

Nuclear Energy Technology Knowledge Transfer Workshop Tuesday-Thursday, May 14-16, 2019

Objective: Transfer selected fundamental nuclear energy technology history and experience – including important lessons learned – to the next generation of leaders from industry, government and academia.

Location: **Salt Palace Convention Center, Salt Lake City, Utah**

Overview: The Workshop will examine the following primary topics:

Historical development of nuclear energy technologies with a concise description of each of the research and prototype reactors that were built, the advantages and disadvantages of each and the technical reasons leading to abandonment of most of these technologies in favor of commercial offerings of PWR/BWR technologies for most reactors built globally. This review of technology development will be set against the backdrop of the historical government and business struggles that shaped today's nuclear energy enterprise.

Evolution of the safety case, plant design and operations of nuclear energy facilities. The operating experience from several accidents and operating events will be described including important lessons learned that have strongly influenced the safety case, design and operations of power reactors.

Original bases for selected safety concepts, design features and configurations – including the “hows” and “whys” of important decisions. Key messages will be characterized from the perspective of the developer, the designer, the regulator, the license holder and the licensed operator. Selected examples of these decisions will be examined in light of contemporary perspectives – with the objective of relating the lessons learned from operating experience to ongoing operations of licensed power reactors, and future innovation in and development of new nuclear energy systems.

Achieving a sustainable future for nuclear energy. Major challenges will be discussed including credibly valuing the attributes of nuclear energy (e.g., economics, environmental effect, public health, grid resilience) as part of a diverse energy production portfolio – at the intersection of public policy and the energy market. This discussion will also examine the priorities for supporting the current nuclear power fleet and the potential for advanced nuclear energy systems; the roles of government and the private sector in shaping nuclear energy's future; and approaches to achieving sustainable leadership for nuclear energy in government and the private sector.

The presentation team for the Workshop includes senior personnel with extensive careers in the nuclear energy industry – beginning in the 1950s through to the present time. The team's experience is drawn from roles in the Naval Nuclear Propulsion Program; commercial power reactor development, design, operations and regulation; national laboratories; and academia. The team led previous Workshops in November 2015 and November 2016 which were well received.

Participants are being invited from the commercial nuclear industry, academia, the national laboratory complex, DOE, NRC, professional societies and trade organizations.

- The Workshop is sponsored by the Idaho National Laboratory. Costs to participants are solely travel-related.
- A tutorial will be distributed prior to the Workshop to ensure participants have a fundamental knowledge of nuclear science and energy technologies. The tutorial will highlight topics important to fully understanding the key messages in the Workshop.

WORKING AGENDA – SPRING 2019 KNOWLEDGE TRANSFER WORKSHOP
Salt Palace Convention Center, Salt Lake City

May 14, 2019

- 8:00 a.m. **Welcome** (Phillip Finck)
- 8:05 a.m. **Introduction/Overview** (Phil Hildebrandt)
- 8:35 a.m. **Fundamentals – Q&A on tutorial distributed prior to Workshop** (George Borlodan)
- **Nuclear Energy**
 - **LWR Plant Systems**
 - **Safety System Configurations**
 - **Nuclear Regulation and Industry Organizations**
- 10:00 a.m. **Break**
- 10:15 a.m. **Management and Management Processes** (Phil Hildebrandt)
- 11:00 a.m. **Nuclear Energy Development 1940s-1960s**
- **Policies** (Roger Mattson)
- 12:00 p.m. **Working Lunch – Sustaining the Current Nuclear Power Fleet** (TBD)
- 12:30 p.m. **Nuclear Energy Development 1940s-1960s (continued)**
- **Technologies** (Finis Southworth)
 - **Naval Nuclear Propulsion Program** (Phil Hildebrandt)
- 2:00 p.m. **Break**
- 2:15 p.m. **Nuclear Energy Development 1940s-1960s (continued)**
- **Commercializing Nuclear Energy – perspectives on the industry leaders and decisions shaping the commercial offerings** (Phil Hildebrandt)
- 3:00 p.m. **Safety Case Evolution, Accidents and Operating Events**
- **In the Beginning...** (Finis Southworth)
 - **Three Mile Island Unit 2 accident** (Roger Mattson)
 - **Davis-Besse Loss of Reactor Cooling event** (Phil Hildebrandt)
 - **Chernobyl accident** (Roger Mattson)
 - **Fukushima Dai-ichi accident** (Roger Mattson)
 - **Generic Lessons Learned from Accidents and Events** (Roger Mattson)
- 5:00-6:00 p.m. **Optional Video – Nuclear Meltdown Disaster (Inside the Fukushima Crisis and Its Aftermath)**

