HFICD
A Division of the American Nuclear Society

HUMAN FACTORS, INSTRUMENTATION & CONTROLS
DIVISION OF THE AMERICAN NUCLEAR SOCIETY

SPRING 2015 NEWSLETTER
http://hficd.ans.org

RAISING THE BAR:
NPIC-HMIT CONFERENCE 2015

HFICD sponsored the 9th International Conference on Nuclear Plant Instrumentation, Control & Human–Machine Interface Technologies (NPIC & HMIT 2015), which was successfully held at The Westin Charlotte Hotel in Charlotte, North Carolina (USA), from February 23–26, 2015. This topical meeting of ANS is the premier forum for nuclear instrumentation and control (I&C) and human factors engineering professionals to meet with leaders within the industry and academia, gauge the state of the technology, exchange information, and discuss future directions.

Overseen by General Chair Dr. H.M. Hashemian, President and CEO of Analysis and Measurement Services Corporation (AMS), this year's NPIC & HMIT conference had a spectacular turnout with over 440 participants from 26 different countries and more than 350 papers submitted. More than 60 technical sessions included scientific and technical papers presented by numerous participants from utilities, academia, government, and suppliers across the world. Technical sessions covered a wide range of issues, from day-to-day operational challenges and regulatory issues to advanced technology topics, contributing to a well-rounded view of the past, present, and future of I&C and HMI technologies.

Plenary sessions were held on the first three mornings of the conference and featured excellent speakers from high-level government officials, executives of nuclear utilities, and vendor organizations. Plenary topics focused on a range of I&C and HMI issues, from nuclear cyber security to modernization of nuclear plant I&C and improved nuclear safety.

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THOUGHTS FROM THE CHAIR

—John M. Mahoney

It has been a great winter! Our team of leaders worked tirelessly to make the 9th International Conference on Nuclear Plant Instrumentation, Control & Human–Machine Interface Technologies (NPIC & HMIT) held February 23rd - 26th in Charlotte a premier conference for our Division and the ANS. The results are in and proven – the best attendance and participation in the history of the Division. Dr. Hashemian, our Program General Chair and his project team brought us industry experts to discuss key focus areas at the forefront of the challenges that affect nuclear energy options for our future. This year's NPIC & HMIT Conference exceeded our projections of more than 400 attendees and our vendor exhibitors were extremely happy with the opportunities that the conference brings with new and return business. Our vendor participation has been expanding and that tells us we are on-track to align with industry businesses and the solution that they provide.

With such a wonderful success behind us, we have already started planning and have announced our Program General Co-chairs for the 10th International NPIC & HMIT Conference in 2017. Sacit M. Cetiner, who was our 2015 Technical Program Chair will host the 2017 event along with Clayton Scott. Please take an opportunity to congratulate them and discuss opportunities to volunteer.

Memberships in our division continue to grow with new statistics just released in April indicating we are at 765 members growing more that more than 15% over the past year.

I believe that growth is founded on our 4 strategic mission components I discussed in the last newsletter:

- Professional Development - encourage development and recognize achievement and performance.
- Sharing Information and Advancements in Technology –regularly inform members and provide information about science, standards, and technologies.
- Growing HFICD Membership - grow membership and remain dedicated to mission.
- Engaging the Public and Policy Makers – Support ANS outreach programs that increase awareness and contributions of nuclear science and technology to meet societal needs and improve our quality of life.

Thanks to your individual and collective efforts. The future will be better for it!

Kindest Regards,

John Mahoney, PMP
HFICD 2014–2015 Chair

EPRI | Instrumentation and Control Notes

Two guidance documents that EPRI developed with Luminant and other nuclear utilities help suppliers understand exactly what utilities need to establish effective cyber security requirements. EPRI Reports 1025824 (Cyber Security Procurement Methodology) and 1019187 (Technical Guideline for Cyber Security Requirements and Life Cycle Implementation Guidelines for Nuclear Plant Digital Systems) are revolutionizing the way all power generation plants – not just nuclear power facilities – are solving cyber security challenges. The documents establish a dependable, standard approach to cyber security that will last over time. Luminant has been able to detect and solve problems early in the con¬tracts phase, thereby avoiding cyber security-related missteps during the design phase that can cause increases in the scope and budget or cre¬ate workarounds.

