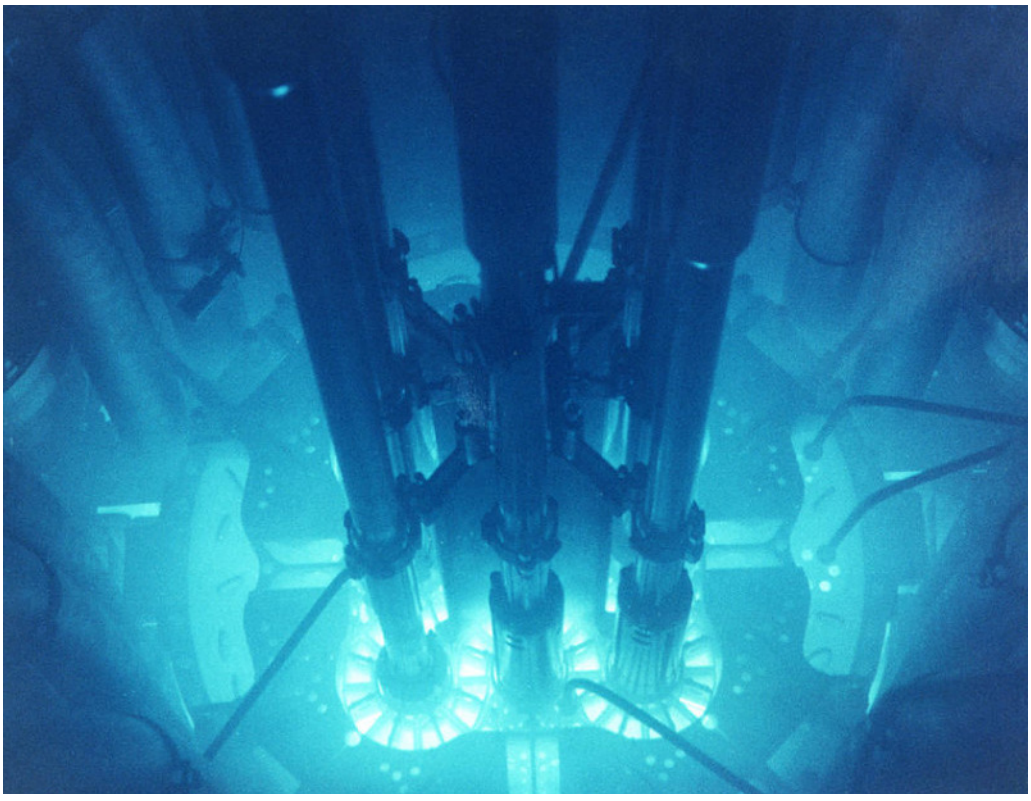
Sixtieth
Annual Meeting Program

Advanced and Small Modular Nuclear Power Reactors



Hyatt Regency Bethesda
One Bethesda Metro Center
7400 Wisconsin Avenue
Bethesda, MD 20814

March 25–26, 2024

Cover: The Advanced Test Reactor core in operation, showing the Cherenkov effect (blue glow) at the Idaho National Laboratory.

NCRP Mission:

To support radiation protection by providing independent scientific analysis, information and recommendations that represent the consensus of leading scientists.

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Introduction

Advanced and Small Modular Nuclear Power Reactors

Sixtieth Annual Meeting of the National Council on Radiation Protection and Measurements (NCRP)

On behalf of the NCRP and our 2024 Program Committee, welcome to the 2024 NCRP Annual Meeting! Our organization dates from 1929, and this meeting celebrates the 60th anniversary of receiving our Congressional Charter. The themes of our annual meetings vary from year to year. Sometimes we inform our members, and members of the public, about our current activities. This year, we felt it was essential to brief our members, and the wider radiation protection community, about advanced and small modular nuclear reactors (SMRs). As science and the effects of climate change become more conclusive, the search has been underway for energy sources to replace carbon fuels. Energy from renewables such as solar and wind dominate the conversation in the popular press. There is also recognition that nuclear energy, which currently produces about 20 % of electrical energy in the United States, could play an important role. The currently operating power reactors in the United States use designs that were originally developed for naval use in the 1950s and 1960s. Expansion of nuclear power faces three major issues: high construction costs, concerns about safety, and the growing volume of spent reactor fuel. Overcoming these issues is essential for future expansion of the use of nuclear power.

The current U.S. nuclear power fleet use (light) water as the energy moderator for neutrons as well as a means to cool and move heat from the fuel. The average age of these reactors is about 42 y old, but many have had substantial modernization to continue to operate safely. Additionally, new designs have recently emerged to fill specific market needs. These designs have made considerable advancements in safety, costs and reliability.

The Energy Act of 2020 defined ***advanced*** reactors as those with significant improvements compared to currently operating reactors. The improvements of advanced reactors include standardized designs with modular construction that reduce costs and facilitate proposed streamlining of licensing. Advanced reactor designs use different types of moderators, coolants and fuel, and many designs would be SMRs. To enable discussion at this meeting, we have made a distinction between advanced reactors and SMRs. Advanced reactors include designs that utilize coolant other than water to increase the recoverable heat produced and to allow the use of alternative fuels. Alternative coolants include gas (helium), liquid sodium, or other liquid salts. Alternative fuels include those with different forms of uranium or the use of other fissile materials. As the name indicates, SMRs are much smaller than the existing large reactors, typically in the range of 10 to 300 MW, and they typically use current fuels and light water as coolant.

For the vision of advanced and SMRs to become reality, initial investments in research and development are required. The U.S. Congress established the Advanced Reactor Demonstration Program in 2020. This program, led by the U.S. Department of Energy (DOE), has undertaken a unique partnership of private and federal funding to accelerate new reactor development. Our meeting program offers a balance of the

description of new technology, the role of government, and critical issues that must be addressed, within the context of radiation safety.

Our program covers two topical areas, each with two technical sessions, followed by interactive Q&A, with keynote presentations by three of our award recipients. The topical areas are Technology Overview and Critical Issues. Our first Technology Overview session lays the groundwork to understanding reactor technologies, terminology, and the fundamental concepts and processes for electrical generation. This session includes the perspectives of the U.S. Environmental Protection Agency and states, through the Conference of Radiation Control Program Directors. Our second Technology Overview session expands discussion with papers describing National Aeronautics and Space Administration applications for space exploration and three high temperature advanced reactor designs.

Our first session on Critical Issues includes several papers on diverse topics. These include a discussion of potential emergency preparedness considerations, meeting radiological survey requirements with robotics, an evaluation of the future of nuclear power, the economics of reactors (both large and small), critical issues identified by the recent National Academies of Sciences' study on advanced reactors, fast reactors and recycling, and radiation protection for small mobile military reactors. Our second session on Critical Issues includes papers on new perspectives on regulation, environmental justice challenges (and opportunities), a utility perspective on operational radiation protection, and the evolution of radiation protection practices in advanced reactors.

The Program Committee hopes that you find the content informative and educational and that you leave the meeting with ideas and contacts useful for future endeavors. We are glad you are here and that we can share a snapshot of this important technology!

Award Recipients

The **John D. Boice, Jr., Young Investigator Award**, established in April 2019, is given this year to Lukas M. Carter from the Department of Medical Physics at Memorial Sloan Kettering Cancer Center. This Award is given to recognize an early career professional engaged in some aspect of science pertaining to radiation protection and measurements.

The **Forty-Seventh Lauriston S. Taylor Lecture** will be delivered by Dr. Richard A. Meserve, J.D.
Dr. Meserve is one of those rare individuals who serves two professions with distinction: science (he received his PhD from the Stanford University Department of Applied Physics), and law [he received his Juris Doctor from Harvard Law School (magna cum laude)]. He is currently the Chair of the National Academies of Science, Engineering, and Medicine Study Laying the Foundation for New and Advanced Nuclear Reactors in the United States. Dr. Meserve is a former Chair of the U.S. Nuclear Regulatory Commission (NRC) (1999 to 2003), Past President of the Carnegie Institution for Science (2003 to 2014), and legal Counsel for the President's Science and Technology Advisor

Please Note: The technical program and the Q&A from each session are being recorded. In addition, all areas of the meeting are being recorded and photographed. If you wish to opt-out of videos/photos please visit the registration desk. The photographs will be posted and are publicly available on the NCRP flickr account.

(1977 to 1981). He served as a Law Clerk for U.S. Supreme Court Justice Harry A. Blackmun.

The **Twentieth Annual Warren K. Sinclair Keynote Lecture** will be delivered by Dr. Kathryn Huff. Dr. Huff currently leads the DOE Office of Nuclear Energy as the Assistant Secretary. She received her PhD in nuclear engineering from the University of Wisconsin-Madison in 2013 and her undergraduate degree in physics from the University of Chicago. Before joining DOE, she was a professor in the Department of Nuclear, Plasma, and Radiological Engineering at the University of Illinois at Urbana-Champaign, where she led the Advanced Reactors and Fuel Cycles Research Group. She was previously a postdoctoral fellow in both the Nuclear Science and Security Consortium and the Berkeley Institute for Data Science at the University of California-Berkeley.

The **Seventh Thomas S. Tenforde Lecture** will be delivered by Mr. Christopher Hanson, current Chair of NRC. Mr. Hanson has more than two decades of government and private-sector experience in the field of nuclear energy. Mr. Hanson earned master's degrees from Yale Divinity School and Yale School of Forestry and Environmental Studies, where he focused on ethics and natural resource economics. He earned a Bachelor of Arts degree from Valparaiso University in Valparaiso, Indiana. Prior to joining NRC, he served as a Staff Member on the Senate Appropriations Committee, where he oversaw civilian and national security nuclear programs. Before working in the Senate, Chair Hanson served as a Senior Advisor in DOE's Office of Nuclear Energy. He also served in the Office of the Chief Financial Officer, where he oversaw nuclear and environmental cleanup programs, and managed the department's relationship with Congressional Appropriations Committees.

