

Risk Management . . . for Tomorrow's Challenges

Ronald A. Knief, Ph.D.
XE Corporation,¹ Albuquerque, NM

INTRODUCTION

“Attendees at the opening plenary session of the Embedded Topical Meeting on Risk Management [. . . for Tomorrow's Challenges] were welcomed by immediate past ANS President Bill Burchill and ANS Executive Director Jack Tuohy. . . . Burchill said that he was reminded of the work done by . . . GPU Nuclear, where interest in risk management grew in the aftermath of the 1979 accident at the utility's Three Mile Island-2.” [1]

GPUN's interest manifested itself in a 1989 Risk Management Symposium with proceedings published as a book.[2] The venue then shifted to ANS with the first of three embedded topical meeting in June 1992 at Boston. A subsequent hiatus ended when the September 11, 2001, terrorist attacks indicated clearly that risk management was needed differently and “now more than ever,” leading to the 2003 topical in San Diego . . .and then this 2009 meeting in Washington, DC.

THE TMI-2 CONNECTION

The March 1979 accident at Three Mile Island Unit 2 (TMI-2) caused neither deaths nor injuries to plant workers or the general public, nor did it release a significant quantity of radioisotopes to the environment. However, in leading to a billion-dollar cleanup and six-and-one-half-year shutdown of the undamaged TMI-1 sister plant, it nearly bankrupted its owner General Public Utilities (GPU). The accident also had a major impact on the U.S. utility industry and on world nuclear power in general. [2]

In the near-term aftermath of the TMI-2 accident, the GPU Nuclear Corporation was established as the GPU subsidiary responsible for the cleanup of TMI-2 and the operation of TMI-1 and Oyster Creek reactors. TMI-2 accident lessons were identified [3] and numerous actions taken to avoid future replay of the unacceptable consequences. Ultimately, after the restart of TMI-1 and return of a modicum of normalcy, a Risk Management Group (RMG) was established in fall 1987 under the visionary leadership of Vice-President Robert L. Long to develop a framework for proactive identification, evaluation, and cost-effective reduction and management of risks of all types.

The RMG – for the author and his four colleagues one of the greatest professional opportunities of their lives – set out to learn as much as possible about risks and their management in nuclear and other high-hazard, high-performing industries. This began with a thorough literature search, and progressed to interviews with individuals and organizations known for their innovative ideas, experience, and/or reputations for safe and reliable operation. A capstone effort was development and practical demonstration of a local systematic risk management process.

Analysis of nuclear-utility risks identified four broad, highly inter-related categories:

- (1) health and safety,
- (2) functional capability,
- (3) public image and reputation, and
- (4) financial well-being.

[plus (5) security (as added so emphatically post-9/11 and described subsequently)]

The first of these relates to the potential for serious injury to plant personnel, the public, and/or the environment, including the explicit nuclear component – with its unique radiation exposure – as well as industrial health and safety. Regulatory bodies, such as NRC, EPA, and OSHA, promulgate requirements and guidelines

¹ Current affiliation: Sandia National Laboratories, raknief@sandia.gov

related to these risks. Compliance, however, does not assure control of the risks, e.g., as was demonstrated by the TMI-2 accident. Extensive probabilistic safety assessment (PSA) studies have focused on the technological risks and are being used increasingly for risk-informed decision making.

The plants and related equipment are important aspects of functional capability and, thus, their potential loss, impairment, or unavailability represent significant risk. Plant availability depends on operation, maintenance, design, and other elements that sustain the ability to produce electricity and, thereby, generate revenues. Equipment damage engenders direct repair or replacement costs, as well as charges for replacement power during an associated plant outage. Also important in this regard are the capabilities of personnel individually and in groups to accomplish the work necessary to support the "final product" - in this case safe and reliable generation of electricity. Legal proceedings and regulatory hearings also have the ability to tie-up key personnel and impair functional capability.

Public image and reputation are shaped by many factors including news media coverage. A primary concern is that political actions (or inactions) will follow, such as those that plagued the Seabrook and Shoreham nuclear stations, the latter of which ultimately was cancelled. Potential public-relations and political "fallout" also are secondary risks related to violation of health and safety regulations, even when there are no substantive physical consequences.

Financial risks are inherent in all business activities, and especially with increasing focus on profitability and competitiveness in an environment that requires addressing risks in the other three categories. Legal-liability risks encompass direct compensation for accidents or other harm. However, they can also include costs associated with litigation related to radiation exposures (even when within regulatory limits) and to license and other proceedings instigated by anti-nuclear elements. Although court awards may be large (and related to perception of risks), the costs of the litigation tend to be very high independent of whether the company "wins" or "loses" a particular action.