NPIC-HMIT CONFERENCE 2015

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Speakers of particular note included U.S. NRC Commissioner William Ostendorff, who discussed how cyber security issues will be a continual challenge, even with the NRC making significant progress in this area; Mr. Ken Canavan, Director of Plant Technology at EPRI, who gave an in-depth discussion on how advancing risk technology is shaping the future of nuclear power; and Mr. Preston Gillespie, Senior Vice President of Nuclear Operations at Duke Energy, who gave an engaging presentation on digital applications in a nuclear environment.

The conference banquet, held on Tuesday February 24 at the NASCAR Hall of Fame in uptown Charlotte, included an awards ceremony recognizing the conference's major sponsors and HFICD 2014 Don Miller Award winners, Dr. Hidekazu Yoshikawa and Dr. Douglas Chapin. The evening was rounded out with live music, cocktails, and an elegant sit-down dinner. Conference attendees experienced full access to the 40,000 square-foot exhibit space and enjoyed interactive exhibits that showcased the history and heritage of NASCAR.

The NPIC & HMIT 2015 Conference was co-sponsored by a number of national and international organizations, industry suppliers, national and international laboratories, academic institutions, and media partners.

In addition, considerable support for the conference was received from the international I&C and HMI community, as well as a number of conference funding sponsors. Major donors included Schneider Electric, Rolls-Royce, and Westinghouse. In addition, more than 30 exhibitors took part in the conference, showcasing their latest technologies, products, and services. Overall, the conference was an enormous success, and one of the most lively and relevant topical meetings by ANS in recent years. The next NPIC & HMIT Conference is currently planned as an embedded topical at the 2017 ANS Annual Meeting in San Francisco.

2015 HFICD OFFICIALS

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Dan Santos

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Term Ending in 2017
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Upcoming ANS Meetings

2015 ANS Annual Meeting
JUNE 7–11, 2015
"Nuclear Technology: An Essential Part of the Solution"
San Antonio, Texas
Grand Hyatt San Antonio
- Division Program Committee Meeting:
  Sunday June 7 from 11am - 12pm
  Meetin room TBD
- Division Executive Committee Meeting:
  Sunday June 7 from 12pm - 2pm
  Meeting room TBD

Utility Working Conference and Vendor Technology Expo
AUGUST 9–12, 2015
Amelia Island, Florida
Omni Amelia Island Plantation

2015 ANS Winter Meeting and Nuclear Technology Expo
NOVEMBER 8–12, 2015
Washington, D.C.
Marriott Wardman Park

2016 ANS Annual Meeting
June 12-16, 2016
New Orleans, Louisiana
Hyatt Regency New Orleans

ABOUT HFICD — WHO WE ARE

The Human Factors, Instrumentation & Controls Division (HFICD) of the American Nuclear Society (ANS) is devoted to the human component of nuclear energy, along with the underlying instrumentation, control, and human–machine interface technologies. HFICD has been part of the ANS since 1979, when the Technical Group for Human Factors was formed. The Group became a division in 1985 and was broadened to include Instrumentation & Controls in 2008. Today, the HFICD has more than 800 members (166 working in utilities, 128 consultants, 99 educators, and many others).

The HFICD focuses on the information processing, control, and human system interaction aspects of nuclear systems. This includes the sensors that transduce physical processes into signals, monitoring, control and communications systems that process data into information and manage control and protective actions, the interfaces that display plant operational and health information, and the human cognitive capabilities that enable perception and interpretation of information.

Among the HFICD's main goals are to disseminate HFICD information among its members and to promote HFICD–related activities in the nuclear power industry.

Human Factors, Instrumentation & Controls Division Growth

HFICD has progressed significantly to 765 members in 2015 with an overall increase of 37% in the last 10 years. Between 2005 and 2008, the annual membership increased from 557 to 592 members.

In the next three years from 2008 to 2011, there was a drastic increase going from 592 to 768 members. This increase in membership was synchronous with the resurgence of nuclear power with the rise of the new generation of reactors, leading to innovative solutions for alternative energy. The modernization of instrumentation and control technologies from analog to digital, related problems of software reliability and common cause, issues with cyber-security, multi-modular control rooms, potential applications of online monitoring have been calling attention to the field of human interfaces and instrumentation and control. HFICD's expansion over the years can be found in Figure 1.