NCRP gratefully acknowledges:

- the Coast Guard Color Guard who will open our Annual Meeting; and
- Kimberly Jordan of NRC who will sing our National Anthem.

Monday, March 25, 2024

Opening Session

8:10 am **Presentation of the Colors**
Coast Guard Color Guard

Singing of the National Anthem
Kimberly Jordan
U.S. Nuclear Regulatory Commission

8:15 am **NCRP Welcome**
Kathryn D. Held
President, NCRP

8:20 am **Introduction**
William E. Kennedy, Jr., *Program Chair*
Willie O. Harris & Kathryn A. Higley,
Program Co-Chairs

Twentieth Annual Warren K. Sinclair Keynote Address

8:30 am **Introduction of the Speaker**
Kathryn D. Held

U.S. Department of Energy, Office of Nuclear Energy Advanced Reactor Research, Design, Development and Demonstration
Kathryn D. Huff
U.S. Department of Energy

Advanced and Small Modular Reactors Technology Overview: Part 1

William E. Kennedy, Jr., *Session Chair*

9:00 am **Radiation Protection Professional's Guide to Nuclear Reactors**
Kathryn A. Higley
Oregon State University

9:20 am **Advanced Reactors: Implications for EPA's Fuel-Cycle Standards**
Daniel Schultheisz
U.S. Environmental Protection Agency

9:40 am **Small Modular Reactors, Advanced Reactors, and Other Nuclear Technologies: State Perspectives**
Jeffrey D. Semancik
Conference of Radiation Control Program Directors

10:00 am **Break**

Advanced and Small Modular Reactors Technology Overview: Part 2

Wesley E. Bolch & Ruth E. McBurney,
Session Co-Chairs

10:20 am **Space Nuclear Reactor Commonalities with Advanced and Small Modular Reactors**
Michael G. Houts
National Aeronautics and Space Administration

10:40 am **Natrium© Technology Overview**
Jesse Cheatham
TerraPower

11:00 am **Technology Overview of Fluoride Salt Cooled High-Temperature Reactors**
Per F. Peterson
Kairos Power

11:20 am **Auora Powerhouse: A New Reactor Design**
Everett L. Redmond, II
Oklo, Inc.

11:40 am **Interactive Q&A**

12:00 pm **Lunch**

Advanced and Small Modular Reactor Critical Issues: Part 1

Richard R. Brey & Kathryn A. Higley, *Session Co-Chairs*

1:30 pm **NuScale VOYGR Small Modular Reactor Emergency Planning Zone Methodology Overview**
Steven M. Mirsky
NuScale

1:50 pm **New Perspective on Nuclear Regulation: Insights from Aviation's Hazard Threshold**
Bret Kugelmass
Last Energy

2:10 pm **Changing Paradigms: Meeting Radiological Survey Requirements with Robotics**
Matt Mahowald
X-Energy

2:30 pm **Future of Nuclear in the Pacific Northwest**
Gregory V. Cullen
Energy Northwest

2:50 pm **Economics of Nuclear Reactors: Large and Small**
Abdalla Abou-Jaoude
Idaho National Laboratory

3:10 pm **Key Findings of the National Academy of Engineering Study "Laying the Foundation for New and Advanced Nuclear Reactors in the United States"**
Michael Ford
Princeton Plasma Physics Laboratory

3:30 pm **Oklo: Fast Reactors and Recycling**
Everett L. Redmond, II
Oklo, Inc.

3:50 pm **Radiation Protection Considerations for Small Mobile Nuclear Reactors**
Jama D. VanHorne-Sealy
U.S. Army

4:10 pm **Interactive Q&A**

4:30 pm **Break**

Forty-Seventh Lauriston S. Taylor Lecture on Radiation Protection and Measurements

5:00 pm **Introduction of the Lecturer**
William E. Kennedy, Jr.

Lessons from the Fukushima Daiichi Accident
Richard A. Meserve
Covington & Burling, LLP

6:00 pm **Reception**

Tuesday, March 26, 2024

8:00 am **NCRP Annual Business Meeting**

9:30 am **Break**

Seventh Thomas S. Tenforde Topical Lecture

9:45 am **Introduction of the Lecturer**
Cynthia G. Jones

Embracing Risk-Informed Thinking at the Nuclear Regulatory Commission
Christopher T. Hanson
U.S. Nuclear Regulatory Commission

Advanced and Small Modular Reactor Critical Issues: Part 2

Willie O. Harris & Cynthia G. Jones, *Session Co-Chairs*

10:15 am **Radiological Emergency Preparedness: How Risk-Informed Regulation Prepares Us for the Future**
Todd R. Smith
U.S. Nuclear Regulatory Commission

Summary

10:35 am **How do Advanced and Small Modular Reactors Affect the Environmental Impacts of Nuclear Energy**
Jessica R. Lovering
Good Energy Collective

10:55 am **Operational Radiation Protection for Small Modular Reactors**
John Duhig
Ontario Power Generation

11:15 am **Radiation Protection Aspects for Advanced Reactors**
David Perkins
Electric Power Research Institute

11:35 am **Closing Panel Discussion**
Cynthia G. Jones, *Moderator*
Jesse Cheatham
Michael Ford
Kathryn A. Higley
Michael G. Houts
Bret Kugelmass

12:00 pm **Wrap-Up**
William E. Kennedy, Jr., *Program Chair*

12:10 pm **NCRP Vision for the Future and Program Area Committee Activities**
Kathryn A. Higley
President Nominate

12:30 pm **Adjourn**

Monday, March 25, 2024

Opening Session

8:10 am

Presentation of the Colors
Coast Guard Color Guard

Singing of the National Anthem
Kimberly Jordan
U.S. Nuclear Regulatory Commission

8:15 am

NCRP Welcome
Kathryn D. Held, *President*
National Council on Radiation Protection and Measurements

8:20 am

Introduction
William E. Kennedy, Jr., *Program Chair*
Willie O. Harris & Kathryn A. Higley, *Program Co-Chairs*



Twentieth Annual Warren K. Sinclair Keynote Address

8:30 am

Introduction of the Speaker
Kathryn D. Held

U.S. Department of Energy, Office of Nuclear Energy Advanced Reactor Research, Design, Development and Demonstration
Kathryn D. Huff
U.S. Department of Energy

In this talk, Assistant Secretary Huff will provide a potential vision for the future of nuclear power globally and will describe what the federal government, particularly the U.S. Department of Energy's (DOE) Office of Nuclear Energy (NE), is doing today to bring that vision into reality. This work includes laying the groundwork for peaceful nuclear power to help the United States reach net-zero emissions by 2050, for securing and sustaining both the

front and back ends of our nuclear fuel cycle, and for expanding international nuclear energy cooperation. This talk will touch upon the DOE NE mission, vision and programs contributing to these goals as well as the opportunities and challenges ahead. These challenges and opportunities include a need to mobilize bold private capital investments, scale-up a skilled workforce, revive and invent critical supply chains, and underpin it all with processes and policies that center equity and justice.

Advanced and Small Modular Reactors Technology Overview: Part 1

William E. Kennedy, Jr., *Session Chair*

9:00 am

Radiation Protection Professional's Guide to Nuclear Reactors
Kathryn A. Higley
Oregon State University

Nuclear reactors have been around for more than 80 y, supporting national defense, electricity generation, teaching, isotope production, and research. Power production through fission has been a reality for 70 y. Regulations, policies and procedures evolved to ensure the radiation safety of the workforce, members of the public, and the environment, commensurate with the increasing variety of reactor designs, power levels, and applications. Focus on decarbonization of our economy as well as space exploration has led to a renewed interest in the next generation of reactors and a reconsideration of where they might be deployed. Several key questions to be considered include: What do these new designs mean to the radiation protection community? Do any of the advanced reactor projects suggest the need to revisit our radiation protection guidance or regulations? A brief overview of the fundamentals of reactor design(s) and operation will be provided, with the intent to contrast current and proposed systems. This presentation will provide meeting participants with background knowledge to support thoughtful interaction and discussion with the subsequent speakers.

9:20 am

Advanced Reactors: Implications for EPA's Fuel-Cycle Standards
Daniel Schultheisz
U.S. Environmental Protection Agency

The U.S. Environmental Protection Agency (EPA) issued its first Atomic Energy Act regulations in 1977. This rule, codified at 40 CFR Part 190, established public health protection standards applicable to the uranium fuel cycle, defined as the steps "associated with the production of electrical power for public use ... through utilization of nuclear energy." These steps begin with milling of uranium ore through reprocessing of spent nuclear fuel, but does not include mining, disposal of spent fuel or high-level waste, or transportation. The rule included both a standard to protect individuals from routine discharges of radioactive materials and a standard to control emissions of specific radionuclides, primarily those likely to be released during reprocessing of spent fuel.

EPA explored key issues involved in updating these standards in 2014 through an Advance Notice of Proposed Rulemaking. In addition to updating the dosimetry, which was based on International Commission on Radiological Protection Publication 2, EPA requested the public's views on how the standards should address new technologies, foremost among these being small modular reactors and the use of nuclear energy for nonelectrical power applications, such as hydrogen production or high-temperature industrial processes.

The growing interest in advanced reactor technologies is prompting reconsideration of updates to the current standards. In particular, the emphasis on nonelectricity uses highlights a gap in the standards, with potential uses illustrated by X-Energy's agreement with Dow, the Biden Administration's designation of "hydrogen hubs," and the International Maritime Organization's pledge for shipping to have net-zero greenhouse gas emissions by 2050. The potential for advanced reactors to lead an expansion of nuclear power may also have implications for EPA's standards related to uranium production and spent fuel management.

