Forging a New Nuclear Safety Construct

WORKSHOP SUMMARY

Convened December 4-5, 2012

Willard InterContinental Hotel

Washington, DC

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Prepared by:
The ASME Presidential Task Force on Response to Japan Nuclear Power Plant Events

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BACKGROUND

The March 2011 Great East Japan Earthquake and Tsunami caused great loss of life and property in the nation of Japan, and devastation to the environment. The extraordinary forces and flooding unleashed on the east coastal area also led to severe nuclear plant damage and radiological releases from the Fukushima Dai-ichi station. The global impact of the accident at Fukushima prompted the ASME President to commission a task force, the ASME Presidential Task Force on Response to Japan Nuclear Power Plant Events, to examine these nuclear plant events and their implications. The task force work culminated in the report "Forging a New Nuclear Safety Construct," which was issued in June 2012.

The unprecedented accident at Fukushima exposed new information on nuclear power plant vulnerabilities to extreme external events and the need for pertinent improvements to designs, procedures, and infrastructure. The multi-unit nuclear plant accident at Fukushima continues to have serious impacts on socio-political, economic, and energy-related issues in Japan and worldwide. The ASME Task Force chose to build on the growing body of U.S. and international technical assessments of these events, and to examine the Fukushima Dai-ichi accident in the context of the broader lessons learned from a half-century of nuclear operations. From the combination of assessments and reviews of the critical elements involved in the accident scenarios, the ASME Task Force proposed a cohesive framework for continued safe operation of nuclear plants.

From the vast body of observations, analyses, and reporting of the events at Fukushima, several points stand out as the most salient factors in assessing its long-term implications:

- The Fukushima Dai-ichi units were the first nuclear reactors in the world in the fifty-plus years of nuclear plant operation to sustain core degradation due to catastrophic external events, the first to involve simultaneous multiple unit failures, and the first light water reactors to release large amounts of radioactivity to the environment.
- The reasons why four of the Fukushima Dai-ichi units were severely damaged, and three suffered core meltdowns, and why ten other nuclear plants in the affected areas were able to survive, are clear and correctible. Principal among those were the now recognized inadequacies in plant design basis for tsunamis, flooding, and accident management.
- The Fukushima Dai-ichi accident revealed no fatal flaw in nuclear technology, yet multiple important safety improvements are being addressed globally for the operating nuclear fleet from the new lessons learned.
- Extensive evaluations of the Fukushima Dai-ichi accident have confirmed the absence of prompt fatalities from radiological effects and the continuing expectation of no significant delayed radiological public health effects. The relatively low potential for radiological health consequences from the Fukushima accident is consistent with prior experience with radiation effects.
- Protection of public health and safety from radiological releases has been and continues to be the primary focus of reactor safety. However, past and present experience shows that the major consequences of severe accidents at nuclear power plants have been socio-political and economic disruptions inflicting enormous cost to society. As of this writing, 23 months after the March 2011 disaster, about 70,000 residents in that region are still not able to return to their homes, pending a more complete radiological cleanup. As of December 2012, only 2 of the 54 previously operating nuclear power plants in Japan are generating electricity, and the nation continues to struggle with an energy supply shortfall. Estimates of the overall economic consequences of the Fukushima Dai-ichi accident are on the order of half a trillion U.S. dollars.

The primary nuclear power safety goal is and will continue to be protection of public health and safety. However, the Fukushima Dai-ichi accident revealed the need for additional steps to further reduce the potential for socio-political and economic consequences resulting from radioactivity releases. On that basis, the ASME Task Force has proposed a new nuclear safety construct to effect such improvement.

A New Nuclear Safety Construct

The set of planned, coordinated, and implemented systems ensuring that nuclear plants are designed, constructed, operated, and managed to prevent extensive societal disruption caused by radioactive releases from accidents, using an all-risk approach.