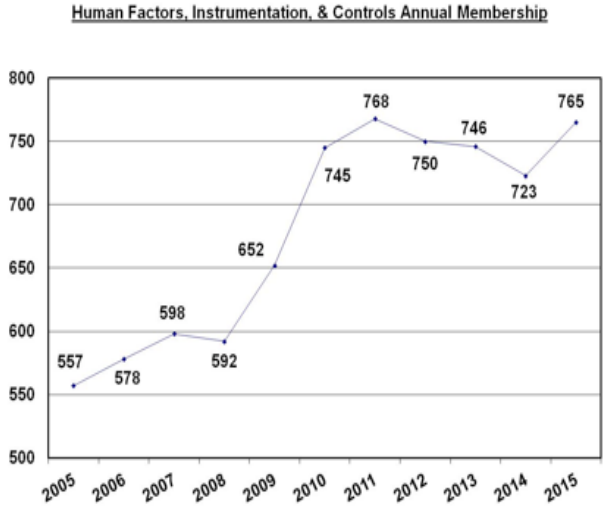


Figure 1: HFICD Annual Membership for the past 15 years.

EPRI | Instrumentation and Control Notes

Because nuclear plants in the United States originally were analog based, the number of engineers with experience in the new digital instrumentation and control technologies is limited. In preparing to implement, operate, and maintain digital systems, utilities must enhance their in-house digital expertise at all levels. Taking an industry-wide approach, Exelon and NextEra Energy collaborated with EPRI to develop training materials that could be used or modified to comply with Institute of Nuclear Power Operations (INPO) requirements, and to identify what materials still needed to be developed. Long term, use of the training modules can reduce the risk of expensive plant mishaps by enabling engineers to find and mitigate potential digital system vulnerabilities before the systems are installed and operating.

ABOUT HFICD — WHO WE ARE

As seen in Figure 2, division members are found across all sectors of the nuclear field from utility, manufacturing, suppliers, consulting companies, national labs, government agencies, students to educational institutions. Utility and consulting companies make up the highest fraction of membership, with both sectors holding 16% of total membership each. Manufacturing, Suppliers and Students take up the second highest percent membership with 8% each of the total members of HFICD as of this year.

EPRI | Human Factors Notes

When upgrading I&C systems with newer digital technologies, some plants have chosen not to make any significant changes to the main control room so as to avoid creating any human factors or operability issues. As a result they are not able to take advantage of capabilities offered by more modern I&C and HSI technology that could potentially enhance safety and operability of the plant. An effective HFE program can help define the appropriate level and types of HFE activities that should be performed as part of the modification engineering process to: 1) take advantage of new system capabilities that can improve human performance, 2) design and implement the changes in a way that does not create any new human factors or operability issues, 3) ensure that the HFE design basis is maintained, 4) ensure that the modification will not lead to degradation in human performance, 5) ensure potential opportunities to improve human performance through appropriate HFE design will be identified and implemented as appropriate, and 6) meet regulatory requirements and expectations regarding application of HFE when needed.