9:40 am

Small Modular Reactors, Advanced Reactors, and Other Nuclear Technologies: State Perspectives
Jeffrey D. Semancik
Conference of Radiation Control Program Directors

The burgeoning interest in small modular reactors (SMRs) and advanced reactors as potential solutions to reduce carbon emissions is gaining momentum. The U.S. Department of Energy is actively championing their development, buoyed by congressional initiatives incentivizing their progress. Meanwhile, the U.S. Nuclear Regulatory Commission is reshaping its regulatory processes and reviewing applications.

Many states recognize the potential benefits of SMRs and advanced reactors in curbing carbon emissions, providing safe, firm dispatchable power, and seamlessly integrating with renewable sources while fortifying fuel security. Additionally, these technologies offer ancillary advantages such as tax incentives, economic stimulation, and workforce development. States are enthused about the prospect of repurposing coal and other industrial sites, and they might even turn to SMRs to rejuvenate aging existing nuclear sites as conventional light water reactors phase out. However, the long-standing promises of solving the nuclear waste quandary remain distant, possibly spanning decades at best. In addition, lingering questions persist regarding social license, offsite emergency response capabilities, environmental impacts, grid infrastructure requirements, and new potential hazards. Above all else, the primary impediment continues to be the lack of a predictable deployment cost. Solid market signals and committed order books remain the biggest barrier for widespread adoption. Understanding how states' concerns, perspectives and eagerness to integrate this technology influence the deployment of new reactors is paramount to wide-scale deployment of new nuclear in time to meet aggressive carbon reduction goals.

10:00 am

Break

Advanced and Small Modular Reactors Technology Overview: Part 2

Wesley E. Bolch & Ruth E. McBurney, Session Co-Chairs

10:20 am

Space Nuclear Reactor Commonalities with Advanced and Small Modular Reactors
Michael G. Houts
National Aeronautics and Space Administration

Innovative fission systems continue to be proposed, with a wide range of potential applications. To assist in the development of these systems it is important that commonalities be identified. Significant commonalities exist between space reactors, advanced reactors, and small modular reactors. For example, all three categories of systems will benefit from semi-autonomous operation and minimal (or zero) maintenance requirements. The unique requirements of the systems may often be best met through the use of nontraditional moderators and reflectors, such as zirconium hydride, beryllium, beryllium oxide, beryllium carbide, yttrium hydride, and others. Nontraditional fuels may also be required, such as engineered coated fuel particles, liquid uranium metal, solid solution carbides, and others. The use of nontraditional moderators, reflectors and fuels may also require the development and utilization of advanced nuclear test facilities. Space reactors and small modular reactors are often subjected to more stringent mass and volume constraints than are traditional reactors. This presentation will provide a discussion of potential commonalities amongst space nuclear reactors, advanced reactors, and small modular reactors.

10:40 am

Natrium© Technology Overview
Jesse Cheatham
TerraPower

The Natrium© Program Mission is to create a cost-competitive, flexible technology for the clean energy future. A high-level overview of key technology decisions like site layout, energy storage and load following, and reactor design are discussed. The combination of the Natrium© design choices enables a reduced emergency planning zone, indefinite passive reactor cooling, and flexible power dispatch without reducing reactor power production. This enables Natrium© increased flexibility in site selection and a complimentary thermal storage capability to support intermittent renewable power sources.

11:00 am

Technology Overview of Fluoride Salt Cooled High-Temperature Reactors
Per F. Peterson
Kairos Power

Fluoride salt cooled high-temperature reactors (FHRs) are novel high-temperature reactors that use fully ceramic tri-structural isotropic particle fuel, with a molten fluoride salt coolant to transfer heat. Due to their high chemical stability and boiling temperature, 1,430 °C,

molten salt coolants are intrinsically low pressure, eliminating stored energy sources that would require a pressure-retaining, low-leakage containment building. This presentation will review the history of FHR technology and recent progress in development and licensing, as well as the implementation of passive safety features.

11:20 am

Auora Powerhouse: A New Reactor Design
Everett L. Redmond, II
Oklo, Inc.

Oklo is focused on deploying advanced nuclear reactors through an innovative business model. Oklo's technology is based on proven fast reactor technology that was previously demonstrated in the United States at Idaho National Laboratory with Experimental Breeder Reactor II. Oklo is designing a 15 MWe micro-reactor with future designs going up to 50 MWe. The prevailing reactor technology business model consists of reactor developers, owners, and operators. Reactor developers sell reactors and services. The owners of those reactors may choose to operate the reactor or partner with a separate operator. Oklo is challenging this paradigm through our build, own and operate model. Through this new business model Oklo is opening up new markets for clean reliable 24/7 power. This presentation will discuss both Oklo's technology and business model.

11:40 am **Interactive Q&A**

12:00 pm **Lunch**

Advanced and Small Modular Reactor Critical Issues: Part 1

Richard R. Brey & Kathryn A. Higley, Session Co-Chairs

1:30 pm

NuScale VOYGR™ Small Modular Reactor Emergency Planning Zone Methodology Overview
Steven M. Mirsky
NuScale

NuScale Power Corporation is the industry-leading provider of proprietary and innovative advanced small modular reactor (SMR) nuclear technology, with a mission to help power the global energy transition by delivering safe, scalable and reliable carbon-free energy. The company's groundbreaking VOYGR™ SMR plants are powered by the NuScale Power Module™, a small, safe, pressurized water reactor that can each generate 77 MWe or 250 MW thermal (gross), and can be scaled to meet customer needs through an array of flexible configurations up to 924 MWe (12 modules) of output. VOYGR™ is the first and only SMR to have its design certified by the U.S. Nuclear Regulatory Commission (NRC). On October 19, 2022, NRC issued a Safety Evaluation approving the NuScale SMR Plume Exposure Emergency Planning Zone (EPZ) Methodology Topical Report. This is the first and only topical report approved by NRC for use in determining a nuclear power plant

plume exposure EPZ different from the current regulations. NRC approval is only for its use with the NuScale VOYGR™ SMR design. An overview of this topical report is presented that includes inputs and methodology. The methodology is consistent with the regulatory basis (10 CFR 50.47) for the current 10 mile plume exposure EPZ in place at operating U.S. nuclear power plants. Depending on the specific site, the methodology in this topical report can be applied to demonstrate the acceptability of a site boundary plume exposure EPZ for the NuScale VOYGR™.

1:50 pm

New Perspective on Nuclear Regulation: Insights from Aviation's Hazard Threshold
Bret Kugelmass
Last Energy

As we assess proportionality of regulatory requirements to magnitude of hazard within the nuclear sector, it is useful to draw comparison to another industry that has begun a substantial regulatory reform.

With the evolution of unmanned aerial vehicle technology, drones have come to occupy a broad spectrum of sizes and functions, calling into question the appropriateness of existing regulatory requirements. In order to enable public benefit and allow new technologies to gain field experience (including advanced safety features) a common sense threshold was adopted; using mass as a proxy for hazard, the Federal Aviation Administration chose to relinquish some measure of authority in an act of regulatory innovativeness and courage.

As microreactors approach deployment, nuclear regulators are presented with a similar opportunity to leverage regulatory tiering, with the potential to improve administrative efficiency and allow for technological progression without compromising commitment to safety. Microreactors are analogous to smaller drones insofar as the maximum credible threat (using source term as a proxy) can be demonstrably distinct from their larger counterparts, requiring only modest analysis. Hence, we propose that nuclear power reactors are ideal candidates for the application of regulatory tiering using power level as proxy.

Additional measures aimed at fostering a risk-informed regulatory environment are also recommended. For example, according to NCRP Commentary No. 27 “the use of the epidemiologic data cannot justify using the linear non-threshold model to estimate numbers of excess cancers,” and thus should not be used solely to inform regulatory policy; holistic consideration of societal benefits must be considered.

2:10 pm

Changing Paradigms: Meeting Radiological Survey Requirements with Robotics
Matt Mahowald
X-Energy

Nuclear power generation reactors require intensive capital support during design and construction phases of the project, but ultimately can compete on a loss of coolant experiment and process heat basis once operational, especially when accounting for the climate change cost of other means of power and heat generation as well as the power plant lifetime. To reduce upfront capital expenditure and further minimize reactor outages, radiological maintenance/survey, and operational radiation dose, the XE-100 reactor will employ significantly more robotic integration than previous operating plants. A goal of this program is the minimization of occupational radiation dose to personnel. This session will explore the robotic

implementation for plant process, plant maintenance, and human dose reduction. Aspects of plant design to both accommodate and benefit from online robotic maintenance survey will be outlined, as well as a brief overview of the XE-100.

2:30 pm

Future of Nuclear in the Pacific Northwest
Gregory V. Cullen
Energy Northwest

In the last 5 y both Washington and Oregon have enacted legislation requiring decarbonization of electric energy used in the state. At the same time there is a push to decarbonize the transportation and building heat sectors as well, which lead to a higher demand for electricity. How are utilities in these states planning to meet these requirements and how do they view nuclear as a potential option in their portfolios? As a joint operating agency, Energy Northwest serves many utilities in the region and, as the only commercial nuclear energy facility operator in the Northwest, is at the center of efforts to explore all technology options. Drawing upon a study sponsored by Energy Northwest and completed in early 2020 and the latest conversations and explorations, this presentation will examine the way utilities are approaching this problem and what they are concluding. It will also touch briefly on how the carbon conversation is affecting perceptions of nuclear.

