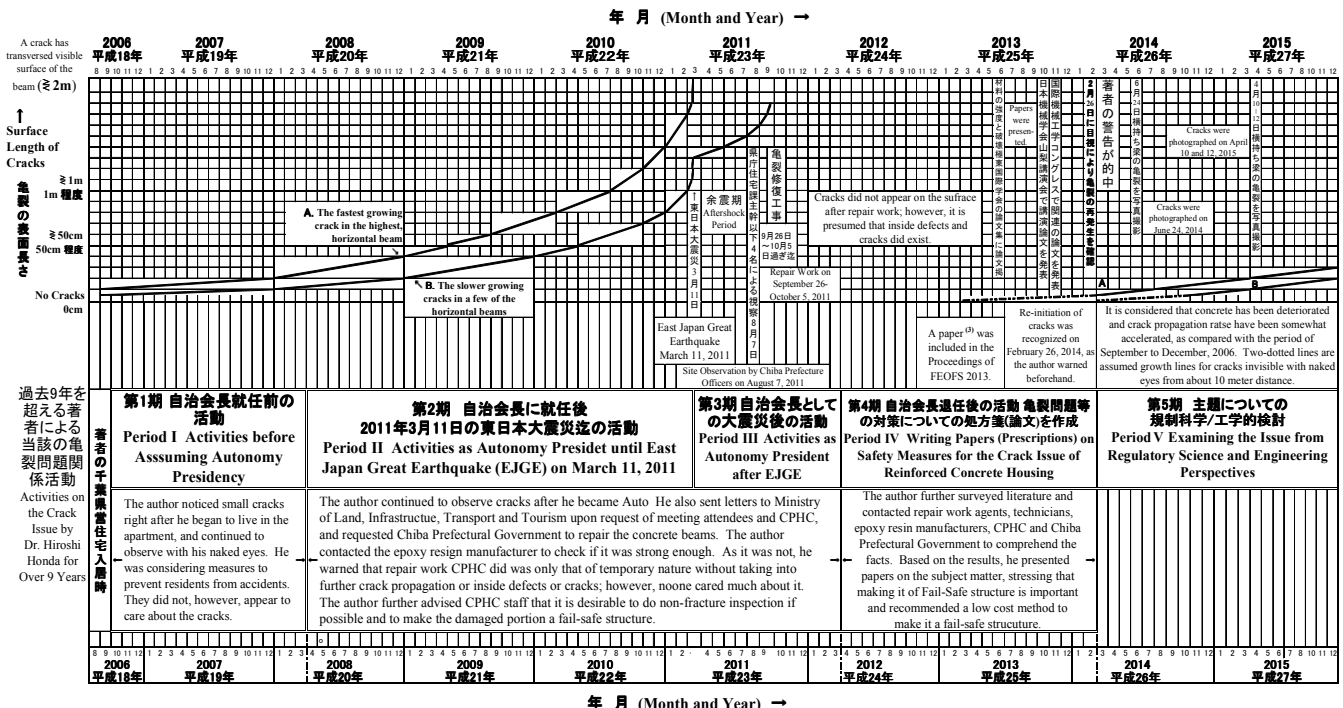
(6) Uncertainty of Fatigue Strength of Racks in Ocean Atmosphere

Rack teeth are in grease, when in mesh with pinion teeth inside the jack house; therefore, effect of the ocean atmosphere on fatigue strength was neglected for the subject design. The quantification of uncertainty regarding this issue and torch-cut finish among others may need to be further investigated.

9.2. Reinforced Concrete Housing Complexes Damaged by the March 11th East Japan Great Earthquake [3], [34]

1) Introduction

The author began to observe behavior of the cracks on the surface of the horizontal beams and handrails of the passage of then ten year old, subject building, from September, 2006 to date, as shown in Figure 14; however, few residents cared about this phenomenon. He found that they were propagating over years, probably due to cyclic stresses and strains stemming from thermal expansion and shrinkage of the reinforced concrete beams and the other housing parts, and also stemming from relatively smaller earthquakes occurred until the March 11th event in 2011.