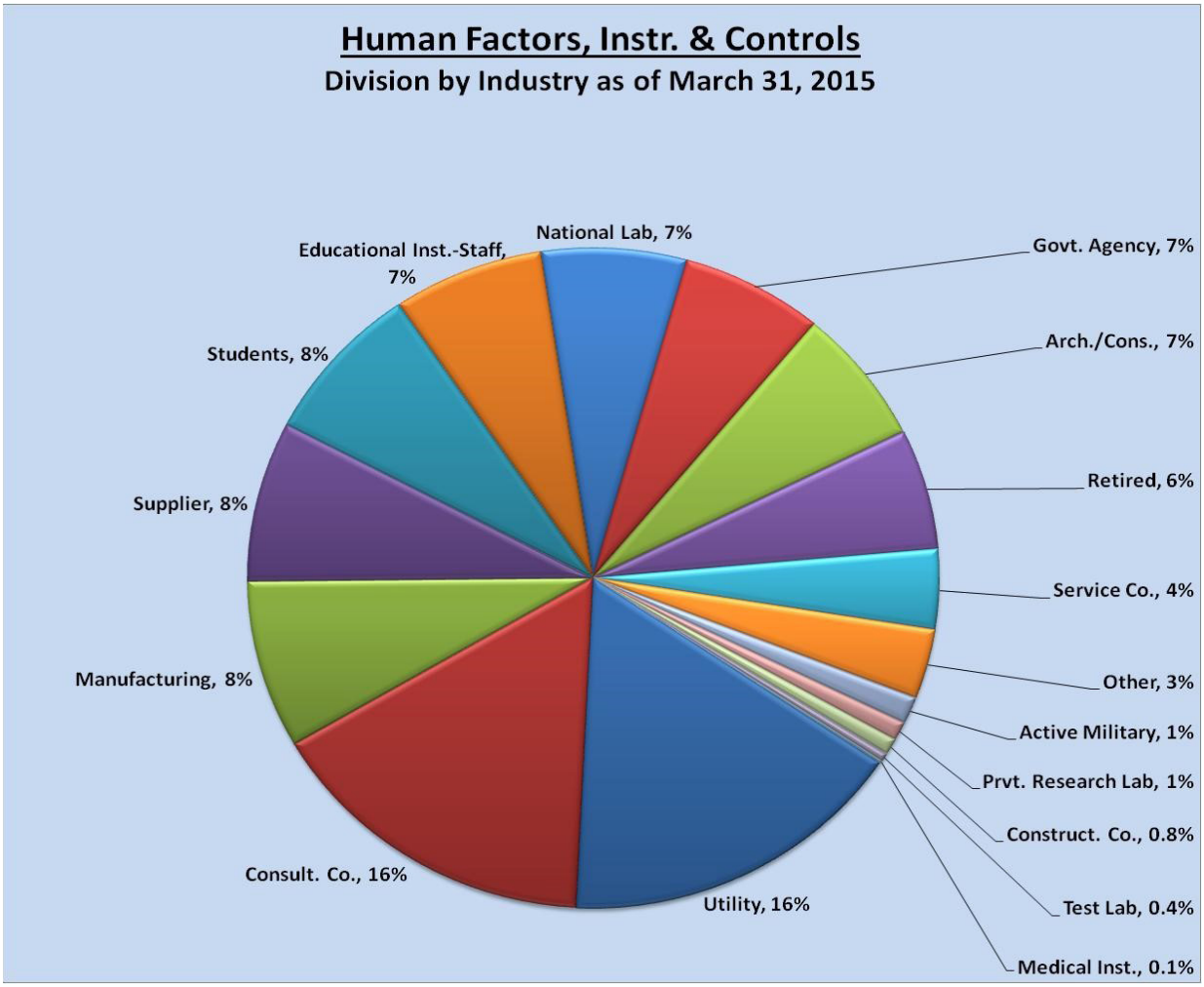
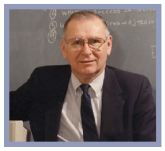


Figure 2: HFICD membership by industry.

ANS-HFICD SCHOLARSHIP


Dr. R. E. Uhrig

Human Factors, Instrumentation & Controls Division Announces the First Recipient of the Robert E. Uhrig Graduate Scholarship

Mr. Zachary Welz was named the inaugural winner of the Robert E. Uhrig, Human Factors Instrumentation and Control Division (HFICD) Graduate Scholarship. The Robert E. Uhrig Graduate Scholarship is a $4,000 scholarship given annually to one graduate student in nuclear engineering whose research focuses on technical disciplines related to Instrumentation and Control and Human–Machine Interface Technologies for nuclear power or other nuclear engineering applications.

Zach is a first year graduate student at the University of Tennessee working under Dr. Wes Hines, who was once a Research Assistant Professor for Dr. Uhrig. Zach performs research in the development of advanced prognostic algorithms, and, more recently, in the development of a framework for implementation of lifecycle prognostics. The implementation requires data mining algorithms to extract data related to the time in service, service stresses, and condition of high value or safety critical nuclear power plant assets from the plant computer and the computerized maintenance management system (CMMS). He is funded by Lloyds Registry Foundation to work on a project entitled "An International Joint Research Centre for the Safety of Nuclear Energy". Zach is also the student representative for the HFICD executive committee. Zach completed his Master's degree in Nuclear Engineering in Spring, 2015 and expects to complete his Ph.D. in 2018.