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May 15, 2019

- 8:00 a.m. **Safety Case Evolution, Accidents and Operating Events (continued)**
- **Contemporary Safety Case** (Finis Southworth)
 - **Risk Analysis Methods and Applications** (Bob Youngblood)
- 9:15 a.m. **Selected Commercial Experience Affecting the Safety Case**
- **Loss of Power** (Roger Mattson)
 - **Incomplete Understanding of the Safety Basis** (Greg Gibbs)
- 10:00 a.m. **Break**
- 10:15 a.m. **Design Decisions in Context**
- **Operating Temperatures and Effects on Material Choices** (Phil Hildebrandt)
 - **Reactivity Control for Commercial Reactors** (Phil Hildebrandt)
 - **Common Cause/Mode Failure** (Phil Hildebrandt)
 - **Fuel Cladding for Commercial Reactors** (Finis Southworth)
- 12:00 p.m. **Working Lunch – “The Future of Nuclear Energy in a Carbon-Constrained World,” – an interdisciplinary MIT study** (Dave Petti – INL)
- 1:00 p.m. **Design Decisions in Context (continued)**
- **Design Shortfalls – from Operating Experience** (Greg Gibbs)
 - **Essential Service Water Design** (Greg Gibbs)
 - **Surveillance Testing** (Greg Gibbs)
- 1:45 p.m. **Verification Testing for Design and Analysis**
- **Pressure Suppression Pool Damage** (Roger Mattson)
 - **Loss of Flow Test Facility/Semiscale** (Finis Southworth)
- 2:15 p.m. **Break**
- 2:30 p.m. **Operations Perspective** (George Borlodan)
- **Licensed Operation**
 - **System Interactions**
 - **Human-Machine Interface**
 - **New Control Room Design**
- 3:45 p.m. **Economics of Nuclear Energy**
- **Historical and contemporary perspectives** (Greg Gibbs)
 - **Historical development, commercialization and initial deployment costs** (Bob Varrin)
 - **Perspectives on historical costs for constructing nuclear power facilities – domestically and globally** (Bob Varrin)
- 5:00 p.m. **Open Discussion/Adjourn**

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May 16, 2019

- 8:00 a.m. **Achieving a Sustainable Future for Nuclear Energy**
- **Major challenges**
 - **Defining a credible future value proposition as part of a fuel-diverse energy production portfolio** (Phil Hildebrandt)
 - **Public policy and the energy market structure** (Phil Hildebrandt)
 - **Achieving sustainable leadership in the private sector and government to shape the future of nuclear energy** (Phil Hildebrandt)
 - **Establishing roles of private industry and government** (Greg Gibbs)
 - **Approaches to reducing the construction costs for building nuclear power facilities** (Bob Varrin)
- 10:00 a.m. **Break**
- 10:15 a.m. **Achieving a Sustainable Future for Nuclear Energy (continued)**
- **Future Nuclear Energy Systems**
 - **Potential role of evolutionary and advanced nuclear energy systems** (Finis Southworth)
 - **Safety Case approach and regulatory regime for advanced nuclear energy systems** (Phil Hildebrandt)
 - **Technologies, infrastructure and costs for implementing expanded/new fuel cycles to support deployment of evolutionary and advanced nuclear energy technologies** (Bob Varrin)
- 12:00 p.m. **Working Lunch – “21st Century Nuclear Energy Initiative – Strategy for the Development and Deployment of Evolutionary and Advanced Nuclear Energy Systems,” [TBD]**
- 12:30 p.m. **Design Decisions – Panel Discussion**
- **Achieving credible design decisions – Audience participation** (led by Phil Hildebrandt)
- 2:45 p.m. **Break**
- 3:00 p.m. **Wrap-up and Open Discussion** (Phil Hildebrandt)
- 5:00 p.m. **Adjourn**



Philip C. Hildebrandt
Special Assistant
to the Laboratory Director,
Idaho National Laboratory
*Major Projects, Industry
and Regulatory Strategy*

Mr. Hildebrandt has over 50 years experience in the nuclear and power generating industries. His experience has been gained through a wide range of engineering and management assignments in the Naval Nuclear Propulsion Program and in commercial nuclear power plants. This experience has included senior management roles and consultation to commercial power generating companies and utilities, and government and government contractors in the recovery/restart, performance improvement, project management and engineering management of reactor facilities and other nuclear/chemical facilities. Mr. Hildebrandt has worked closely with senior and executive management within power generating companies and utilities, as well as the Nuclear Regulatory Commission, the Department of Energy, the Department of Defense, and the Department of Commerce.