Note: The Author had to do all these work without any compensation, even though he had to spend much time and money to complete his work.

Figure 14. Initiation and Propagation of Cracks in Horizontal Beams of the Reinforced Concrete Housing and the Author's Activities for the Safety Measures.



Figure 15. Front View of Reinforced Concrete Housing.



Figure 16. Back-Side of Horizontal Beams [Cracks propagated at white band portions before the epoxy resin was applied. (Photographed on 13 February 2013.)].

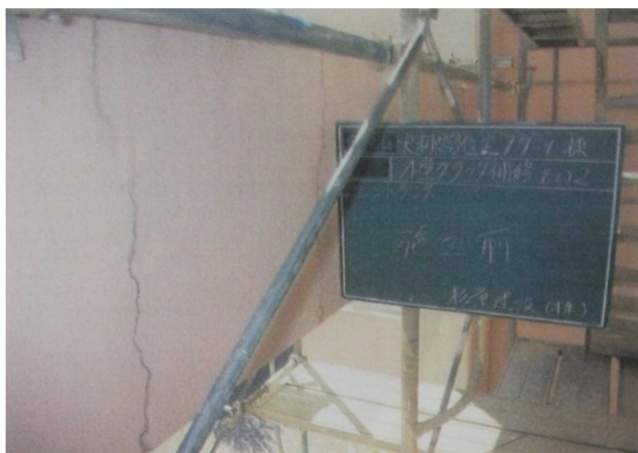


Figure 17. Cracks Seen on the Surface of Horizontal Beam under Repairing (Photographed during the Period of September 26 to October 5, 2011).

Figures 15 and 16 respectively show a front view of the reinforced concrete housing of Chiba Prefectural Housing Corporation (CPHC) built in F. Y. 1996, with horizontal beams at its center, and a back-side view of the beams repaired after the great earthquake on March 11, 2011.

The damage of this building was relatively small, compared with those in Tohoku Area, partly because the epicenter was relatively far away from Narashino City, partly because no tsunami came over to the area, and partly because the solid was not liquefied in the area, which was located several kilometers away from the coast. The author was serving as President of the Resident's Association of the housing complex from April 2008 to March 2012, and took care of communicating with officers at national and local governments, and CPHC to repair the damaged parts of the horizontal beams, handrails, etc. of then fifteen-year-old building

2) Observation of Crack Behavior

The cracks were steadily propagating over the years, as shown in Figure 14. The widening of the crack mouths was recognized by the time of the aftershocks in March and April, 2011, and some of the cracks transversed visible surface of the beams, as shown in Figures 14 and 17.

The author was concerned about prospective falls of concrete mass, which can lead to injury of the residents, and wrote to one of the director generals of Ministry of Land, Infrastructure, Transport and Tourism (MLIT) on July 29, 2011 concerning this and related matters. As a result, a principal technical officer in charge of public housing and his associates at Chiba Prefectural Government came to meet with the author, and observed the site.

3) Disaster Prevention Measures

The author requested CPHC to show design data of the building, such as structural dimensions and details, material properties, mechanical strength, fracture toughness and crack propagation data of the concrete and steel materials, used for the housing, and to adopt a fail-safe measure in repairing the structure; however, no data were given to the author by CPHC, seemingly because of the political reasons and partly because of unavailability of the information.

The ten-day-repair-work began on September 26, 2011, with epoxy resin used for crack bonding and surface coatings, without prospective fatigue of bonded parts taken into consideration by either a bond maker or a contractor. The author considers that it is desirable to conduct non-destructive measurement of crack shape, length and depth for concrete and steel portions, if technically possible, evaluation of the fracture toughness and fatigue strength of bonded parts and adjacent area, and evaluation of property of materials taken from those actually used, and identify the bonding method and material for the next repair to completely prevent the housing from falls of concrete mass.