Information obtained from the literature searches was expanded significantly through interviews with individuals and organizations actively pursuing risk management, safety, and related efforts. The principal focus was the nuclear power industry. Interviews and visits were conducted to address perspectives of other nuclear utilities, regulators, reactor vendors, R&D and consultant organizations, "overviewers" (such as the Institute of Nuclear Power Operations [INPO] and Nuclear Utility Management and Resources Council [NUMARC] – a forerunner of the Nuclear Energy Institute [NEI]), insurers, and acknowledged experts. Sources from the U.S., Canada, and Western Europe were included.

Two other industries - airline/aerospace and chemical - were the secondary focus. Collectively, they share with the nuclear industry recognized hazards with the potential for catastrophic accidents, established safety records, key operator and human-factor interactions, and application of state-of-the-art technology.

Thus, these three industries, other organizations, and a variety of perspectives within each formed the basis of the study. Additionally, it was recognized that there were certain common-denominator "attributes" which impacted risk-management or safety. Four major categories were identified:

1. MANAGEMENT - risk management system, organization culture, documentation and procedures, communications, experience and feedback
2. PEOPLE - employee wellbeing, training and qualification, human factors
3. ACTIVITIES - operations, maintenance, technical support
4. EQUIPMENT - hardware, configuration, and control; quantitative risk assessment (QRA).

The attributes were incorporated into a generic list of risk-management questions provided in advance of each interview. Specialized questions were developed as appropriate (e.g., prior to a comprehensive overseas visit with Electricite de France). Overall, interviews with over 70 companies and 400 individual experts have been conducted.

Concurrent with the studies and interviews, the Risk Management Group conducted a variety of activities intended to heighten the company's overall awareness of risk and related management issues. A seminar series followed by roundtable discussions was developed to showcase the current thinking on risk-related topics by acknowledged leaders. RMG discussed its mission and activities at the staff meetings of each of GPU Nuclear's Divisions. Debriefings on the highlights of the extended series of interviews in Sweden, France, and the United Kingdom were conducted for senior management. Position papers were prepared on important topics relating to risks.

RISK MANAGEMENT EXERCISE

One of the most important goals of the risk management study was to identify a comprehensive approach to managing risk locally. A multi-step generic process was selected for systematic evaluation of a very broad range of risks in a format that supports sound management decisions. This process, based primarily on work by Vernon Grose described in his book *Managing Risk – Systematic Loss Prevention for Executives* [4] and consistent with recommendations from insurance specialist George Head [5] and from interview participants.

The process consisted of the following steps:

- (1) Identify hazards
- (2) Screen hazards and identify preventive actions and their costs
- (3) Evaluate hazards for severity, probable frequency, and cost of preventive actions
- (4) Prioritize preventive actions (preference to high risk and low cost)
- (5) Implement preventive actions
- (6) Monitor and provide feedback

INAUGURAL RISK MANAGEMENT SYMPOSIUM

Reporting the results of the year-long study presented a conundrum. A lengthy report did not seem to be a meaningful alternative.

A format of choice ultimately was to conduct a two-day Risk Management Symposium [2] in September 1989 at Parsippany, NJ where the GPUN headquarters was located. This was a very effective way to bring together members of GPUN management with many of the key interview participants from the three industries, different perspectives, and a wide geographical distribution. The audience of about 70 was roughly equally divided between the two constituencies. Progressive methods and the state-of-the-practice in safety and management of risks were described with lively exchange of ideas among all involved. The plenary-session program and session topics are shown in the table below. Full papers proceedings were published.[2]

I – RISK MANAGEMENT: EXPANDING HORIZONS IN NUCLEAR POWER AND OTHER INDUSTRIES – 1989 – GPUN – PARSIPPANY, NJ [2]

PLENARY SESSION

Risk Management at GPU Nuclear – *Robert L. Long (GPU Nuclear Corp)*

Risk Assessment and Risk Management – Basic Concepts and Terminology – *Stan Kaplan (Pickard, Lowe & Garrick, Inc.)*

Guidelines for Communicating About the Risks of Nuclear Energy Effectively, Responsibly, and Ethically – *Vincent T. Covello (Columbia University)*

Decision and Risk Analysis at Westinghouse – *Robert K Perdue (Westinghouse Electric Corporation, PA)*

Lessons Learned from Man-Made Catastrophes – *Edwin L. Zebroski (Aptek Engineering Services)*