2:50 pm

Economics of Nuclear Reactors: Large and Small
Abdalla Abou-Jaoude
Idaho National Laboratory

In the past several decades, Western nuclear projects like Vogtle (United States), Flamanville (France), and Olkiluoto (Finland) have faced significant budget overruns. These escalations have not always been observed in other countries such as China, Russia and Korea, where costs remained comparatively competitive. In the United States specifically, the cost overruns arise from a mix of challenges: poor project management, regulatory shifts, inefficiencies in constructions, unestablished supply chains, high labor costs, complexities of First-of-a-Kind technologies, and inherent risks of megaprojects. For nuclear to play a larger role in future deployment scenarios, U.S. designers are leaning more heavily on smaller reactors, either small modular reactors (SMRs with 100s of megawatt electric in power outputs) and microreactors (10s of megawatt electric in power outputs). In both classes, driving down costs will depend on:

- shifting more activities from the site to the factory where better quality controls can be implemented;
- learn by doing as was observed for submarine reactors;
- adopting standardized designs with minimal change between sites;
- firm order books to invest in workforces and supply chains; and
- adequate project management and execution.

Still, differences in economic dynamics can be expected between these two classes of reactors. For instance, microreactors are likely to be much more sensitive to fuel costs and will need to minimize staffing (even tending towards autonomous operations). On the other hand, SMR designs will need to streamline construction activities as much as possible to avoid the pitfalls of previous larger constructions in the West.

Advanced and Small Modular Nuclear Power Reactors

3:10 pm

Key Findings of the National Academy of Engineering Study "Laying the Foundation for New and Advanced Nuclear Reactors in the United States"
Michael Ford
Princeton Plasma Physics Laboratory

The world confronts an existential challenge in responding to climate change, resulting in an urgent need to reduce greenhouse gas emissions from all sectors of the economy. Nuclear power currently provides a significant portion of the worlds low-carbon electricity, and advanced nuclear technologies have the potential to be smaller, safer, less expensive to build, and better integrated with the modern grid. However, if the United States wants advanced nuclear reactors to play a role in its plans for decarbonization, there are many key challenges that must be overcome at the technical, economic and regulatory levels. A recent study by the National Academy of Engineering — "Laying the Foundation for New and Advanced Nuclear Reactors in the United States" — discusses how the United States could support the successful commercialization of advanced nuclear reactors with a set of near-term policies and practices. Dr. Ford, one of the committee members for the Study, will review key recommendations of this report to include discussion of technology research gaps, new business use cases, project management and construction concerns and the necessity to prioritize community engagement, strengthen the skilled workforce, and develop competitive financing options.

3:30 pm

Oklo: Fast Reactors and Recycling
Everett L. Redmond, II
Oklo, Inc.

Oklo has set upon the mission to license and deploy an American facility that will recycle used nuclear fuel, recovering its fissionable constituents, for their use in manufacturing new fuel for Oklo's forthcoming fleet of fast-spectrum advanced reactors. This first-of-a-kind facility leverages the technology and the lessons learned over several decades of fuel-cycle development and operation, while ensuring the intrinsic integration of security, material safeguarding, and environmental stewardship. The implementation of this recycling capability serves to unlock the energy resources held in the nation's inventory of used nuclear fuel in a commercially viable manner. The pyroprocessing technology Oklo is utilizing has been proven over decades of engineering scale operations. The presentation will provide an overview of the technological approaches being used by Oklo to deploy this facility, along with the role that new capability will fill within a multi-recycling fast reactor fuel cycle.

3:50 pm

Radiation Protection Considerations for Small Mobile Nuclear Reactors
Jama D. VanHorne-Sealy
U.S. Army

The advances made in small modular reactors (SMRs) and nuclear fuel created an opportunity to provide flexible on-demand power for emergency and temporary operations. This

nuclear power evolution necessitates a holistic assessment of how radiation protection applies to mobile nuclear reactor power. SMRs are likely to be used in environments where lives depend on quickly establishing power operations with little time for the historic methodical approach to nuclear power radiation protection. Rather health physics must protectively use all tools to consider the various acceptable use applications, taking a risk-based approach, and developing new processes and procedures that will ensure not only the protection of the civilian population and workers, but protection of any operating environment. This talk will discuss radiation protection considerations and recommendations for use of advanced technology in understanding the variables and risks.

4:10 pm **Interactive Q&A**

4:30 pm **Break**

Forty-Seventh Lauriston S. Taylor Lecture on Radiation Protection and Measurements

5:00 pm **Introduction of the Lecturer**
William E. Kennedy, Jr.

Lessons from the Fukushima Daiichi Accident
Richard A. Meserve
Covington & Burling, LLP

Meserve will describe his extensive involvement with nuclear safety matters in Japan in the aftermath of the Fukushima Daiichi accident. He will discuss the causes of the accident and the many lessons it provides. Among other things, the accident demands increased scrutiny of external events, greater awareness that emergency planning must expand beyond radiation impacts, the need for a competent and independent regulator, and a focus on safety culture. He will describe the changes that have been introduced in Japan and around the world as a result of the accident, as well as outstanding issues that warrant further response.

6:00 pm **Reception**

Tuesday, March 28, 2023

8:00 am **NCRP Annual Business Meeting**

9:30 am **Break**

Seventh Thomas S. Tenforde Topical Lecture

9:45 am **Introduction of the Lecturer**
Cynthia G. Jones

Embracing Risk-Informed Thinking at the U.S. Nuclear Regulatory Commission
Christopher T. Hanson
U.S. Nuclear Regulatory Commission

The nuclear industry is evolving at a fast pace and there is significant interest and investment in advanced reactors and accident tolerant fuels. The U.S. Nuclear Regulatory Commission (NRC) plays an important role-providing regulatory stability while ensuring the safe and secure use of nuclear material to protect people and the environment. To keep pace with the highly dynamic innovative nuclear landscape in which the NRC operates, the agency must be prepared to regulate emerging technologies and address novel challenges. Embracing and incorporating risk-informed thinking across all facets of the agency is a critical part of the agency's journey as a modern, risk-informed regulator.

Advanced and Small Modular Reactor Critical Issues: Part 2

Willie O. Harris & Cynthia G. Jones, Session Co-Chairs

10:15 am **Radiological Emergency Preparedness: How Risk-Informed Regulation Prepares Us for the Future**
Todd R. Smith
U.S. Nuclear Regulatory Commission

The U.S. Nuclear Regulatory Commission (NRC) is realizing its vision to become a modern risk-informed regulator and is ready to address emergency preparedness for evolutionary nuclear technologies. Advanced reactor designs are expected to have design features that provide simplified, inherent, passive, or other innovative means to accomplish their safety and security functions. These various safety enhancements—different from those of current large light-water reactor technologies—present an opportunity for emergency preparedness (EP) to adapt as well. NRC has issued a final rule on EP for small modular

reactors and other new technologies. The final rule provides a performance-based, technology-inclusive, risk-informed, and consequence-oriented regulatory framework suitable for evolutionary reactor designs. The final rule is consistent with NRC's longstanding graded approach to EP and established planning basis concept. A graded approach is a risk-informed process in which the requirements are set commensurate to the relative radiological risk (consequences), source terms, and the potential hazards of the facility, among other considerations. The risk-informed, consequence-oriented approach considers all potential sources of radiological release including internal and external initiating events, multi-unit and multi-module accidents, and nonradiological hazards from adjacent facilities. The regulation is technology-inclusive to provide flexibility in employing innovative ways to implement required EP functions. The performance-based aspect of the rule requires maintenance and continued demonstration of emergency response functions and emphasizes capabilities over prescriptive planning, consistent with the National Preparedness Goal. Although the future of nuclear technology may look different, EP will be in place to ensure adequate protection of public health and safety.

10:35 am

How do Advanced and Small Modular Reactors Affect the Environmental Impacts of Nuclear Energy
Jessica R. Lovering
Good Energy Collective

This talk will provide a brief overview of how the environmental impacts of nuclear energy may differ for advanced and small modular reactors designs, as compared with traditional, large-scale light-water reactors. We will look at land footprint, water use, and nuclear waste.

10:55 am

Operational Radiation Protection for Small Modular Reactors
John Duhig
Ontario Power Generation

Ontario Power Generation plans to construct four GE Hitachi BWRX-300 small modular reactors at the Darlington nuclear site in Bowmanville, Ontario with commercial operations planned to commence in 2029. Future operations of BWRX-300 reactors and other small and micro modular reactors are expected to be different than currently operating nuclear power reactors. Key differences, such as staffing models, will influence the development of operational radiation protection programs. This presents an opportunity to introduce new radiation protection efficiencies by finding new ways to meet our fundamental requirements and creating fit-for-purpose radiation protection programs.

11:15 am

Radiation Protection Aspects for Advanced Reactors
David Perkins
Electric Power Research Institute

Advancements in nuclear technologies since the 1950s allowed for the development and implementation of commercial light and heavy water reactors in use globally today. Technology advancements over the years have led to the evolution of the Generation III/III+ reactors

to the Generation IV reactors. These advanced reactors include water-cooled small modular reactors (SMR) and nonlight water reactors. Deployment of these advanced reactors have the potential to generate clean, carbon-free electricity and heat, but will also be competing with natural gas, solar, wind, and the existing commercial nuclear fleet. In many cases, the proposed advanced reactors are based on technologies that have already been researched, developed, and deployed over the past six-plus decades. Some of these technologies were operated in demonstration modes as far back as the late 1950s, with few advanced to commercial operations. The operations of these technologies and the data from these technologies is currently very limited, and mostly based on the operation of past research, test, and prototype reactors, and a limited number of commercial reactors.

The Electric Power Research Institute (EPRI) Advanced Nuclear Technology Program, in collaboration with the Nuclear Energy Institute, has developed the advanced reactor roadmap, identifying key enablers and actions to enhance the deployment of these technologies. Further efforts require EPRI to identify the technology gaps and key activities and areas for radiation protection personnel to consider for these future designs. This paper provides an overview of the technology map moving forward and radiation protection considerations.