4) Concluding Remarks

Neither Chiba Prefecture nor CPHC appeared to have appreciated the author's voluntary work of over nine years without compensation, while CPHC was spending relatively

much money for seemingly insufficient repair work and relatively meaningless maintenance work. Paying nothing to engineering and scientific work, while spending relatively much money for seemingly, meaningless laborer's work is an issue to be resolved to stop meaningless money spending to reward the professional engineering and scientific work. Use of regulatory science and engineering to assess each professional's work should be encouraged by national and local governments to adopt sound regulations to resolve the subject issue.

There are many other issues as well to be discussed concerning quantification of vulnerability, uncertainty and probability in regulatory engineering. Not only the strength, fracture and fatigue behavior of contact areas, such as those of the rack and pinion and crack-bonded portions discussed in Sections 9.1 and 9.2 of the current paper, but also fatigue and deterioration of the flanges of the pressure vessels, tightened with bolts and nuts, which led to leakage of hydrogen gas and cooling water at Fukushima Daiichi Nuclear Power Plant, are typical examples that may not be covered by existing Codes and Standards.

A fall of concrete ceiling boards at Chuo Highway Sasago Tunnel due to corrosion fatigue/cracking and/or deterioration of bolts, hangers and bond are another typical example. The issues such as fail-safe structure and systems of systems also need to be addressed by regulatory engineers and scientists to secure safety of our society.

10. Safety Engineering Symposium on July 2 and 3, 2015 in Tokyo [5]

A total of five papers [5], [6], [34], [35], [36] were presented at OS 7 "Issues and Proposals in Rationalizing Regulations -Toward Quantification of Vulnerability, Uncertainty and Probability in RS and RE" at the subject symposium, and relevant discussion was made at the other sessions such as keynote sessions, as well. The author presented a keynote speech for OS 7 [5], a majority of which is summarized on Pages 2 to 6 of the current paper.

Strategic plan of reducing risks associated with decommissioning of Fukushima Daiichi nuclear furnace was presented by a representative of Nuclear Damage Compensation and Decommissioning Facilitation Corporation. [35] In this paper, the plan is defined as a measure for continuous reduction of surfaced risks. Its basic concept, its relationship with safety regulations, risk reduction of medium to long term themes to be dealt with, and future tasks to be conducted were also discussed.

Regulatory transparency was also discussed regarding ionizing radiation [6] and golden rice,[36], [37] by contrasting RS and RE approaches with ideology. Finally, fatigue and fracture issues of offshore and building structures were presented by the author, [3], [34] as shown on Pages 10 to 13 of the current paper.

Regulatory issues, indicated and/or discussed in some other papers, were also discussed, totally or partially triggered

by questions raised by the author, at Special Lecture Sessions 1 and 2, [38], [39] and at some of the presentations at sessions such as OS 1 [40]-[42] and OS 8. [43]-[45]

11. JSME Annual Meeting Sessions on September 13 and 14, 2015

A paper on issues and some approaches in rationalizing regulations [46] was presented by the author as a report of the aforementioned SCJ OS-7 at Session on Technological, Engineering and Environmental Education at the JSME Meeting. Regulatory issues were also discussed at Citizen's Forum C17100 on Food Safety -System for Securing Food Safety from Farm to Table-, [47] Citizen's Forum C21100 on Finding Risk and Safety of Technology with Law and Economics: A Case for Recall Concealing by Mitsubishi Motors Corporation,[48] and Workshop W21100 on Regulation and Innovation, including those in general, medical system, and automatic driving system. [49] In these sessions, the author joined discussion, by raising questions to the speakers.

12. Japanese-French Symposium on Smart Cities on September 15 and 16, 2015 [50]-[53]

The subject symposium was held, aiming at developing an integrated and innovative approach to design the future, sustainable and smart cities, through smart resources network, transportation, buildings and citizen-centric digital services. The author raised questions to each speaker of the specific sessions regarding whether the presented technologies will significantly help achieve reduction of emission of greenhouse gas by eighty percent by year 2050, a target set by EU, and how RS and RE can help facilitate this. None of the presenters, except that of window glass with variable insulation efficiency, responded to the author with the positive answer. This means that further improvement in both system and element efficiency, and scientific and technological breakthrough may be needed to achieve the globally conceded environmental goals, regarding the sustainability of our planet, including prevention of global warming.