Twenty Year Retrospective on Risk Management – *Chauncey Starr (President Emeritus, Electric Power Research Institute)*

ORGANIZATIONAL SAFETY CULTURE

MANAGEMENT SYSTEMS AND FEEDBACK

ROLE OF HUMAN PERFORMANCE

APPLICATIONS OF QUANTITATIVE RISK ASSESSMENT

SYSTEMATIC RISK MANAGEMENT

ANS EMBEDDED TOPICAL MEETINGS

The success of the Symposium immediately suggested that the process be extended both in scope and participation. The American Nuclear Society (ANS) seemed particularly well suited to provide the proper forum. The then-somewhat-recent concept of special-topical embedded in national meetings turned out to be the proverbial “perfect match.” Those interested primarily in the risk management could attend the embedded topical while “rubbing elbows” with those from the main meeting. Those in attendance at the main meeting could participate selectively in topical-meeting sessions. Since all summaries were included a single *Transactions* everyone had a record of what transpired. Key members of the organizing committee and a number of the speakers had been participants in the symposium, especially Bob Long – who also was president of ANS – and B. John Garrick as the general chairs, and Ron Knief as chair of the technical program committee.

This embedded topical meeting addressed a very broad perspective on the wide range of risks that face the nuclear and other industries. Special attention was devoted to innovative approaches for addressing risk reduction and management.

It was noted “the term *RISK MANAGEMENT* conjures up very narrow visions to many.” To some it is the actuarial approach used by the insurance industry, to others the nuclear industry focus on probabilistic risk assessment, core-melt frequency, and postulated health effects. While addressing applications in each of these areas, the “expanding horizons” of the topical meeting substantially transcended them. The objectives of the topical meeting were to:

1. Provide a forum for management, safety-specialist, and risk-management personnel to discuss issues and share ideas regarding risk management in potentially hazardous industries
2. Address identification, evaluation, and reduction of risks of all types from multi-disciplinary, multi-industry, and geographically diverse perspectives.

Held in conjunction with the American Nuclear Society's 1992 Annual Meeting in Boston, the Topical Meeting was sponsored by the ANS Power Division. ANS Division co-sponsors were Environmental Sciences, Education and Training, Fuel Cycle and Waste Management, Human Factors, Nuclear Criticality Safety, Nuclear Reactor Safety, and Reactor Operations. Outside co-sponsors and cooperating organizations were the American Institute of Chemical Engineers (AIChE), American Nuclear Insurers (ANI), American Society of Mechanical Engineers (ASME), Electric Power Research Institute (EPRI), Flight Safety Foundation, Harvard School of Public Health/Office of Continuing Education, International Atomic Energy Agency (IAEA), Risk & Insurance Management Society (RIMS), and the Society for Risk Analysis (SRA).

The meeting began with an opening plenary session which served as a tutorial on risk management and set the context for the meeting.[6] As shown in the table below, the session drew upon two nuclear industry executives, an NRC Commissioner, the professor credited with directing the seminal nuclear-reactor PRA, an aviation safety expert, a risk-communication specialist, an insurance-/financial-industry publisher, and the founding president of Electric Power Research Institute.

Collectively, the sixty papers in the nine concurrent sessions drew speakers from the nuclear, chemical, airline/aerospace, and insurance industries with perspectives of management, technical support, safety specialist, regulator, consultant, and research personnel. A distinctly international flavor was provided by the speakers and session moderators from Canada, France, Germany, Norway, Switzerland, Sweden, and the United Kingdom.

The closing plenary session provided a broad perspective on risk management and summarized the topical meeting. Speakers (see table below) included an astronaut, a former member of the national transportation safety board (NTSB), a chemical-industry safety specialist, a nuclear utility executive, and two professors.

The embedded topical meeting format was designed to provide a maximum potential for attendees to participate with question and answer periods following each session. The meeting was an excellent opportunity for all parties concerned to address the continually “expanding horizons” of risk management. Proceedings were published in book form.[9]

II – RISK MANAGEMENT: EXPANDING HORIZONS – 1992 – ANS – BOSTON, MA [7]

OPENING PLENARY AND TUTORIAL ON RISK MANAGEMENT

Risk Management-Expanding Horizons: An Introduction – *Ronald A. Knief (Ogden Environmental and Energy Services), Robert L. Long (GPU Nuclear Corporation)*

Facing Reality Minimizes Risk – *James L Gallagher (Westinghouse Electric Corporation)*