As a consultant to the Laboratory Director of the Idaho National Laboratory, Mr. Hildebrandt provides assistance in the development of major projects, industry liaison and regulatory strategy. He is participating in development of a multi-decade strategy for the future of nuclear energy that includes recommendations for rebuilding the U.S. nuclear industrial infrastructure and positioning U.S. industry to continue to be a leader in the global nuclear energy marketplace.

A graduate of Auburn University with a Bachelor of Electrical Engineering, he is a graduate of the Bettis Reactor Engineering School in the Naval Nuclear Propulsion Program and has completed graduate studies in electrical engineering at George Washington University. He is a registered Professional Engineer in Virginia and Ohio.



Greg Gibbs
GEMC, Inc.
Greg Gibbs, President

Areas of Specialization

- Engineering Management Naval, Commercial and INL
- Project Management Nuclear Plant RDD&D
- Management assessments for troubled organizations
- Performance improvement program development/implementation
- Nuclear ship overhaul/repair/testing – commercial nuclear plant test program planning, direction and execution
- NRC inspection programs

Previous Positions

- Principal Consultant – Utility and DOE Executive Management
- Project Director Next Generation Nuclear Plant
- Director WesDyne, LLC Board of Directors
- Chief Engineer and Site Engineering Manager
- Engineering Director Commercial Nuclear Plants
- Quality Assurance Director Commercial Nuclear Plant
- Assistant Nuclear Engineering Manager Naval Shipyard
- Nuclear Test Engineering Division Head Naval Shipyards
- Emergency Director Commercial Nuclear Plants
- Reactor Engineer USNRC

Education and Experience

- Bachelor of Science in Mechanical Engineering
- Numerous Nuclear Operations/Corrosion/Chemistry courses
- SRO Cert final exam BWR 4



George F. Borlodan

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Having joined the US Naval Nuclear program in 1970, Mr. Borlodan now has over 45 years of experience in the nuclear industry. Most of this time has been spent in leadership positions in multiple disciplines but with a focus on Operations and Training.

Within his early eight year naval career, he qualified on two different nuclear systems, participated in multiple submarine patrols, and developed his career in training by serving at the US Navy Nuclear Prototype School.

His commercial nuclear career began with Westinghouse Electric Corporation where he provided instruction on the Westinghouse Pressurized Water Reactor (PWR) to engineers and operators. The Three Mile Island (TMI) event resulted in him acquiring an NRC Senior Reactor Operator (SRO) License at the Beaver Valley Power Station. During this time, he advanced his education by attending evening classes and, utilizing his naval and SRO training, gained a degree in engineering technology.

Nuclear leadership experience advanced when he became the VP and General Manager of Energy Training Corporation, a nuclear engineering and training company. During this period he led the growth of this small business to over 100 staff; and he additionally advanced technically with SRO certifications at Diablo Canyon and Indian Point nuclear plants.

Key positions held in recent years include member of DC Cook's design basis recovery System Readiness Review Board, Plant Engineering Manager at DC Cook nuclear plant, and Director of Fleet Projects for Next Era Energy.

His current position for the last 5 years as Pre-Operations Director for EDF Energy Nuclear New Build (NNB) in the United Kingdom has proved to be an opportunity to assert his years of experience in the formation of a nuclear new construction operations' organization. This position has also included his membership to the Board of Directors of NNB, a \$27B plus Project.



Neil E. Todreas, Sc.D.,
Professor Emeritus
Massachusetts Institute of
Technology, Cambridge, MA

Dr. Neil Todreas is the Korea Electric Power Corp. Professor of Nuclear Engineering (Emeritus) and a Professor of Mechanical Engineering (Emeritus) at the Massachusetts Institute of Technology. He has served at MIT for 44 years, including an eight-year period from 1981 – 1989 as the Nuclear Engineering Department Head. Since 1975 he has been a co-director of the MIT Nuclear Power Reactor Safety summer course which presents current issues of reactor safety significance to an international group of over 30 nuclear engineers each summer in a one-week course. His area of technical expertise is thermal and hydraulic aspects of nuclear reactor engineering and safety analysis.