11:35 am

Closing Panel Discussion:
Cynthia G. Jones, *Moderator*
Jesse Cheatham
Michael Ford
Kathryn A. Higley
Michael G. Houts
Bret Kugelmass

12:00 pm

Wrap-Up
William E. Kennedy, Jr., *Program Chair*

12:10 pm

NCRP Vision for the Future and Program Area Committee Activities
Kathryn A. Higley
President Nominate

12:30 pm

Adjourn

Program Committee

William E. Kennedy, Jr. *Chair*
Anacortes, Washington

Co-Chairs

Willie O. Harris
CN Associates
Bayport, New York

Kathryn A. Higley
Oregon State University
Corvallis, Oregon

Members

Wesley E. Bolch
University of Florida
Gainsville, Florida

Richard R. Brey
Idaho State University
Pocatello, Idaho

Cynthia G. Jones
U.S. Nuclear Regulatory Commission
Washington, DC

Ruth E. McBurney
Conference of Radiation Control Program Directors
Frankfort, Kentucky

Register online: https://ncrp.civdigital.com/2024-annual-meeting/

2025 Annual Meeting

The Million Person Study: Current Results and Vision for Radiation Epidemiology and Protection

John D. Boice, Jr. & Lawrence T. Dauer, *Co-Chairs*

March 24–25, 2025
Bethesda, Maryland

Annual Warren K. Sinclair Keynote Address

Dr. Kathryn D. Huff has been selected to give the 20th Warren K. Sinclair Keynote Address at the 2024 Annual Meeting of the National Council on Radiation Protection and Measurements (NCRP). The Address, entitled "U.S. Department of Energy, Office of Nuclear Energy Advanced Reactor Research, Design, Development and Demonstration," will be a featured presentation at the 60th NCRP Annual Meeting to be held March 25-26, 2024, at the Hyatt Regency Bethesda, Bethesda, Maryland. The Address will be given at 8:30 a.m. on March 25, 2024. The keynote speaker series honors Dr. Warren K. Sinclair, NCRP's second President (1977 to 1991).

Dr. Huff leads the Office of Nuclear Energy as the Assistant Secretary. Before joining the Department of Energy, she was a professor in the Department of Nuclear, Plasma, and Radiological Engineering at the University of Illinois at Urbana-Champaign, where she led the Advanced Reactors and Fuel Cycles Research Group. She was previously a post-doctoral fellow in both the Nuclear Science and Security Consortium and the Berkeley Institute for Data Science at the University of California - Berkeley. She received her PhD in nuclear engineering from the University of Wisconsin-Madison in 2013 and her under-graduate degree in physics from the University of Chicago. Her research has focused on modeling and simulation of advanced nuclear reactors and fuel cycles.

She has previously been an active member of the American Nuclear Society, a past chair of the Nuclear Nonproliferation and Policy Division as well as the Fuel Cycle and Waste Management Division, and recipient of both the Young Member Excellence and Mary Jane Oestmann Professional Women's Achievement awards. Through leadership within Software Carpentry, SciPy, the Hacker Within, and the Journal of Open Source Software, she has also advocated for best practices in open, reproducible scientific computing.

Lauriston S. Taylor Lecture

Dr. Richard A. Meserve has been selected to give the 47th Lauriston S. Taylor Lecture at the 2024 Annual Meeting of the National Council on Radiation Protection and Measurements (NCRP). The Lecture, entitled "Lessons from the Fukushima Daiichi Accident," will be the featured presentation at the 60th Annual Meeting to be held on March 25-26, 2024, at the Hyatt Regency Bethesda, Bethesda, Maryland. The Lecture will be given at 5:00 p.m. on March 25, 2024. The lecture series honors the late Dr. Lauriston S. Taylor, NCRP Founding President (1929 to 1977) and President Emeritus (1977 to 2004).

Dr. Meserve is senior of counsel with the law firm of Covington & Burling, LLP, where he was a partner. He focuses on issues at the intersection of law, regulation, science, and public policy. Dr. Meserve served as the ninth President of the Carnegie Institution for Science from April 2003 through August 2014. From 1999 to 2003, Meserve was chairman of the U.S. Nuclear Regulatory Commission. Early in his career, he served as legal counsel to President Carter's science and technology adviser and was a law clerk to Justice Harry A. Blackmun of the U.S. Supreme Court and to Judge Benjamin Kaplan of the Massachusetts Supreme Judicial Court. Dr. Meserve is former chairman of the International Nuclear Safety Group, chartered by the International Atomic Energy Agency. He is also a former chair of the Nuclear and Radiation Studies Board of the National Academies of Sciences and Engineering and has served as a member of the Blue Ribbon Commission on America's Nuclear Future; the National Commission on Energy Policy; the National Academies Science, Technology, and Law Committee (co-chair); the National Academies Committee on Science, Engineering, and Public Policy; and the MIT Department of Nuclear Science and Engineering Visiting Committee. He serves on numerous legal and scientific committees, including many chartered by the National Academies of Sciences and Engineering.

For the National Academies, Dr. Meserve is Chair of the Committee on Laying the Foundation for New and Advanced Nuclear Reactors in the United States; Co-Chair for the National Science, Technology and Security Roundtable; and a Member of the Committee on International Security and Arms Control. He is an Advisor to the American Academy of Arts and Sciences' (AAAS) Study of the Global Nuclear Future and a Member of AAAS's Committee on New Models for U.S. Science and Technology Policy. He was Chairman of the International Atomic Energy Agency's International Nuclear Safety Group from 2003 to 2022. Dr. Meserve is a Member of the Board of Directors for the Kavli Foundation, TAE Technologies, Inc., and the Energy Futures Initiative Foundation. He is a Fellow of AAAS, the American Association for the Advancement of Science, the American Physical Society, and the Phi Beta Kappa Society.

Dr. Meserve earned a BA from Tufts University; a JD from Harvard Law School, where he was editor of the Harvard Law Review; and a PhD in applied physics from Stanford University. He has been honored with numerous awards over the years.

Thomas S. Tenforde Topical Lecture

Chair Christopher T. Hanson has been selected to give the 7th Thomas S. Tenforde Topical Lecture at the 2024 Annual Meeting of the National Council on Radiation Protection and Measurements (NCRP). The Lecture, entitled "Embracing Risk-Informed Thinking at the Nuclear Regulatory Commission," will be a featured presentation at the 60th NCRP Annual Meeting to be held on March 25-26, 2024, at the Hyatt Regency Bethesda, Bethesda, Maryland. The Lecture will be given at 9:45 a.m. on March 26, 2024. The topical lecture series honors Dr. Thomas S. Tenforde, NCRP's fourth President (2002 to 2012).

The Honorable Christopher T. Hanson was designated Chair of the U.S. Nuclear Regulatory Commission by President Joe Biden, effective January 20, 2021. He was sworn in as a Commissioner on June 8, 2020, and is filling the remainder of a 5 y term ending on June 30, 2024.

Chair Hanson has more than two decades of government and private-sector experience in the field of nuclear energy. Prior to joining the NRC, he served as a Staff Member on the Senate Appropriations Committee, where he oversaw civilian and national security nuclear programs.

Before working in the Senate, Chair Hanson served as a Senior Advisor in the U.S. Department of Energy's Office of Nuclear Energy. He also served in the Office of the Chief Financial Officer, where he oversaw nuclear and environmental cleanup programs and managed the department's relationship with Congressional Appropriations Committees. Prior to joining the department, he served as a consultant at Booz Allen Hamilton, where he led multiple engagements for government and industry in the energy sector.

Chair Hanson earned master's degrees from Yale Divinity School and Yale School of Forestry and Environmental Studies, where he focused on ethics and natural resource economics. He earned a Bachelor of Arts degree in Religious Studies from Valparaiso University in Valparaiso, Indiana.

John D. Boice, Jr., Young Investigator Award

Established in April 2019 by a generous donation by President Emeritus / Director of Science, John D. Boice, Jr., the Young Investigator Award recognizes an early career professional engaged in some aspect of science pertaining to radiation protection and measurements. Dr. Lukas M. Carter has been selected as the fourth recipient of the award that includes a travel grant to attend the annual meeting of NCRP where he will be recognized for his accomplishments.

Dr. Carter is a Resident in the Department of Medical Physics at Memorial Sloan Kettering Cancer Center. He earned his PhD in chemistry, specializing in radiochemistry, from the University of Missouri. He holds a board certification in Nuclear Medicine Physics and Instrumentation from the American Board of Science in Nuclear Medicine.

Dr. Carter's research focuses on internal radiation dosimetry innovation, including software and methods for personalized dose assessment, computational phantom development, and dosimetric uncertainty characterization. He applies his expertise in dosimetry to preclinical, translational, and clinical radiopharmaceutical science, as well as radiation protection. His work also extends to advancing quantitative imaging techniques, including dual-isotope positron emission tomography (PET), nonstandard radionuclides in PET, and numerous basic radiopharmaceutical science collaborations.

Dr. Carter's academic and professional journey is marked by several awards and recognitions, including the Ruth L. Kirschstein National Research Service Award, the Alavi-Mandell Award of the Society of Nuclear Medicine and Molecular Imaging (SNMMI), and he has been recognized as an honoree in the SNMMI “Ones to Watch” campaign. He is an active member of various professional societies and has authored numerous influential publications contributing to the fields of nuclear medicine, radiochemistry, medical physics, and health physics.