Regulatory Risk Coherence – *Forrest J. Remick (U.S. Nuclear Regulatory Commission)*

Two Decades of PRA: What Next? – *Norman C. Rasmussen (Massachusetts Institute of Technology)*

The Role of Feedback in the Airline Industry – *John H. Enders (Flight Safety Foundation)*

Communication in Reducing Facility Siting Risk – *Ann S. Bisconti (U.S. Council for Energy Awareness)*

Rethinking Risk Management – *H. Felix Kloman (Tillinghast)*

Unintended Consequences of Single-Issue Risk Assessment: A Proposal for Regulatory Restructure – *Chauncey Starr (Electric Power Research Institute)*

BROAD-CONTEXT RISK MANAGEMENT APPROACHES

RISK-BASED AND MATRIX APPROACHES TO MANAGEMENT

RISK MANAGEMENT APPLICATIONS

ORGANIZATION CULTURE

RISK MANAGEMENT ACTIONS TO ENHANCE HUMAN RELIABILITY

FACTORS AFFECTING RELIABILITY OF HUMAN ACTIONS

INCIDENT INVESTIGATION AND FEEDBACK

RISK COMMUNICATION

APPLICATIONS OF QUANTITATIVE RISK ASSESSMENT TO NUCLEAR REACTOR SAFETY

QUANTITATIVE APPROACHES TO MANAGING DIVERSE RISKS

RISK MANAGEMENT GENERAL CHAIRS' CLOSING PLENARY

Risk Management General Chairs' Closing Plenary – *B. John Garrick (PLG, Inc.) & Annick Carnino (IAEA)*

Reliability Implications on Manned Spaceflight via Illustration of Shuttle Mission STS-43 – *Jim Adamson (National Aeronautics and Space Administration)*

To Best Manage Transportation Risk-Regulate or Deregulate? – *Vernon Leslie Grose (Omega Systems Group)*

Risk Management Practices at Unocal – *Donald L. Hanley, Narayanan Sankaran (Unocal)*

How to Communicate Risk to Skeptics: An Environmental Perspective – *Lester B. Lave (Carnegie-Mellon University)*

Evaluation of Risk Management Practices at Yankee Atomic Electric Company – *S. P. Schultz (Yankee Atomic Electric Company)*

Risk-Based Radiation Protection Standards – *Dade W. Moeller, (Harvard School of Public Health)*

RISK MANAGEMENT POST 9/11

The “Expanding Horizons” of the very successful first embedded topical meeting went beyond both insurance and conduct of quantitative risk assessment – areas to which the term risk management had been frequently applied. Although the organizers of the Boston meeting had intended to continue with further meetings, it took the September 11, 2001, terrorist attacks to end the hiatus and revitalize the effort with clear indication that risk

management was needed needed “now more than ever” and would include significant leading new focus. Thus, was born the 2003 embedded topical meeting in San Diego.

The call for papers asked for “the broadest possible perspective on (1) the wide range of risks that face the nuclear industry, other high-hazard industries in the nation and world as a whole as we now understand in the aftermath of events 9/11/2001 and (2) the innovative risk management approaches now used to balance all aspects of asset protection, safety, and cost.” It was intended that full papers be published as had been the case in Boston, but an insufficient number were received. (Several selected papers are included in these proceedings in the section entitled Chair’s Choice.)

Meeting organizers moved up from the Boston meeting – Ron Knief and Bill Hannaman to general chair and technical program chair, respectively. Honorary chairs were Bob Long and John Garrick (who, as shown in the table below, also served as plenary speakers).

The plenary session’s first three speakers addressed risk, safety, and safety culture. Then the subjects shifted to dealing with terrorism from four very different perspectives – through focus on the diverse topics of military combat, lessons from catastrophes, QRA and psycho-social effects.

III – RISK MANAGEMENT...NOW MORE THAN EVER – 2003 – ANS – SAN DIEGO, CA [8]

OPENING PLENARY

Risk: Manage It or It Will Manage You – *Theodore Marston (EPRI)*

Managing Risk Through Developing a Strong Safety Culture – *Richard Taylor (BNFL)*

Behavior-Based Safety: Reducing Risk Where It Counts – *Dennis Ruddy (BWXT Y-12)*

MAG-11 Operational Risk Management in Operation Iraqi Freedom – *Col R. D. "Tex" Alles (U.S. Marine Corps)*

Risk Management Lessons from Man-Made Catastrophes: Implications for Aerospace and Anti-Terrorism – *Ed Zebroski (Consultant)*