Critical Elements of the New Safety Construct

- **It is founded on the existing nuclear safety construct**. The new construct will expand on the evolving safety frameworks, reaching beyond adequate protection of public health and safety to prevention of significant socio-political and economic consequences from a severe nuclear accident.
- **It extends the design basis to consider all risks, and includes rare yet credible events**. The ASME Task Force proposes that the new safety construct be based on an “all-risk” approach, addressing a broad range of challenges to nuclear power plant safety, including internal and external hazards initiated by human actions or natural events, during all modes of plant operation, evaluated in a risk-informed manner. “Cliff-edge” events–those for which a small incremental increase in severity can yield a disproportionate increase in consequences–should be discovered and mitigation approaches implemented. The objective in addressing rare events with potentially extreme consequences is to take reasonable and practical measures to deal with credible events that until now have not been fully considered, while realizing that the overall risk can never be zero.
- **It extends beyond regulations**. It is the ASME Task Force view that accountability for protection of people and property must extend beyond the regulatory requirements to plant designers, manufacturers, owners and operators.
- **It must be embraced globally**. The ASME Task Force recognizes the inherent difficulty in applying any standard across different corporate and regulatory regimes and cultures, but the reality remains—as evidenced starkly by the Fukushima Dai-ichi accident—that the viability of nuclear energy is a global proposition, and that safety principles and improvements must be applied to all plants to meet the purpose of this initiative.

Figure 1 is a simple characterization of how the New Nuclear Safety Construct builds upon the existing safety construct. While relying on the current design basis, it recognizes that additional measures could be needed to address rare yet credible events, and that the best way to accomplish this is to use an all-risk approach. The figure, which is not to scale, shows a progression of safety measures, starting with the design basis; then additional prevention measures from the post-9/11 (September 11, 2001) equipment and accident management improvements; plus the difference in inherent safety features of new reactors; then the safety improvements from the international regulatory and industry post-Fukushima efforts; and, finally, an additional level of coordinated systems to address requirements for avoiding disruption of society. One of the critical issues to be resolved for achieving an effective safety construct is the important role that regulatory authorities will play in resolution of the extended safety basis emerging after Fukushima, and the role of industry in implementing additional safety requirements that satisfy the goal of societal protection. These improvements require coordinated efforts of regulatory authorities, plant owners-operators and other industry stakeholders, with industry taking a leadership role.

Figure 1 - Relationship of the New Nuclear Safety Construct to Existing & Emerging Safety Constructs

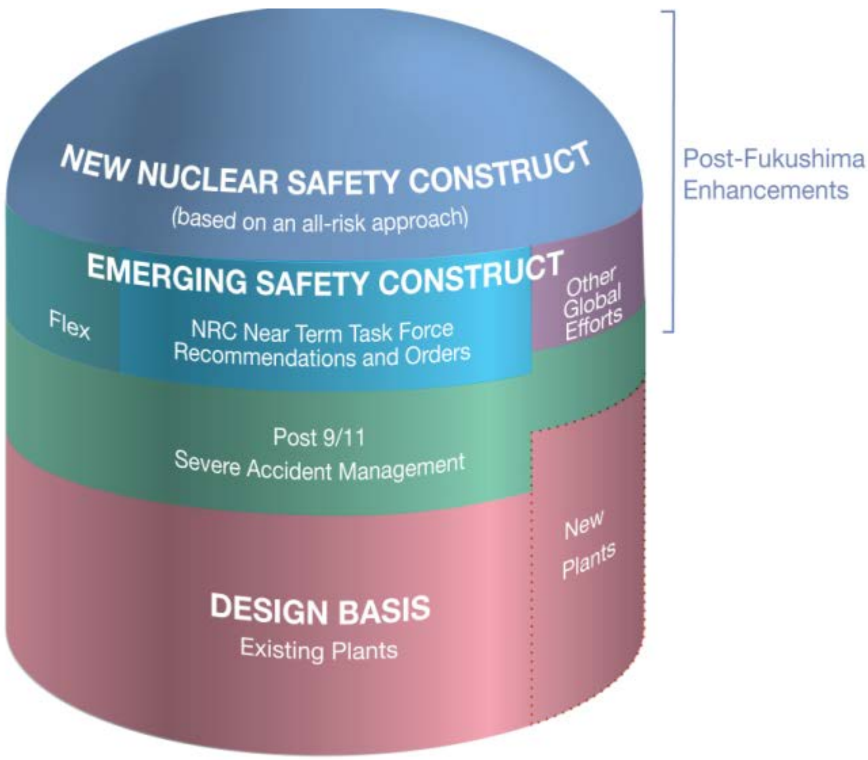

Figure 2 - Cross Cutting Linkage between the Key Components of the New Nuclear Safety Construct