Biographies

Abdalla Abou-Jaoude, *Speaker*, is the Advanced Reactor Research Integrator at Idaho National Laboratory (INL). He is leading several projects across seven U.S. Department of Energy (DOE) programs and is a recognized expert on advanced reactor technology. His main three focus areas are: (1) advanced modeling and simulation, (2) molten salt technology, and (3) nuclear technoeconomics. On modeling and simulation, Dr. Abou-Jaoude leads the National Reactor Innovation Center's Virtual Test Bed, and is the Nuclear Energy Advanced Modeling and Simulation Campaign point of contact to the U.S. Nuclear Regulatory Commission. On the molten salt reactor (MSR) side, he is the confirmatory analysis technical lead for the Molten Chloride Reactor Experiment to be built at INL, he manages work packages for various DOE campaigns and Integrated Research Projects on multiphysics simulation of MSRs, and led the first ever fueled chloride salt irradiation in history. On nuclear technoeconomics, Dr. Abou-Jaoude is the activity lead for the Systems Analysis and Integration Campaign on advanced reactor technoeconomic assessment, he manages a project for the Integrated Energy System Campaign on developing advanced reactor cost data for hybrid systems, another for the Microreactor Program on developing detailed cost estimates for microreactors, and a fourth for the Gateway for Accelerated Innovation in Nuclear on creating a database of reference advanced reactor cost estimates.

Previously at INL, Dr. Abou-Jaoude has been involved in various aspect of advance reactor designs, notably for molten salt reactors, sodium fast reactors (namely the Versatile Test Reactor), nuclear space thermal propulsion, and heat-pipe based microreactors. He also previously supported a private-public partnership with a U.S. utility to evaluate hydrogen-cogeneration options at nuclear power plants. He graduated with a doctorate in Nuclear Engineering from Georgia Tech in 2017 and was the INL Deboisblanc Distinguished Postdoctoral Associate in 2018. He obtained a MEng in Mechanical with Nuclear Engineering from Imperial College London in 2013.

Wesley E. Bolch, *Program Committee / Session Co-Chair*, is Professor of Biomedical Engineering and Medical Physics in the J. Crayton Pruitt Family Department of Biomedical Engineering at the University of Florida (UF). He serves as Director of the Advanced Laboratory for Radiation Dosimetry Studies at UF. Dr. Bolch earned his BSE degree in environmental engineering in 1984, his ME and PhD degrees in radiological physics in 1986 and 1998, respectively, from the University of Florida. He has been certified by the American Board of Health Physics since 1994 and licensed in Radiological Health Engineering by the Texas Board of Professional Engineers since 1992. In 2011, Dr. Bolch was elected Fellow of both the Health Physics Society and the American Association of Physicists in Medicine. He has been a member of the Society of Nuclear Medicine's Medical Internal Radiation Dose (MIRD) Committee since 1993, a member of NCRP since 2005, and a member of Committee 2 of the International Commission on Radiological Protection (ICRP) since 2005. Within the latter, he serves as C2 Secretary and Leader of the ICRP Task Group on Computational Phantoms and Radiation Transport. He has published over 200 peer-reviewed journal articles, co-authored/edited 14 books/book chapters, and served as author on two NCRP reports, two ICRP publications, and two MIRD monographs.

Dr. Bolch has managed a broad research program including (1) National Institutes of Health (NIH) and U.S. Department of Energy funded projects to construct high-resolution models of the skeleton to support dose-response studies in radionuclide therapy and radiation epidemiology; (2) NIH funded projects to develop scalable NURBS-based and voxel-based computational phantoms of adult and pediatric patients and associated software for organ dose assessment in nuclear medicine, computed tomography, interventional fluoroscopy, and radiotherapy; (3) private company funded projects to develop stereotactic kilovoltage x-ray treatments for age-related macular degeneration and glaucoma; and (4) Centers for Disease Control and Prevention funded projects in stochastic modeling of worker inhalation and gamma-ray exposures following radiological accidents and potential terrorist events. He is the recipient of the 2014 Distinguish Scientific Achievement Award by the Health Physics Society acknowledging outstanding contributions to the science and technology of radiation safety.

Biographies

Richard R. Brey, *Program Committee / Session Co-Chair*, Professor of Health Physics, Chair Department of Nuclear Engineering and Health Physics, Director of the Idaho State University (ISU) Health Physics Program. Dr. Richard Brey received his PhD from Purdue University in Health Physics in 1994. He was the recipient of the Elda E. Anderson Award in 2002. He has engaged in a wide variety of research varying from radiation physics and detection to agricultural applications of radiation and radiation producing machines, this list importantly includes internal dosimetry; in which he has engaged in various collaborative efforts including the evaluation of historical exposures, evaluation of animal experimental data, and redefining/evaluating radioactive material translocation models. Since 1995 Dr. Brey has been the director of an environmental radioanalytical laboratory which performs approximately 1,200 sample analyses per quarter. Over the years he has served as the Director of the ISU Technical Safety Office and University Radiation Safety Officer as well as in other administrative and technical positions.

Jesse Cheatham, *Speaker*, has worked at TerraPower for 13 y with a technical focus on the development of sodium cooled fast reactor designs. Leading teams on optimizing the technical trade-offs between mechanical, thermal hydraulic, neutronic, and fuels performance of multiple core designs. Innovative work led to 151 patent or patent pending applications covering energy, software, hardware, and nuclear power. Dr. Cheatham received his PhD from the University of Michigan, Ann Arbor and is Professional Engineer.

Gregory V. Cullen, *Speaker*, joined Energy Northwest in 1993 and is the vice president for Energy Services and Development. In this capacity, he is responsible for the operation and maintenance of Energy Northwest's non-nuclear generating projects including hydro, wind, solar, and storage facilities, as well as utility supporting programs and services. Mr. Cullen oversees the development of projects and programs in a broad range of areas, including clean energy generation and storage, electrification, demand response, support services, and advanced nuclear energy demonstration and deployment.

Mr. Cullen holds a BS degree in Engineering Physics from Northwest Nazarene University and an MS degree in Mechanical Engineering from the University of Washington.

John Duhig, *Speaker*, is an ABHP-certified Health Physicist working for Ontario Power Generation on the Darlington New Nuclear Project to construct the first GEH BWRX-300 Small Modular Reactor. Mr. Duhig is certified as a Senior Health Physicist for the Darlington pressurized heavy water reactors and as a Radiation Safety Officer for the Darlington Class II irradiation facility. He previously worked for Laurentis Energy Partners on radioisotope and nuclear byproduct management projects and for Cameco Corporation in the uranium conversion sector. Mr. Duhig has a BS in Medical and Health Physics from McMaster University and a MEng in Nuclear Engineering from Ontario Tech University.

Michael Ford, *Speaker*, is the Associate Laboratory Director for Engineering at the Princeton Plasma Physics Laboratory (PPPL). In this role, he leads the exploration of engineering technologies critical to the development of fusion energy systems and is responsible for all Laboratory engineering support. Dr. Ford is also a Research Fellow at Princeton's Andlinger Center for Energy and the Environment. Dr. Ford previously held positions as Strategy Development Director at Argonne National Laboratory and Environmental Research Fellow at Harvard University. He has published in leading journals such as *Energy Policy* and *Nature Energy*. Dr. Ford led Phase I of the U.S. Department of Energy (DOE)-funded National Demonstration Reactor Siting Study, served as a committee member for the National Academies study "Laying the Foundation for New and Advanced Nuclear Reactors in the United States" and served from 2021 to 2023 as a member of the DOE Nuclear Energy Advisory

Committee. CAPT (Ret) Ford also served a distinguished career as an officer in the U.S. Navy. He commanded the cruiser USS Bunker Hill and the destroyer USS Mustin and served as senior nuclear engineer aboard the aircraft carrier USS Nimitz. He has decades of light water reactor operating experience and was a member of the Navy Nuclear Propulsion Examining Board. Dr. Ford earned his PhD in Engineering at Carnegie Mellon University.

Kathryn D. Held, *President*, became President of the NCRP in January 2019. She held the position of Executive Director and Chief Science Officer from 2016 to 2018. She was first elected to the Council in 2006 and served on the NCRP Board of Directors from 2008 to 2014. She was Vice President from 2011 to 2016 of Program Area Committee 1 on Basic Criteria, Epidemiology, Radiobiology, and Risk. She also served as Chair of the Program Committee for the 2011 Annual Meeting on "Scientific and Policy Challenges of Particle Radiations in Medical Therapy and Space Missions." Dr. Held was a member of Scientific Committee (SC) 1-22 on Radiation Protection for Astronauts in Short-Term Missions and Phase I of SC 1-24 on Radiation Exposures in Space and the Potential of Central Nervous System Effects and an advisor to several NCRP committees.

Dr. Held is an Associate Radiation Biologist in the Department of Radiation Oncology, Massachusetts General Hospital (MGH) and Associate Professor of Radiation Oncology (Radiation Biology) at Harvard Medical School (HMS). At MGH, Dr. Held leads a team that is involved in research on molecular mechanisms for the induction of bystander effects by high energy particles in cells and tissues, characterization of charged particle beam induced DNA damage responses and cell killing, and mechanisms for regulation of DNA damage response by cell-cell communication. Dr. Held also teaches radiation biology to radiation oncology medical and physics residents and graduate students at MGH/HMS.

Dr. Held earned her PhD in biology from the University of Texas, Austin. She has served on review panels for numerous federal agencies including the National Institutes of Health, the National Aeronautics and Space Administration (NASA), and the U.S. Army Medical Research and Material Command programs and other organizations such as the Radiological Society of North America. She is on the Editorial Boards of Radiation Research and the International Journal of Radiation Biology, and has served on committees for the National Academy of Science/National Research Council, NASA, and the American Society of Radiation Oncology. She is a past President of the Radiation Research Society.