He was the lead author on an international conference paper titled "Prognostics for Light Water Reactor Sustainability: Empirical Methods for Heat Exchanger Prognostic Lifetime Predictions," which received the 2nd European Conference of the Prognostics and Health Management Society (PHME'14) Best Paper Award in Nantes, France, July 8-10, 2014. The paper was invited for a journal submission, which is currently under review.

Zach's advisor states, "Zach has shown key characteristics of a successful Ph.D. student. He is a fabulous student who has demonstrated a capacity to learn independently. Zach is a great communicator and hard worker." The division expects great things from Zach in the future.


Dr. Wes Hines and Zach working on a heat exchanger fouling test bed.

EPRI | Human Factors Notes

An effective HFE program can help define the appropriate level and types of HFE activities that should be performed as part of the plant's modification engineering process. The Electric Power Research Institute's report 3002002770 "Guidance for Developing a Human Factors Engineering Program for an Operating Nuclear Power Plant", published in December 2014, provides guidance for utilities on developing a HFE program for modifications made to operating nuclear power plants. The guidance is applicable to new builds once they begin operation and the utility takes over HFE design responsibility. The report addresses development of HFE programs for individual plants as well as fleet-wide programs that provide a standard approach that can be adapted for application at specific sites.

INSTRUMENTATION & CONTROL FOCUS:

IN-SITU CONDITION MONITORING OF COMPONENTS IN SMALL MODULAR REACTORS USING PROCESS AND ELECTRICAL SIGNATURE ANALYSIS

For reliable and economic long-term operation of Small Modular Reactors (SMRs), continuous in-situ monitoring of critical equipment must be developed and incorporated in the reactor design phase. This capability is attractive for remote deployment of SMRs with longer fuel cycles and for minimizing unplanned outages, thus enhancing the utilization of these power-generating systems in small electric grid environments. These technologies contribute to smart condition-based maintenance, reduced human resources, remote monitoring of reactor components, and semi-autonomous operation and are also important for monitoring critical parameters during severe accidents and for post-accident recovery.

Small integral light water reactors have in-vessel space constraints and many of the traditional instrumentation are not practical in actual implementation. In order to resolve this issue, research is being performed to develop techniques for indirect measurement of process parameters. Examples of some of the process measurements of interest are primary coolant flow rate in the reactor vessel, characteristics of motor-driven coolant pumps, and water levels in steam generators.

Research and development, funded by a grant from the US DOE Nuclear Energy University Program (NEUP), was performed to develop and demonstrate in-situ equipment monitoring methods for SMRs with applications to reactor internals such as coolant pumps, valve-actuators, and control rod drive mechanisms. The overall objective was to integrate electric signature analysis (ESA) [1] and process measurements to perform remote monitoring of SMR components.

The focus of this research is to develop monitoring and diagnostics methods using easily accessible measurements. Both experimental and physics-based modeling approaches were developed to establish the feasibility of implementing such techniques and incorporate them during the SMR design phase.

One of the goals of the current research is to develop non-invasive techniques for monitoring key reactor parameters. Inferential methods, which relate the process parameter of interest to a measurement that is accessible on machinery, are of particular interest.

For example, when the load on an induction motor changes, the current drawn by the motor changes. Changes in both frequency and magnitude characteristics are seen in the motor current and motor power signatures, which are indicative of changing load conditions. Thus, the motor in this case acts as a transducer. The relationship between electrical and process signatures was demonstrated on an experimental flow control loop.

The following are the highlights of the research [2]:

- An existing flow control loop was upgraded with new instrumentation, data acquisition hardware and software. The upgrading of the experimental loop included the installation of a new submersible pump driven by a three-phase induction motor. All the sensors were calibrated before full-scale experimental runs were performed.

EPRI | Human Factors Notes

Appropriate application of human factors engineering (HFE) principles and guidance in the design of plant modifications has become more important as operating plants modernize their instrumentation and control (I&C) systems, control rooms and human-system interfaces (HSIs).