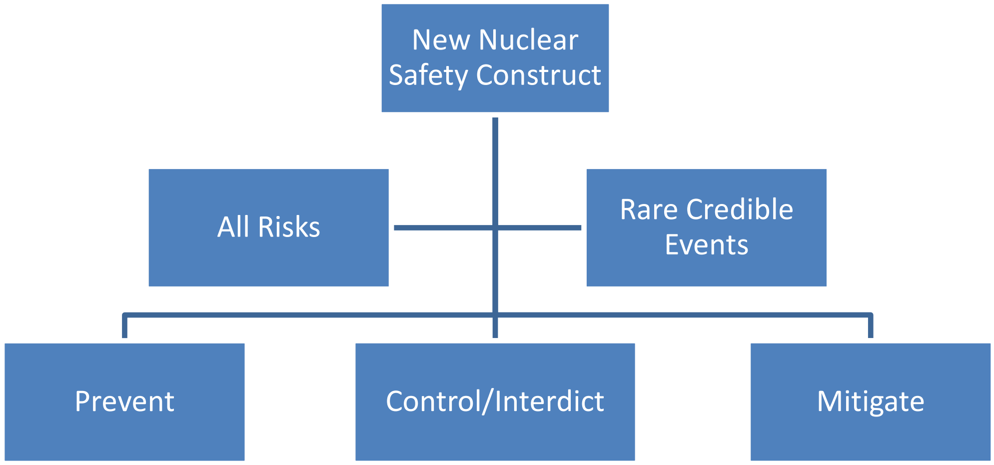

Table 1 is a visual representation of the NNSC key components (first column of the table) and the cross cutting common links (second, third, and fourth columns of the table) that shows the relationship of the elements of the NNSC in one place.

Table 1 - Cross Cutting Linkage between the Key Components of the New Nuclear Safety Construct

KEY COMPONENTS	CROSS CUTTING COMMON LINKS		
	Prevent	**Control/Interdict**	**Mitigate**
Command and Control	Habitable control room Rare event Emergency Operating Procedures (EOPs)	Coping capability Verified Severe Accident Management Guidelines (SAMGs)	Authority and responsibility criteria
Design Basis	Design Basis extension Defense-in-greater-Depth	Risk and processes Internal and external events Man-made and natural	Minimize release and venting criteria Containment integrity criteria
Decision Making	Extended safety limits	Authority /responsibility	Decision criteria
Instruments	Hardened plus black-box	Monitor and repair	Interpret and diagnose
Guidelines	Design, construction and operation	Emergency actions	Extreme and rare events
Heat sinks	Core cooling assurance	Actuate and repair cooling	Replace /supplement cooling
Training	Safety culture and drills	Handle Beyond Design Basis Accident scenarios	Core damage and release criteria
Communications	Hardened and powered	Plant and media wide	Remove barriers
Licensing Basis	PRA/Deterministic	Risk based criteria	Venting / evacuation criteria
Impacts	Industry response/actions	Regional response/actions	National response/actions
Safety Management Systems	Investment and support Remove cliff edges	Methods and staffing Know cliff edges	Multi-unit/site plans Repair/replace/recover

WORKSHOP SUMMARY

The ASME Presidential Task Force on Response to Japan Nuclear Power Plant Events hosted a workshop on December 4-5, 2012 at the Willard Intercontinental Hotel in Washington, DC. The purpose of this workshop was to engage the global nuclear community in a dialog about the recommendations contained in the ASME Presidential Task Force report entitled "Forging a New Nuclear Safety Construct." The report is available at: http://files.asme.org/asmeorg/Publications/32419.pdf

In attendance at the New Nuclear Safety Construct (NNSC) workshop were 125 of the world's most influential decision-makers and leaders with representation from 20 countries. The ASME task force designed a series of sessions to address many of the key recommendations and topics from the task force report. Sessions were aimed at getting more focused dialog on key elements of the report and its recommendations. Session objectives were stated at the beginning of each session in order to allow participants to cover complex topics in narrow windows of time with efficiency and focus.