13. Concluding Remarks

Leaders in industry, government and academia have been increasingly calling for regulatory reforms to uplift national economy in Japan, especially after Prime Minister Shinzo Abe took over the cabinet on December 26, 2012. Similar trends in regulatory reforms can also be seen in a number of nations around the world.

The current paper summarizes a variety of presentations and discussions on regulatory science and engineering approaches and case studies among others at selected

conferences. It is important to note that expansion and globalization of SETO has led to expansion of the issues one will deal with RS and RE approaches, as may be seen from Table 2 Validated Topics and Tracks with the ASME/VUPRE Conference 2012, 5. Issues of Disaster Prevention & Management and Role of Regulatory Engineering, 6. Energy Mix Planning for the Nation, and 7. Role of Renewable Energy, among others.

It is also shown that many of the specific presentations have given and/or shall give an impact on the regulatory agencies, regulated communities, scientists and engineers, and general public among others in the United States, Europe and Japan, among other nations and regions.

In particular, fracture and fatigue testing, various analyses, and RE issues raised on racks of a jack-up oil drilling rig have given a significant impact on regulatory agencies, regulated communities and scientists and engineers among others. Crack issues of a reinforced concrete housing complex showed that a resident with engineering background could contribute a great deal to the safety issues, with RE approaches, without any engineering equipment; however, what is needed is understanding of the value of this type of work on the part of a local government, legal circle, general residents and public, among others, who might neglect it under political or other circumstances in some of the nations.

The SCJ sponsored Safety Engineering Symposium demonstrated importance of the risk communication and management, regulatory transparencies, and RS and RE approaches. The JSME Annual Meeting 2015 and Japanese-French Symposium on Smart Cities 2015 have shown important issues for the future, many of which are yet to be resolved with RS and RE approaches in years to come.

The author sincerely hopes that the issues discussed in the current paper will be of significant value to those that may be concerned in the global arena.

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Nomenclature

ATS: Air transportation systems
 CPHC: Chiba Prefecture Housing Corporation
 DNV: Det Norske Veritas
 EBM: Electron Beam Melting
 EOS: Electro Optical Systems
 ERP: Enterprise resource planning
 FEA: Finite element analysis
 FEOFS: The Far East and Oceanic Fracture Society
 FIA: Federation Internationale de l'Automobile
 FOAT: Failure-oriented-accelerated testing
 GL: Guideline
 HALT: Highly-accelerated-life-testing
 HT80: Steel with high tensile strength of 70~80+ kgf/mm²
 IP-HISA: Integrated public health information statics administration
 IPV: Intelligent parameter varying
 JSCE: The Japan Society of Civil Engineers
 JSME: The Japan Society of Mechanical Engineers
 LFC: Leveraged Freedom Chair
 MLITT: Ministry of Land, Infrastructure, Transport and Tourism
 MTTF: Mean-time-to-failure
 NEDO: New Energy and Industrial Technology Development Organization, Japan
 NFTDC: Non-Ferrous Materials Technology Development Center, Hyderabad, India
 OS: Organized Session
 PDfR: Probabilistic-design-for-reliability
 PHM: Prognosis and health monitoring
 PHS: Patient health care systems

PMMS: Planned Maintenance Management Services
 PPE: Personal Protective Equipment
 PRA: Probabilistic risk assessment
 PRM: Probabilistic risk management
 PRONTO: An Australian ERP software vendor
 QT: Quick time
 RE: Regulatory Engineering
 RS: Regulatory Science
 SAP: Software Application Process
 SCJ: Science Council of Japan
 SLM: Selective Laser Melting
 SoPS: System-of-policy-systems
 SoS: Systems of systems
 TRANSPARENT: Software for modeling and analysis of complex systems by a technology group
 VU: Vulnerability and uncertainty
 VUP: Vulnerability, uncertainty and probability
 VUPRE: Vulnerability, Uncertainty, and Probability in RE
 WHO: World Health Organization

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