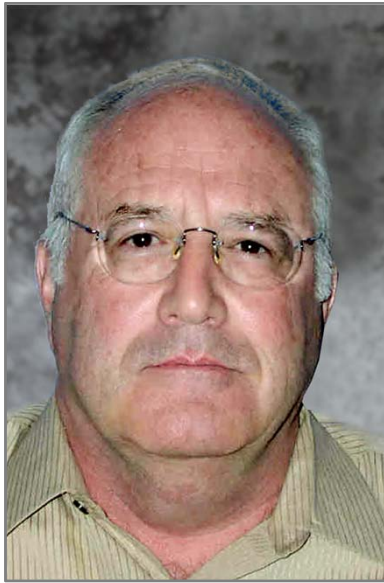
Following his graduation thru the MS degree in mechanical engineering at Cornell University, he started his professional career at Naval Reactors working on submarine and surface nuclear vessels. Then following his Sc. D in Nuclear engineering at MIT he worked at the Atomic Energy Commission (AEC) on organic cooled /heavy water moderated and sodium cooled reactors. He returned as a faculty member to MIT in 1970 and has remained there until he retired to part-time service in 2006. In 1992, he became the first faculty member to be named to the Korea Electric Power Co. Professorship of Nuclear Engineering at MIT, itself being the first chair dedicated to nuclear engineering at MIT and perhaps at US universities

He has an extensive record of service for government (Department of Energy – DOE, US Nuclear Regulatory Commission – USNRC, and national laboratories), utility industry review committees, and international scientific review groups. He has served as a member and chair of the Advisory Council of the Institute of Nuclear Power Operation (INPO). He was the chair of the US Nuclear Regulatory Commission (NRC) panel on Appendix K (which ushered the best estimate approach with uncertainty into the regulatory practice, instead of the so-called conservative approach used until then). In the early 2000s he served as co-chairman of DOE's Generation IV technology road map planning committee. His professional service has involved many international assignments, including technical leadership of the panel to assess the safety and restart plan for the Canadian Ontario Hydro Company's nuclear fleet .

His current service is as a member of the Oak Ridge National Laboratory Nuclear Science and Engineering Directorate Advisory Committee, the Executive Advisory Council of the North American –Young Generation in Nuclear Organization and the French CEA Nuclear Energy Division Scientific Committee.

He has written or been co-author of more than 240 publications, a two-volume textbook published in 1990 , of which Vol I was revised in 2012 and Vol II is currently under revision, which is widely used internationally for the study of reactor thermal analysis and a reference book on safety features of light water reactors.

He is a member of the US National Academy of Engineering and a fellow of the American Nuclear Society (ANS) and the American Society of Mechanical Engineers (ASME).



Robert W. Youngblood
Senior Risk Consultant,
Risk Assessment and
Management Services
Department
Idaho National Laboratory

Bob Youngblood's degrees are in physics (BA Reed College, MS & PhD from the State University of New York at Stony Brook). He also served from 1969 to 1972 in the US Army, as an instructor at the US Army Signal Center and School (Fort Monmouth, New Jersey).

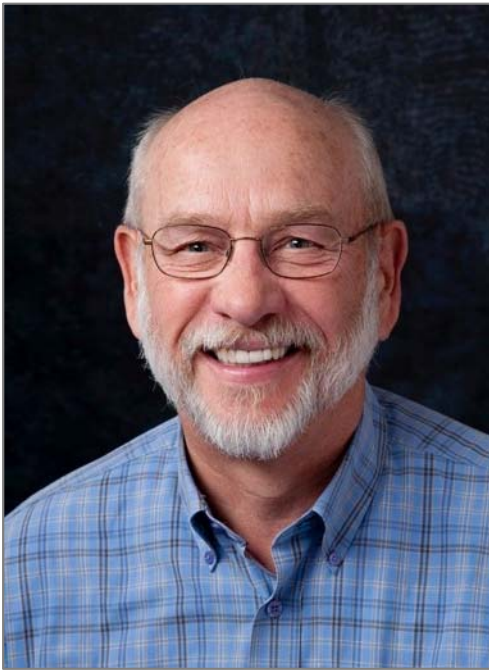
Bob is a member of the American Physical Society, the American Society of Mechanical Engineers, and the American Nuclear Society, for which he serves on the Executive Committee of the Nuclear Installations Safety Division, the Risk-Informed and Performance-Based Principles and Policies Committee, and the Nuclear Risk Management Coordinating Committee.

In 1981, as the US Nuclear Regulatory Commission (USNRC) was increasing its usage of risk analysis partly as a result of the Three Mile Island Accident, Bob joined a group in Brookhaven National Laboratory's Department of Nuclear Energy, which supported the USNRC in methods development and application of risk analysis to licensing, generic safety issue resolution, Individual Plant Examinations, and design certification of advanced reactors. Highlights of this period include development of Top Event Prevention Analysis and the formulation of an approach to the analysis of functional unreliability of "passive" systems based on the "limit surface" concept, an idea that was carried through a PhD thesis at the University of Michigan, for which Bob served as a mentor and reader.

