

Key Note Lecture 1



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Challenges for Instrumentation, Controls, and Human-Machine Interface Technologies in Current and Future Nuclear Power Plants

Instrumentation, controls, and human-machine interfaces are essential enabling technologies that strongly influence nuclear power plant performance and operational costs. The nuclear power industry is currently engaged in a transition from traditional analog-based instrumentation, controls, and human-machine interface (ICHMI) systems to fully (apart from the transducer element) digital systems. This transition has primarily occurred in an ad hoc fashion through individual system upgrades at existing plants and has been constrained by licenseability concerns. Although international implementation of evolutionary nuclear power plants and the expectation of new plants in the United States have spurred design of more fully digital plant-wide ICHMI systems, the experience base in the nuclear power application domain is limited. Additionally, design and development programs by the U.S. Department of Energy (DOE) for advanced reactor concepts, such as the Generation IV (Gen IV) Program and Next Generation Nuclear Plant (NGNP), introduce different plant conditions (e.g.,

higher temperatures, different coolants, etc.) and unique plant configurations (e.g., multi-unit plants based on small reactors with shared systems, balance of plant architectures with reconfigurable co-generation options) increase the need for enhanced ICHMI capabilities to fully achieve programmatic goals related to economic competitiveness, safety and reliability, sustainability, and proliferation resistance and physical protection. As a result, significant challenges remain to be addressed to enable the nuclear power industry to effectively and efficiently complete the transition to safe and comprehensive use of modern ICHMI technology.

To respond to the technology challenges, a preliminary technology research, development, and demonstration (RD&D) roadmap is under development by ICHMI technology experts. This roadmapping effort is focused on the ICHMI issues associated with the NNGP and Gen IV programs but can serve as the basis for establishing a cross-cut program among all DOE nuclear power programs to leverage effort on common issues. The roadmap identifies and describes a variety of programmatic goals related to ICHMI, challenges to accomplishing these goals, and the technological needs and innovations that will be necessary to overcome these challenges.

This talk summarizes the technologies encompassed within the ICHMI field, describes the status of ICHMI technology usage in nuclear power plants, discusses the rationale for developing and applying advanced ICHMI technologies within nuclear power plants, and identifies recommended technology RD&D focus areas.

David E. Holcomb

David E. Holcomb has been an Oak Ridge National Laboratory (ORNL) research scientist for 14 years where he has focused on nuclear power reactor instrumentation and controls (I&C), radiation detector materials, reactor physics, temperature measurement, and sensors for harsh environments.

Dr. Holcomb holds a Ph.D. in nuclear engineering from The Ohio State University (OSU) (March 1992), an M.S. in nuclear engineering also from OSU (June 1990), and a B.S. degree in engineering science specializing in engineering physics from Colorado State University (May 1987). Dr. Holcomb has also served as an Adjunct Assistant Professor at the University of Tennessee, Knoxville, in the Nuclear Engineering Department since 1995. He is a member of the American Nuclear Society, where he is the incoming vice chair of the Human Factors Division, and the Institute of Electrical

and Electronics Engineers. Dr. Holcomb recently served as the technical chair for instrumentation and controls at the Nuclear Power Instrumentation, Controls, and Human Machine Interface Technologies (NPIC&HMIT 2006) ANS topical meeting. Dr. Holcomb has also served as a co-chair of an International Atomic Energy Agency (IAEA) technical meeting on nuclear power instrumentation held in Knoxville, Tennessee in 2005. Dr. Holcomb holds four patents and has previously served as the chair of the ASTM International subcommittee on fundamentals of temperature measurement. Dr. Holcomb has also advised a national academy of science national materials advisory board on improving energy efficiency within the manufacturing sector through improved process controls.

Dr. Holcomb is a member of the advanced reactors systems and safety group within the ORNL Nuclear Science and Technology Division. He has until recently been serving as the ORNL team lead for space reactor instrumentation. He is currently the U.S. principal investigator for an ongoing Department of Energy (DOE) sponsored International Nuclear Energy Research Initiative (I-NERI) project between ORNL, Westinghouse, and the Instituto de Pesquisas Energéticas e Nucleares in Brazil focused on developing advanced instrumentation and controls for integral primary systems reactors. Dr. Holcomb has also recently lead a U.S. Department of Energy National Nuclear Security Administration (DOE/NNSA) Office Of Non Proliferation Research and Engineering project on growth and application of zinc metaborate as a semiconductor type neutron detector. Dr. Holcomb also currently serves as the chief technical advisor on a DOE/NNSA project to develop arrays of miniature ^3He detectors for improved efficiency field neutron detection. Dr. Holcomb has in the recent past served as the U.S. principal investigator on an I-NERI project (focused on developing improved sensing and controls for nuclear power plants) between ORNL and OSU representing the U.S. and the Korean Atomic Energy Research Institute, Chosun University, and Cheju National University representing South Korea. Dr. Holcomb has also recently led a DOE sponsored nuclear energy research initiative project to develop a scintillation based neutron flux and temperature probe for use at high temperature reactors.

Dr. Holcomb continues as a member of the DOE office of Nuclear Energy advisory team recommending the technology development path for instrumentation, controls, and human machine interface technology. Additionally he continues to serve as a reactor physics and instrumentation technical advisor to the DOE sponsored gas turbine

modular helium reactor project and has in the past been a member of ORNL's high flux isotope reactor experimental review committee. Dr. Holcomb was also the principal investigator for a project to develop an amorphous hydrated silicon based pixelated beam line monitor for the Spallation Neutron Source (SNS) and a project to develop improved neutron phosphors for the SNS. Dr. Holcomb also led an ORNL Laboratory Director's Research and Development project on developing solid-state neutron detector materials. Dr. Holcomb was the co-inventor for an alpha particle based process to assist cellular genetic material transfer. He served as the task lead on a DOE sponsored project to assess the impact of improved harsh environment sensors on U.S. energy usage and waste production. Dr. Holcomb has also served as an advisor to U.S. Nuclear Regulatory Commission (NRC) staff on advanced instrumentation technology. He is currently a senior technical contributor on all of ORNL's digital I&C projects for the NRC.