Session reports

The following is a list of key summary points from the plenary and breakout sessions.

Plenary Panel Working Session 1 – The Development and Implementation of a New Nuclear Safety Construct

This session described the essential elements of the New Nuclear Safety Construct and sought to move toward consensus among workshop participants on these elements. The session identified some of the key steps needed for the development and implementation of the NNSC.

Summary of key points:

- There is a near term need for convergence of definitions, metrics, and terminology.
- The balance between prevention and mitigation needs to be clarified, though both must be considered. This should be based on minimizing off-site impacts.
- Sufficient analysis should be completed to understand the vulnerabilities of the plants so we know what gaps exist and thus what remains to be done. We don't want to have "knee-jerk" reactions for plant modifications.
- It was never ASME's intent to say how things are to be done, but rather to provide an umbrella process.
- Various concepts that are being implemented globally, such as FLEX, hardened core, bunkering, etc., should be considered in the implementation of the NNSC.
- There are variations in practices around the world. Achieving consistency of safety improvements will be a challenge.
- In implementing a NNSC, there is a need to define the division of responsibility between licensee initiated actions and regulatory actions.

Breakout Session 1 - Extending and Standardizing the Design Basis for Severe Events

This session discussed how the design basis of nuclear power plants should be extended to accommodate additional aspects of severe accidents, including which additional accidents or design features should be considered for operating plants and new plants. Session participants also discussed the ASME Task Force premise of utilizing an "all risk" approach to avoid undue socio-political and economic consequences of severe accidents. The progress made by the global nuclear industry with the safety improvements realized in advanced designs and with Fukushima-related initiatives was also discussed.

Summary of key points:

- The NNSC is not a regulatory issue. There are clear lines between industry and regulator. Industry can go further.
- Design basis is a legal framework as far as it is incorporated in the U.S. licensing process and is under the purview of the regulator. The NNSC proposes enhancements to the design basis (e.g. design extensions), but use of a different terminology may be beneficial.
- The NNSC rises above design details and standards to provide purpose to the changes already being made around the world.
- There is a need for a clear framework for the relationship between the current design basis, the NNSC and the path forward.
- Harmonization is a better goal than standardization.
- The plant retention of radioactivity, relying on necessary systems and actions, constitute a social contract.
- Defense-in-Depth may need a structural change to account for rare yet credible events.
- Generation III plants would measure up well against the NNSC, but currently operating Generation II plants would most likely need some back-fits. This could result in some Generation II plants needing major financial investments, which may not pass a cost benefit analysis.
- Battery power and non-electric pumping systems deserve priority attention. Steam driven systems can present operational challenges.
- Terms like standardization and interdiction have different meanings around the world. To apply the NNSC globally, terminology differences must be harmonized.

Breakout Session 2 - The Role of Risk-Informed Regulation and an All-Risk Approach

This session addressed the role of risk-informed regulation and an all-risk approach in supporting the elements of a New Nuclear Safety Construct. Risks from both natural and man-made events, including rare yet credible events, are to be considered by defining appropriate risk metrics. The role of risk management standards across all nuclear power plant operating modes was explored.