Willie O. Harris, *Program Committee Co-Chair / Session Co-Chair*, has over 42 y of experience in radiation protection at power reactors, which has included over 25 y in program management and oversight. Prior to retirement he was the corporate radiation protection manager of the largest fleet of nuclear power plants in the United States. He is currently Senior Director of Radiation Protection for CN Associates. In this role, he has written several technical reports for the Electric Power Research Institute, provides consulting services for several sites in decommissioning and operational radiation protection programs at nuclear power plants.

He holds a bachelor's degree in radiation protection. He is a certified health physicist, a registered radiation protection technologist, and held a senior reactor operator certification.

Mr. Harris has served on the Council since 2017 and is Chair of Program Area Committee 2, a member of the Budget and Finance Committee, and on the Board of Directors of NCRP. He has been a member of the Health Physics Society since 1990. He is currently the Secretary for the AAHP Executive committee.

Kathryn A. Higley, *President Nominate / Program Committee Co-Chair / Session Co-Chair / Speaker*, is the Oregon State University (OSU) Distinguished Professor of Nuclear Science and Engineering. She recently served as the Interim Director for the Center for Quantitative Life Sciences at OSU, a genome-enabled and data-driven, high-performance computing research center in the life and environmental sciences. For more than a decade she was Head of the School of Nuclear Science and Engineering. Dr. Higley received her PhD and MS in Radiological Health Sciences from Colorado State University and her BA in Chemistry from Reed College. She has held Reactor Operator and Senior Reactor Operator's licenses and is a former Reactor Supervisor for the Reed College TRIGA reactor. Dr. Higley started her career as a Radioecologist for Portland General Electric

She later worked for the Pacific Northwest National Laboratory as a Senior Research Scientist in environmental health physics. Dr. Higley has been at Oregon State University since 1994, teaching undergraduate and graduate topics on radioecology, dosimetry, radiation protection, radiochemistry, and radiation biology. She previously served as Vice Chair of the International Commission on Radiological Protection's Committee 4 (Application of the Commission's Recommendations). She is a fellow of the Health Physics Society and a Certified Health Physicist.

Dr. Higley was first elected to the Council in 2014, appointed to the Board of Directors in 2023, and has been a member of the Budget and Finance Committee since 2022. She was Co-Chair of Council Committee (CC) 2 on Meeting the Needs of the Nation for Radiation Protection and a Member of CC 1, Radiation Protection Guidance for the United States; Program Area Committee 5, Environmental Radiation and Radioactive Waste Issues; SC 46-17, Radiation Protection in Educational Institutions; and SC 64-23, Cesium in the Environment. She was a member of the 2016 Annual Meeting Program Committee on "Meeting the Needs of the Nation for Radiation Protection" and presented "Education or Training: Does it Matter?" the same year. Dr. Higley served on the WARP (Where Are the Radiation Professionals?) Initiative Workshop. At the end of the 2024 Annual Meeting she will become the seventh President of NCRP.

Her areas of interest include environmental transport and fate of radionuclides, radioecology, radiochemistry, radiation dose assessment, nuclear emergency response, environmental regulations, and risk communication.

Michael G. Houts, *Speaker*, has a PhD in Nuclear Engineering from the Massachusetts Institute of Technology. He was employed at Los Alamos National Laboratory for 11 y where he served in various positions including Team Leader for Criticality, Reactor, and Radiation Physics and Deputy Group Leader of the 70 person Nuclear Design and Risk Analysis group. Dr. Houts has been a National Aeronautics and Space Administration (NASA) employee for 22 y, and currently serves as Nuclear Research Manager for NASA's Marshall Space Flight Center, and is also the principal investigator for NASA's Space Nuclear Propulsion (SNP) project. Recent awards include a NASA Distinguished Service Medal, a NASA Exceptional Service Medal, a NASA Exceptional Engineering Achievement Medal, and being selected as an Associate Fellow of the American Institute of Aeronautics and Astronautics.

Cynthia G. Jones, *Program Committee / Session Co-Chair*, is a nuclear engineering and health physics expert with nearly 40 y of experience in operational nuclear security, safety, and radiation protection policies. Before retiring in 2023, Dr. Jones served as the U.S. Nuclear Regulatory Commission's (NRC) senior technical expert and Commission-wide resource providing technical advice on nuclear and materials policy, programs, and operational issues associated with advanced reactor design, nuclear security, radiation protection, and international policy. From 2012 to 2016, she worked at the U.S. Mission to International Organizations in Vienna, Austria as Nuclear Safety Attaché on nuclear safety issues and programs providing programmatic and policy oversight for the United Nations and the International Atomic Energy Agency's safety programs on behalf of the United States. In 2015, she was presented with a U.S. State Department Superior Honor Award for her efforts in facilitating a successful U.S. strategy at the 2015 Diplomatic Conference for the Convention on Nuclear Safety. With experience as a physicist, health physicist, and nuclear engineer, Dr. Jones has extensive international experience in both radiation safety and nuclear security, and has more than 95 publications, reports or speeches in the fields of nuclear science and radiation protection.

Before joining NRC, Dr. Jones worked as a physicist at the National Bureau of Standards, and held positions as both a reactor and medical physicist at the University of California, Los Angeles, and the Oak Ridge Institute for Science and Education. She includes German as her foreign language.

Biographies

William E. Kennedy, Jr., *Program Committee Chair / Session Chair*, has extensive experience as a project manager, task leader, and individual contributor covering a broad range of health physics and nuclear engineering topics. He received his BS and MS degrees in Nuclear Engineering from Kansas State University. Mr. Kennedy has been involved in the development of environmental pathway and radiation dosimetry models used to assess potential health and environmental impacts that resulted from releases of radionuclides to the environment.

He specializes in the use of these models in environmental dose reconstruction, radioactive materials transport, radioactive waste disposal, and evaluation of nuclear facility operating practices. Over the past 37 y, Mr Kennedy has led and contributed to a variety of projects for the U.S. Nuclear Regulatory Commission, the U.S. Department of Energy, the Electric Power Research Institute, and private industry. He has been involved with development of the technical basis for revised standards and regulations, and serves as the chair of ANSI/HPSN13.12, Surface and volume Radioactivity Standards for Clearance. He served as a consultant to the International Atomic Energy Agency (IAEA), Vienna, Austria, and was a member of the IAEA Advisory Groups to evaluate the Derivation of Exempt Quantities for Application to Terrestrial Waste Disposal and Derivation of Exempt Quantities for Recycle of Materials from Nuclear Facilities.

He was an invited lecturer for IAEA training courses on Management of Radioactive Waste from Nuclear Power Plants at Argonne National Laboratory; on Safety Assessment Modeling for Low and Intermediate Radwastes in Rio de Janeiro, Brazil and in Cairo, Egypt; and on Environmental Monitoring in Kiev, Ukraine. In 1990, he received the Health Physics Society's (HPS) prestigious Elda E. Anderson Award. He served as a member of the HPS Board of Directors from 1998 through 2001 and was selected as a fellow of the society in 2002. He was a member of the U.S. delegation to the 10th Congress of the International Radiation Protection Association in Hiroshima, Japan.

Bret Kugelmass, *Speaker*, is the Founder and Chief Executive Officer of Last Energy. A visionary entrepreneur and engineer, Mr. Kugelmass has been a leading voice on the essential role nuclear energy plays in achieving deep decarbonization and energy security for the near future.

In 2017, Mr. Kugelmass founded the Energy Impact Center (EIC), a Washington DC-based research institute. Over the course of 5 y EIC engaged in intense global industry and governmental collaboration becoming an internationally regarded thought leader on the role of nuclear power in accelerating the transition to clean energy. Their work on fast-tracking deployment roadmaps for small modular reactors became the basis of their key subject matter contributions to the governments of the United States, United Kingdom, Netherlands, and Sweden.

Building upon a foundation of engineering excellence, years of nuclear industry research, strong government credibility, and access to private capital, Mr. Kugelmass navigated the organizational transition leading EIC to become a full-fledged commercial developer of small modular reactors, emerging as Last Energy. With a goal of revolutionizing the delivery model for nuclear power, Last Energy aims to accelerate the global energy transition to abundant clean power, ushering in a new future of human flourishing. A former Silicon Valley entrepreneur, Mr. Kugelmass is known for his work pioneering autonomous aerospace technology. He received his Masters degree in Mechanical Engineering from Stanford University.

Jessica R. Lovering, *Speaker*, is the co-founder and Executive Director of Good Energy Collective, a new organization building the progressive case for nuclear energy as an essential part of the broader climate change agenda and working to align the clean energy space with environmental justice and sustainability goals. She completed her PhD in Engineering and Public Policy at Carnegie Mellon University. Her dissertation focused on how commercial nuclear trade affects international security standards and how very small nuclear reactors could be deployed at the community level. She is a Fellow with the Energy for Growth Hub, looking at how advanced nuclear can be deployed in sub-Saharan Africa, and a Senior Visiting Fellow with the Fastest Path to Zero Initiative at the University of Michigan.

Biographies

Matt Mahowald, *Speaker*, started professional life as an underwater astronaut (U.S. Naval Submarine Engineering Laboratory Technician and Scuba Diver). Following, he worked at the Massachusetts Institute of Technology Nuclear Reactor Research Laboratory (NRL) managing radiation protection programs including reactor radiochemistry, radiological survey, training plant operators, and other standard reactor focused radiation protection programs. These efforts supported the NRL mission as a National Science User Facility for material irradiation and experimentation as well as commercial processes including, but not limited to, neutron transmutational doping of high purity silicon.