In 1996, Bob joined SCIENTECH as a member of the Risk and Thermal Hydraulics Group, which supported the USNRC; later, Bob became leader of the Licensing and PSA Group. While at SCIENTECH, Bob led a project on Performance-Based Regulation, which began an ongoing involvement with decision analysis, and worked on precursor analysis of the US Enrichment Corporation's gaseous diffusion plants, as well as development of performance-based approaches to the regulatory oversight of byproduct materials systems.

In 2000, the part of SCIENTECH responsible for NRC support was acquired by Information Systems Laboratories, where Bob became a Vice President and the Chief Technical Officer of the Nuclear Systems Analysis Division. In addition to corporate duties including business development, Bob led ISL's project on development of the Mitigating System Performance Indices (MSPI's) and other tools of USNRC's "Reactor Oversight Process." (ISL was teamed with the INEEL on this.) During this period, ISL became NRC's commercial contractor on accident precursor analysis. Also during this period, Bob led a pilot application of precursor analysis for NASA.

In 2008, Bob joined the INL. From 2009 until 2011, Bob served as pathway lead in the "Risk-Informed Safety Margin Characterization" (RISMC) pathway. He served as INL PI of a Laboratory-Directed Research and Development (LDRD) project with MIT that advanced the state of practice in Bayesian calibration of simulation models. Bob continues to support NASA's Office of Safety and Mission Assurance in development and application of risk analysis methods and formulation of policy and guidance.



Roger J. Mattson

Summary

- Fifty-one years experience in nuclear safety, licensing and related fields
- Expert in safety assessment and risk management
- Managed technology teams and organizations ranging in size to 500 persons
- Served on boards of directors and safety oversight in the nuclear industry
- Developed strategic plans for government and industry

Education

- Ph.D., Mechanical Engineering, University of Michigan, 1972
- M.S., Mechanical Engineering, University of New Mexico, 1966
- B.S., Mechanical Engineering, University of Nebraska, 1964, cum laude

Mattson has diversified experience in engineering and management with Sandia Laboratory, Atomic Energy Commission, Nuclear Regulatory Commission and Environmental Protection Agency. He served as president of International Energy Associates Limited, an international consultancy, and was a founder and chief operating officer of SCIENTECH, Inc., a leading nuclear safety company. For the past 14 years, he has consulted with a range of clients in the private sector and the National Labs.

Mattson's technical expertise is in heat transfer and fluid flow, nuclear safety, nuclear facility licensing, nuclear policies and standards, readiness reviews, risk management, security of nuclear facilities and materials, quality assurance and emergency preparedness. He conducted and managed safety reviews for more than 110 nuclear power plants and other radiological facilities. He led the development of NRC's new requirements after the accident at Three Mile Island in 1979 (NUREG-0578, 0585 and 0660).

From 1974 to 1984, Mattson advised AEC and NRC commissioners on policy issues such as safety goals, radiological protection, standardization, risk assessment and security. He led NRC's reviews of advanced nuclear power plant designs from 1977 to 1984. He participated in NRC's onsite response to the accident at Three Mile Island and several other nuclear incidents. He developed NRC's standards for security, safety, radiation protection and environmental protection of uranium fuel cycle facilities and waste management facilities.

Since leaving NRC in 1984, he has advised managers of NRC licensees, National Laboratories and DOE contractors on policy issues and decision-making in nuclear safety and security. He led readiness reviews for startup of Limerick Nuclear Power Plant Unit 2, Rocky Flats Plant, and K-Reactor at Savannah River. He participated in safety analysis and field reviews of nearly 150 nuclear facilities in the U.S., Europe, the former Soviet Union and the Far East. He co-chaired the International Atomic Energy Agency's development of safety principles for nuclear power plants after the 1986 accident at Chernobyl (INSAG-3, updated to INSAG-12). He served on nuclear safety review boards for five operating nuclear power plants, the Rocky Flats decommissioning site, the DynEx Program at Los Alamos, and the Advanced Test Reactor at Idaho National Laboratory. He established and led nuclear safety consultancies in Ukraine and Kazakhstan. He assisted the president of Maine Yankee and Connecticut Yankee in decommissioning of two nuclear power plants and in the storage of their spent fuel. He led a senior engineering team to address safety issues involving hydrogen in process systems at the Hanford Waste Treatment Plant. He served on the team that responded to lessons learned from the Fukushima Dai-ichi event for the president of the American Society of Mechanical Engineers.