Summary of key points:

- Global risk-informed experience is limited. Senior management and leadership must understand the risk-informed approach better to fully implement it.
- How far is far enough in minimizing core damage frequency? When do we stop making investments to reduce this? There is a need for consensus on this figure of merit.
- There is a need for global discussion and consensus on how far industries should go in considering low frequency external hazards.
- There is need for a communication plan as the global industry moves forward on risk-informed approaches.
- Common terminology should be used when talking about risk.
- Do current safety goals need to be revisited on a global basis? Are they an impediment to the New Nuclear Safety Construct?
- Without risk-informed regulation, the regulator takes responsibility for the risk (does not transfer responsibility to licensees).
- ASME/ANS Joint Committee on Nuclear Risk Management Standards efforts should be integrated with the work being done by International Nuclear Safety Group (INSAG), the International Atomic Energy Agency (IAEA) and Advanced Safety Assessment Methodologies:

Level 2 Probabilistic Safety Assessment (ASAMPSA2). There is need for global harmonization (standards) on Probabilistic Risk Assessment (PRA) methods, scope and application.
- New plants (Generation III) have developed PRAs but they still are implementing severe accident measures, combining risk-informed, deterministic, and expert judgment approaches.

Breakout Session 3 – Accident Management & Human Performance

This session addressed the role of accident management and human performance as elements of a New Nuclear Safety Construct. This role is focused on creating a robust capability to deal with design basis events as well as rare beyond-design basis events. The session addressed individual and organizational human performance efforts during accidents to ensure adequate core cooling and preventing the release of large amounts of radioactivity.

Summary of key points:
- Preparation is a key point – procedures, training, knowledge, organizational roles and responsibilities. Responders must be prepared for the changing situation in an accident. Accidents can progress beyond pre-established procedures – training does not go this far. Need more sophisticated training for personnel, including in-depth training of operators for severe accidents.
- Evaluate the need for periodic, large scale drills that develop over longer periods of time.
- Should there be periodic safety assessments for external events?
- Instrumentation must survive an accident. It is important for diagnosis, prevention/interdiction, and mitigation.
- Critical safety equipment as well as plant staff must be protected during an accident.
- Maintaining communications is important.
- There is a need to prioritize NNSC activities, to ensure that they do not distract from normal safe operation.
- SAMGs and other processes/procedures must be integrated more effectively to have a seamless transition from EOPs.
- There is a need for a standard for how to address human performance during a severe accident.

Breakout Session 4 – Public Protection

This session addressed key elements for public protection from accidents, including the need for state-of-the-art technical basis for emergency planning zone size and emergency response training and exercises based on more realistic accident scenarios. The Linear-No-Threshold debate in radiation protection in terms of science vs. economic and social dimensions was also reviewed. All of these key elements need to be addressed on a globally coordinated and integrated basis. Participants also discussed the set of key steps needed for implementation of the necessary elements.

Summary of key points:
- Emergency Preparedness (EP) Training and Exercises
  - Cannot limit to a single unit; must think of multiple units at a site.
  - Emergency drills should cover all levels of decision-making.
  - Drills/training need to be more realistic (e.g., event sequences and timelines). Need integration of in-plant EP exercises with broader stakeholder exercises. Need to consider full scale simulators and training centers in a collaborative, perhaps global manner.
  - Public communication should be prompt, understandable (layman terms) and not limited to public notification and information.

- Linear No Threshold Model (LNT)
  - Research on the science of low level radiation effects should continue, even though it will be difficult to definitively resolve the LNT issue due to the complexity of the problem.
  - The global nuclear industry needs to better understand and quantify the socio-political and economic impacts of LNT in order to achieve an appropriate balance between costs and benefits, similar to ALARA (As Low As Reasonably Achievable).
  - Top industry leaders need to communicate to the public with a consistent global message and terminology, putting the risk from dose in a relative measure that people can easily understand (e.g., reduction of life expectancy, or dose equivalent to flying across country).
- Emergency Planning Zone (EPZ) Size basis
  - Does the basis of EPZ sizing need to be revisited? Assumptions and data may not be up to date. EPZ size and basis are different from one country to the next.

Breakout Session 5 – Public Trust

This session identified and discussed the factors that engender public trust and the actions that can be taken to achieve it, in particular the importance of effective communications between the technical community and the general public both for everyday occurrences and during accidents.