The Role of Quantitative Risk Assessment in Combating Terrorism – *B. John Garrick (Consultant)*

Psycho-Social Risk for a Nuclear Terrorist Event – *Robert Long (Nuclear Stewardship, LLC)*

FACILITY RISK MANAGEMENT APPLICATIONS

ORGANIZATION CULTURE ISSUES IN RISK MANAGEMENT

SPECIAL SESSION ON SOFTWARE SUPPORT FOR RISK MANAGEMENT

QUANTITATIVE METHODS FOR MANAGING RISK

SPECIAL SESSION: SCIENCE OF COUNTERTERRORISM – PANEL – Mark Prelas (Univ of Missouri, Columbia)

National Overview, *Michael May (Stanford Univ)*

Counterterrorism, *Tushar Ghosh (Univ of Missouri, Columbia)*

Chemical Terrorism, *Tushar Ghosh (Univ of Missouri, Columbia)*

Biological Terrorism, *Mark Prelas (Univ of Missouri, Columbia)*

Aerosol Dispersion, *Sudarshan Loyalka (Univ of Missouri, Columbia)*

Government Response National Guard Bureau, *Paul Spackman (National Guard)*

Local Response, *Stan Salva (Mayor, Sugar Creek, MO), Herb Soule (Chief of Police, Sugar Creek, MO)*

Nuclear Materials, *William Sutcliffe (LLNL)*

SPECIAL SESSION ON COMPUTER TOOLS FOR MANAGING RISK

STANDARDS THAT SUPPORT RISK MANAGEMENT

The highlight of the meeting – in the truest sense a “poster child” for why risk management is needed “now more than ever” – was the Science of Counterterrorism Panel organized by Mark Prelas. It’s papers (see table) examined how technology has proliferated and how the science and technology have changed to adapt to the technology proliferation. The panel of experts then discussed the implications of technology in general – with emphasis on nuclear, biological, and chemical – and their associated threats. Then some very practical aspects were addressed. National planning – a major endeavor given the proliferation of technology and need acquire counterterrorism technologies – is a purview of the National Guard Bureau. Both the mayor and chief-of-police from a representative small community discussed – from ultimate first-responder perspective – the dramatic changes implemented to address response to terrorism that could include weapons of mass destruction.

. . . FOR TOMMOROW’S CHALLENGES

This meeting was developed – again – to address the broadest possible perspective on: (1) the wide range of risks that face the nuclear industry, other high-hazard industries, and, as we now understand in the aftermath of events 9/11/2001, approaches that we have needed “now more than ever” to protect the nation and world as a whole; and, most importantly, (2) innovative approaches to coming to grips with their management.

Specific objectives for the meeting as stated were to:

- (1) Provide a forum for management, safety-specialist, and risk-management personnel to come together and discuss issues and share ideas regarding risk management for traditionally hazardous activities . . . for a world with increasing potential for creating different hazards.
- (2) Address identification, evaluation, and reduction of risks of all types (e.g., health and safety, functional capability, public image, financial, and, uniquely now, security) from multi-industry, multi-industry, and geographically diverse perspectives.

In addition to topics appropriate to the sessions identified for the three previous meetings, creativity was encouraged. Security and anti-terrorism topics were expanded substantially and nanotechnology – a current “hot topic” too new for risks to be determined yet – was introduced to our mix. These full-paper proceedings follow in the footsteps of two of the previous meetings.[2,7]

This topical meeting again had a familiar look with Ron Knief serving as General Chair, this time with Mark Prelas moving up to be Technical Program Chair. Other members of the Organizing Committee are identified at the front of these proceedings.

Honorary Chairs again were Bob Long and John Garrick. Sadly Bob – the initiator of these risk meetings and always our advisor *par excellence* – passed away during the summer of 2009. John remains actively involved in risk management including sponsoring this topical meeting and authoring the thought-provoking book *Quantifying and Controlling Catastrophic Risks* [10].



Robert L. Long
[1936-2009]

The meeting was sponsored by the ANS Nuclear Installations Safety Division (NISD). Co-sponsors were the B. John Garrick Foundation (including funding for these proceedings), Sandia National Laboratories – Nuclear Energy Safety Technology, Electric Power Research Institute (EPRI), Institute for Nuclear Materials Management (INMM), University of Missouri – Nuclear Science & Engineering Institute, and Air Force Institute of Technology (AFIT).