Design and implementation of irradiations studying molten salt coolants, tritium migration, TRISO and silicon carbide cladding performance are among the research he directly supported. The variety of research irradiation, ability to be involved in wide ranging health physics topics, and wonderful campus environment kept him there for 12 y. Seeing the promising performance of TRISO fuel, the grant award of the Advanced Reactor Development Project and the novel high temperature gas reactor design of X-Energy, he started there in 2022 with the charge of aiding in plant design for as low as reasonably achievable and building the XE-100 Operational Radiation Protection Program through construction to initial criticality and commercial operation.

Ruth E. McBurney, *Program Committee / Session Co-Chair*, is the Executive Director of the Conference of Radiation Control Program Directors. In that position, she manages and directs the administrative office for the organization. Prior to taking that position in January 2007, she was the Manager of the Radiation Safety Licensing Branch at the Texas Department of State Health Services, culminating 25 y of service in the Texas Radiation Control Program, most of which involved licensing and standards development.

Ms. McBurney has served on the U.S. Nuclear Regulatory Commission's Advisory Committee on the Medical Use of Isotopes and the U.S. Food and Drug Administration's National Mammography Quality Assurance Advisory Committee. She is currently serving as a Member of NCRP, and has served on the Board of Directors. She served as a consultant to the International Atomic Energy Agency in the categorization of radiation sources and recently served on a committee of the National Academy of Science regarding replacement technologies for high-risk radiation sources. She has also been a U.S. delegate to the International Radiation Protection Association's 10th, 11th, 12th, and 13th Congresses.

Ms. McBurney holds a BS in Biology from Henderson State University in Arkansas and an MS in Radiation Sciences from the University of Arkansas for Medical Sciences. She is also certified in comprehensive health physics by the American Board of Health Physics.

Steven M. Mirsky, *Speaker*, is a nuclear-mechanical engineer and licensed Professional Engineer with over 48 y of nuclear industry experience. His career has included design, engineering, safety analysis, operations, project management, auditing, supervision, management, and executive positions at two nuclear international consulting corporations (nuclear utility services and Science Applications International Corporation) and at two U.S. nuclear power plant owner/licensees (Virginia Electric and Power Company and Baltimore Gas and Electric) before joining NuScale Power. Mr. Mirsky has authored over 100 publications and holds six patents. He has worked for NuScale Power for over 11 y with the first 5 y as the Small Modular Reactor (SMR) Design Certification Application Licensing Manager responsible for the Rockville Maryland office and U.S. Nuclear Regulatory Commission interactions. He is currently a Senior Technical Advisor involved in advanced applications and design improvements to the NuScale SMR and in the design and deployment of the NuScale micro-reactor.

David Perkins, *Speaker*, is a Senior Technical Executive for Electric Power Research Institute (EPRI) serving in the Fuels - Chemistry Program. His current research activities focus on water chemistry and radiation safety technology transfer and support for EPRI members and program participants.

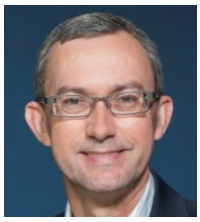
Mr. Perkins's work experience has typically been focused in the radiation protection and pressurized water reactor chemistry controls including potassium hydroxide and zinc injection and source term controls, radiation management, inline and online monitoring, and data analysis. His most recent work has been working with the EPRI Smart Chemistry team, source term, alpha controls and monitoring, inline gamma spectroscopy, data

analysis, and technical transfer internationally. Mr. Perkins has supported many utilities in a variety of assessments focused on pressurized water reactor chemistry controls and optimization processes, source term management, and the as low as reasonably achievable (ALARA) principle.

Before joining EPRI, Mr. Perkins was the Chemistry Manager at Comanche Peak Nuclear Power Plant and worked in many other roles over a 14 y career at the plant site. His responsibilities included: management of the chemistry department technical programs and staff, radiochemistry analysis and operating equipment, focused efforts included active participation in the station ALARA, outage planning and preparation, and technology implementation. He supported many of the aspects that led the effort to implementation of the high pressurized water reactor primary coolant pH program including materials, fuels and chemistry control reviews.

Mr. Perkins received a BS-AST in Nuclear Engineering Technology and an AS-AST in Radiation Protection from Thomas Edison State College and an AAS in Business from Tarrant County College.

Per F. Peterson, *Speaker*, is Co-Founder and Chief Nuclear Officer at Kairos Power, a mission-driven company that is disrupting the industry with iterative development and vertical integration strategies to commercialize a safe and affordable advanced reactor technology in time to impact climate change. Dr. Peterson also holds the William and Jean McCallum Floyd Chair in the Department of Nuclear Engineering at University of California Berkeley. He is an expert in topics related to high-temperature fission energy systems, safety and security of nuclear materials, and waste management. In 2003, he and collaborators proposed the original concept for a molten-salt cooled, solid fueled reactor – the basis for Kairos Power fluoride salt-cooled high temperature reactor.



Everett L. Redmond, II, *Speaker*, is Senior Director Fuel Affairs at Oklo. He is responsible for Oklo's efforts related to fuel fabrication, fuel disposition, and other fuel-related issues including enrichment and deconversion. Dr. Redmond also supports Oklo's government affairs and policy activities. He has been with Oklo since September 2022.

Prior to joining Oklo, Dr. Redmond was a Senior Technical Advisor at the Nuclear Energy Institute (NEI) where he was responsible for programs and policy efforts to support development and commercialization of advanced reactor technologies. While at NEI, he also focused on the uranium fuel supply chain, nonproliferation, and coordinating industry policies related to the front and back end of the fuel cycle including storage and transportation. Dr. Redmond was with NEI from 2006 to 2022. Before joining NEI, he was a Principal Engineer at Holtec International from 1996 through 2006 where he worked on the radiological design of spent fuel storage systems. Dr. Redmond holds a PhD from the Massachusetts Institute of Technology in Nuclear Engineering (1997).

Daniel Schultheisz, *Speaker*, is the Associate Director of the Center for Waste Management and Regulations in the U.S. Environmental Protection Agency's (EPA) Radiation Protection Division. He has led or participated in numerous rulemakings, including as part of the team developing EPA's standards for the proposed repository at Yucca Mountain. He also represents EPA in international activities, including as a member of the Organisation for Economic Co-operation and Development/Nuclear Energy Agency's Radioactive Waste Management Committee.

Jeffrey D. Semancik, *Speaker*, has served as the Radiation Division Director for the Connecticut Department of Energy and Environmental Protection since 2014. Mr. Semancik has served as the chair of the Conference of Radiation Control Program Directors and is active in several working groups including the Committees on Commercial Nuclear Power and on the Naval Nuclear Propulsion Program. He is the U.S. Nuclear Regulatory Commission State Liaison Officer for Connecticut and a type 1 Radiological Operations Support Specialist. He recently served as a member of the National Academies of Science, Engineering and Medicine committee that authored the report on, *Merits and Viability of Different Nuclear Fuel Cycles and Technology Options and the*

Biographies

Waste Aspects of Advanced Nuclear Reactors. Mr. Semancik previously worked at Millstone Nuclear Power Station as a senior licensed reactor operator and member of the station management team. He started his career an officer in the U.S. Navy nuclear program. He holds a BS in physics from the U.S. Naval Academy, an MS in electrical engineering from Rensselaer Polytechnic Institute, and an MBA from the University of Connecticut.

Todd R. Smith, *Speaker*, is the Senior Level Advisor for Emergency Preparedness and Response in the Office of Nuclear Security and Incident Response at the U.S. Nuclear Regulatory Commission (NRC). He previously served in the Policy and Oversight Branch developing emergency preparedness policies, regulations, and guidelines for NRC-licensed facilities and conducting related research to advance the state-of-the-practice in radiological emergency preparedness and response. Prior to joining the NRC, Dr. Smith served in the U.S. Navy as a Submarine Warfare Officer, including assignments as Chemistry and Radiological Controls Assistant, Naval Reactors Lead Engineer for Advanced Reactor Digital Instrumentation and Control, Engineering Department Head, and Special Assistant for Radiological Emergency Planning at Submarine Group 10 in Kings Bay, Georgia. He graduated from Purdue University with an MS and PhD in Nuclear Engineering, specializing in thermal-hydraulics and reactor safety, and holds an MS in Radiation Health Physics from Oregon State University.

Jama D. VanHorne-Sealy, *Speaker*, currently serves as the Director for Occupational Health, including health physics, for the Army Office of the Surgeon General. She previously served as the Manager of the Army Reactor Program, Chief of Health Physics at Army Public Health Center, and as the Nuclear Effects Advisor for the U.S. Army Nuclear and Countering Weapons of Mass Destruction Agency. She was Interagency project lead for the National Radiation Emergency Medical Education and Training Project, wrote the Army's assessment on readiness to fight in a radiologically contaminated battlefield for the President's 2018 Nuclear Posture Review, and served as technical advisor on 11 different Army-wide future radiation-related capabilities projects.

Colonel VanHorne-Sealy served as Director of Radiation Safety and as Assistant Professor of Preventive Medicine and Biometrics for the Uniformed Services University of the Health Sciences. She led the U.S. Department of Defense's Medical Radiobiology Advisor Team and served as Instructor for Armed Forces Radiobiology Research Institute. During the Fukushima Reactor release in Japan, she established an in-country presumptive radiation detection laboratory for the Pacific U.S. Forces and served as a technical advisor to U.S. Forces Japan and U.S. embassy staff. She developed and implemented the first Radiation Safety Program for U.S. Forces in Afghanistan, for which she was selected as the Preventive Medicine Officer of the Year for Deployment.

She is a Fellow of the Health Physics Society and a previous member of the Board of Directors. Her awards include Legion of Merit, Bronze Star, Defense Meritorious Service Medal, and three Meritorious Service Medals.

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Contracts/Grants/Contributors/Sponsors

These organizations have supported the work of the National Council on Radiation Protection and Measurements during the period of January 1 to December 31, 2023.

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