Summary of key points:

- Socio-political consequences of accidents are a function of the event, but are no less determined by the perception of the event by the public.
- People struggle to trust something they don't understand. Must do a better job educating the public to improve science and technology literacy. Need to establish a coordinated effort to upgrade school science education to ensure we are on a path to having an informed public.
- People must trust the people designing, building, and operating the technology and the regulator that monitors it.
- In working with journalists, recognize that they rarely understand the science and are typically skeptical.
- It is important to build lines of communication and trust prior to a crisis. Need to communicate early and frequently, not just during an emergency. Don't want the first encounter with stakeholders, particularly media/policy makers to be during a crisis.
- Need to repeat a message many times. It helps to have a team of communicators and third parties available.
- Need to have a crisis communication plan. In this time of 24/7 news coverage, the media wants continuous coverage during a crisis, even when it is not easy to discern what is actually happening. This leads to speculation.
- Companies are often reluctant to allow individual contributors to speak with the media, so the media may go to more questionable sources. As a result, industry losses control of the message.
- During a crisis, spokespeople must speak clearly using language and terminology the average person can understand. This is a challenge for engineers. Do not use industry terminology/semantics/slang that may be common within the industry, but is unknown by the general public. Recognize the need to talk with empathy and to multiple types of audiences in a crisis.
- Need to establish and disseminate the value proposition for nuclear power globally, including safe and reliable power, environmental friendliness, etc.
- Use social media as a modern and effective communications tool.

Plenary Panel Working Session 2 – The Globalization of the New Nuclear Safety Construct

This session addressed the challenge of achieving consistent application of the proposed New Nuclear Safety Construct, worldwide. Discussions covered principles, priorities, prospective approaches, and initial steps.

Summary of key points:

- Strengthen the roles of international organizations like the World Association of Nuclear Operators (WANO).
- Recognize the importance of regional requirements – one size will not fit all.
- Need agreement at highest levels on shared safety goals and seeking harmonized safety levels.
- Utilize more extensively periodic safety reviews and strengthen peer reviews.
- Global support systems (e.g., a global accident response/assistance system) are very important, but we need to be mindful of their limitations, e.g., language barriers, lack of information sharing protocols, authorization to release on-site information, etc.
- We should be mapping all the technical elements contained in the New Nuclear Safety Construct to the existing framework of standards and regulations – to show what the baseline is and then build from there.
- We should identify points of tangency with other safety improvement initiatives already underway, e.g., in Europe, the U.S. and Asia, and then develop sub-groups aimed at the major NNSC recommendations.
- How are we going to come to agreement on what are “good practices” that go beyond existing regulations?
- Form an International Steering Committee
    - Determine what role global organizations should play in the development of the NNSC.
    - Inventory nuclear safety improvement activities already underway by other organizations, regulators, operating groups, etc.
    - Seek sponsorship from organizations and groups to help defray the expenses of developing and implementing the NNSC
- Convene a planning workshop with the other organizations identified to design a worldwide implementation plan for the NNSC.
- Evaluate participation of the ASME Task Force members in post workshop activities to carry forward with the proposed work – establish roles and responsibilities for ongoing work.

At the conclusion of the workshop, the task force developed a near-term action plan with the following actions confirmed:

- Speaker presentations would be compiled and posted on the ASME website (for those with speaker consent) for participants to view. The presentations are available at: http://events.asme.org/NuclearSafetyConstructWorkshop/
- A summary report would be developed and distributed to workshop participants
- The task force would evaluate the discussions from each session and would provide a summary of the most important topics and focus in on several urgent actions (next steps) to be considered by the global nuclear community.
- Once the priorities are established, engage cognizant individuals or organizations to coordinate the development of implementation plans and schedules.

RECOMMENDATIONS FOR ADVANCING THE NEW NUCLEAR SAFETY CONSTRUCT

The governing principle supporting the global implementation of the NNSC is that it must be led by the nuclear industry, a principle supported by a consensus of interested participants in the Workshop.

It is essential that global nuclear utilities and plant owners be major motivators for the process and program going forward. They have the responsibility for the safety and reliability of their nuclear plants, and for the cost of NNSC implementation.