The opening plenary session (see table below and papers in the first section of these proceedings), explored the “applicability of risk management and risk assessment techniques in nuclear fields – and in other areas such as nanotechnology, security, and civil aviation.” [1]

The special session, Risk Management Related to Proliferation Resistance and Physical Protection, was organized by topical meeting veteran Bob Bari. It presented views on how proliferation resistance and physical protection (PR&PP) are evaluated and assessed for nuclear energy systems and how they are (or can be) improve by risk management. The session included presentations on both national and multi-national programs. Intrinsic and extrinsic characterizations of PR&PP were highlighted in the subsequent panel discussions.

The fascinating double special session, Nuclear Terrorism Risk Management, was organized by topical meeting newcomer John Mercier. The broad range of topics is shown in the table below and by the papers in the respective sections of these proceedings.

IV – RISK MANAGEMENT...FOR TOMORROW'S CHALLENGES – 2009 – ANS – WASHINGTON, DC[10]

RISK MANAGEMENT OPENING PLENARY

Risk Management: The Good, Bad, and Ugly – *Anthony R. Pietrangelo (Nuclear Energy Institute)*

Nanotechnology: Risk Management Challenges and Opportunities – *Mark Hoover (NIOSH)*

The Resilience to Crises Initiative (R2CI): The Role of Multinational, Multidisciplinary Networks – *Anne C. Bader (Principal, Bader Resources)*

Risk Management and Security: Is It Time for a Recalibration? *Dale Klein (Commissioner, U.S. Nuclear Regulatory Commission)*

Cyber Security: Proactive Security and Ensuring the Mission – *Rob Hale (Computer Security Architect, Lockheed Martin)*

Risk Management Techniques Employed in Civilian Aviation – *William R. Voss (President and CEO, Flight Safety Foundation)*

Now That I Have a Risk Assessment, What Do I Do with It? – *David H. Johnson (ABS Consulting)*

ORGANIZATION CULTURE ISSUES OF RISK MANAGEMENT

QUANTITATIVE METHODS FOR MANAGING RISK

SPECIAL PANEL SESSION: RISK MANAGEMENT RELATED TO PROLIFERATION RESISTANCE AND PHYSICAL PROTECTION* – *Bob Bari (BNL)*

RISK MANAGEMENT FOR FIRE RELATED ISSUES

SOFTWARE SUPPORT AND COMPUTER TOOLS FOR RISK MANAGEMENT

SPECIAL SESSION: NUCLEAR TERRORISM RISK MANAGEMENT I & II** – *John Mercier (Noblis)*

RISK MANAGEMENT FOR SAFEGUARDS AND HOMELAND DEFENSE

FACILITY RISK MANAGEMENT APPLICATIONS I & II

* See speaker list in these proceedings

** See agenda and papers in these proceedings

REFERENCES

1. D. Kovan, "Risk Management – Now More Than Ever," *Nuclear News*, January 2010.
2. R. A. Knief (ed.), *Risk Management – Expanding Horizons in the Nuclear and Other Industries*, Hemisphere Publishing, Washington, 1991.
3. R. L. Long and R. A. Knief, "Report of the TMI-2 Lessons Learned Workshop," GPU Nuclear Corporation, GPU-TMI-043, December 1983. (See also R.L. Long, "Summary Report of the GPU Nuclear TMI-2 Lessons Learned Workshop Held at the Sheraton Valley Forge on August 24-25, 1983, *Proc. ANS Executive Conference TMI-2: A Learning Experience*, Hershey, Pennsylvania, October 13-16, 1985.
4. V. L. Grose, *Managing Risk: Systematic Loss Prevention for Executives*, Prentice-Hall, Englewood Cliffs, NJ, 1987.
5. G. L. Head and S. Horn II, *Essentials of the Risk Management Process*, Volumes I and II, ARM-54, Insurance Institute of America, Malvern, PA, 1985.
6. G. M. Taylor, "Risk Management: Seeking a Wider Perspective," *Nuclear News*, vol. 35, no. 10, August 1992, pp. 97-99.
7. *Proceedings Topical Meeting on Risk Management – Expanding Horizons*, American Nuclear Society, La Grange Park, IL, 1993.

8. Embedded Topical Meeting: Risk Management – Now More than Ever, *Trans Am Nucl Soc*, Volume 88 [San Diego], June 2003, pp. 857-937.
9. Embedded Topical Meeting: Risk Management – For Tomorrow’s Challenges, *Trans Am Nucl Soc*, Volume 101 [Washington, DC], November 2009, pp. 949-1067.
10. B.G. Garrick, *Quantifying and Controlling Catastrophic Risks*, Academic Press, 2009.