A small yet inclusive international steering committee is needed soon to establish the path forward, focusing on a global agreement to improve the safety of nuclear reactors, both currently operating and those to be built. Safety is now inclusive of protection of public health and safety and the environment, and protection of society and socio-political and economic impacts. The majority of respondents to the ASME workshop held in December 2012 suggested that a highly regarded international organization strongly tied to power companies or a large power company itself would be a good candidate to take lead responsibility for implementing the NNSC initiative, while stressing the importance of advisory participation from regulators and cognizant international agencies.

Potential members of the international steering committee are: WANO and selected influential utilities (e.g., Electricite de France, Korea Electric Power Company, Tokyo Electric Power Company, Exelon, etc.) and/or representatives of major utility associations (Nuclear Energy Institute, Japan Atomic Industrial Forum, Institute of Nuclear Power Operations, Owners Groups) with an advisory group representing regulatory bodies, international nuclear agencies (Nuclear Energy Agency within the Organization for Economic Co-operation and Development - OECD/NEA, IAEA), and nuclear reactor vendors.

Vendors need to participate because there will be significant design issues to be addressed as part of the actions that will likely come out of the NNSC, particularly for operating reactors.

The participation of regulators in an advisory capacity has to be considered as a priority. They should be involved so that they are fully and currently informed of the efforts of the industry, and could provide important feedback to the efforts.

Because of the potentially large number of candidate members of the international steering committee, it may be necessary to have focused sub-committees, e.g., regulators, vendors, etc., that will provide their collective input to the steering committee.

Some of the first activities that the steering committee might undertake are:

- Converge on overriding goals, objectives, and common terminology, definition and metrics. Over the longer term, it is important to strive for harmonization of processes and activities.
- Identify, categorize and understand initiatives already underway by various international groups to address enhanced nuclear power safety. Determine the feasibility of incorporating these initiatives in the NNSC. The goal is to arrive at a global consensus on a consistent approach to safety improvements, with overall benefits on reliability, cost considerations, and societal recognition.
- Define the components of NNSC, which will be subject to implementation steps. These will likely include design issues, technical issues, procedural issues, training issues, etc., and communication approaches to inform a wide range of audiences. From that list, prioritize and

identify targets for initial implementation. There is a need to make sure the most important ones are undertaken first. These activities must not distract from normal safe plant operation. The goal is to demonstrate success via ongoing tangible achievement.

- Develop a detailed plan and schedule for the first year of implementation.
- Convene a planning workshop led by the steering committee and supplemented by other key stakeholders.
- Define an implementation concept for the New Nuclear Safety Construct, including the roles of the various stakeholders, including ASME.
- Agree on the funding mechanism or approach for moving the New Nuclear Safety Construct forward.
- Develop a communications plan for the NNSC moving forward, including establishing the case for achieving improved safety with the public and governments.

CONCLUSION

While the events at Fukushima Dai-ichi were caused by an extreme and, in some respects, unprecedented natural disaster, the unacceptable outcome is wholly inconsistent with an economically-viable and socially-acceptable use of nuclear energy. This summary report outlines a set of actions to bring together global stakeholders including industry, regulators, professional societies, government agencies and industry organizations to move forward with the implementation of a New Nuclear Safety Construct.

The primary nuclear power safety goal is and will continue to be protection of public health and safety. However, the Fukushima Dai-ichi accident reveals the need for additional steps to further reduce the potential for socio-political and economic consequences resulting from radioactivity releases. The accident at the Fukushima plant has already affected energy portfolios by skewing the importance of nuclear electricity generation and its beneficial impacts on fuel diversification, climate change initiatives, and stability of electrical costs.

The ASME Presidential Task Force on Response to Japan Nuclear Power Events is convinced that the global and thoughtful solutions to the issues raised by the Fukushima Dai-ichi nuclear accident are essential to continue benefitting from use of nuclear power, to expand its use, and to address critical environmental and energy portfolio issues.

APPENDIX: WORKSHOP PARTICIPANT LIST

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