INSTRUMENTATION & CONTROL FOCUS

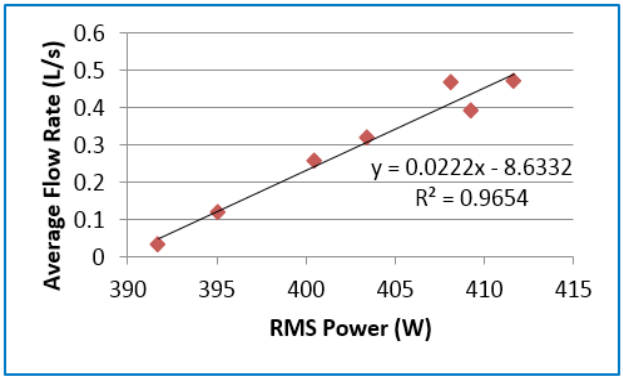
- A frequency controller was interfaced with the motor power supply in order to vary the electrical supply frequency. The experimental flow control loop was used to generate operational data under varying motor performance characteristics. Coolant leakage events were simulated by varying the bypass loop flow rate. The accuracy of motor power calculation was improved by incorporating the power factor, computed from motor current and voltage in each phase of the induction motor.

- A variety of experimental runs were made for steady-state and transient pump operating conditions. Process, vibration, and electrical signatures were measured using a submersible pump with variable supply frequency. High correlation was seen between motor current and pump discharge pressure signal; similar high correlation was exhibited between pump motor power and flow rate. Wide-band analysis indicated high coherence (in the frequency domain) between motor current and vibration signals.

- Wide-band operational data from a PWR were acquired from AMS Corporation and used to develop time-series models, and to estimate signal spectrum and sensor time constant. All the data were from different pressure transmitters in the system, including primary and secondary loops. These signals were pre-processed using the wavelet transform for filtering both low-frequency and high-frequency bands. This technique of signal pre-processing provides minimum distortion of the data, and results in a more optimal estimation of time constants of plant sensors using time-series modeling techniques

- The experimental loop data indicate a clear relationship between motor power and pump discharge (flow rate), as shown in Figure 1.

Even though the pump flow rate experiences limited variation, the result indicates a clear relationship between motor power and flow rate. This relationship can be used to infer pump flow rate using the computed motor power.



Physical and experimental analyses demonstrate a strong relationship between motor power and pump flow rate. This feature of induction motor driven pumps can be used to monitor primary coolant flow rate in SMRs. Furthermore, processing the wideband components of sensor signals provides information about sensor response characteristics and frequency-domain coherence between specified signals [3].

—Belle Upadhyaya
University of Tennessee

1. H.D. Haynes, *Aging and Service Wear of Electric Motor-Operated Valves Used in Engineered Safety-Feature Systems of Nuclear Power Plants: Aging Assessments and Monitoring Method Evaluations*, NUREG/CR-4234 (ORNL-6170/V2), August 1989.
2. B.R. Upadhyaya, J.W. Hines, C. Mehta *et al. In-situ Condition Monitoring of Components in Small Modular Reactors Using Process and Electrical Signature Analysis: Final Report*, Vol. 1 : Development of Experimental Flow Control Loop, Data Analysis and Plant Monitoring, Research Report prepared for DOE Nuclear Energy University Program by the University of Tennessee, NEUP-11-3212-Y3Q4-2014-1, December 2014.
3. B.R. Upadhyaya, C. Mehta, and D. Bayram, *Integration of Time Series Modeling and Wavelet Transform for Monitoring Nuclear Plant Sensors*, *IEEE Transactions on Nuclear Science*, Vol. 61, No. 5, pp. 2628-2635, October 2014.

HUMAN FACTORS FOCUS:
MEETING THE CHALLENGES OF CONTROL ROOM VALIDATION

One key step in designing a new control room is validating the design. Validation is important, not just to designers, but to regulators as well. The U.S. Nuclear Regulatory Commission, for example, evaluates "integrated system validation" (ISV) as part of their human factors engineering safety review process. ISV as an evaluation of the control room design using performance-based tests to determine whether an integrated system design (i.e., hardware, software, and personnel elements) meets performance requirements and supports safe operation of the plant. ISV is conducted for new designs and for significant control room modernization of operating plants. As experience is gained from performing control room validation, industry has found these evaluations to be challenging. One challenge, for example, is coordinating all the demands on the simulator, such as incorporating design changes, training operators, and performing validation tests. Another challenge is identifying acceptance criteria against which to observed performance can be compared.

To help address these challenges, a workshop was held last February on Human Factors Validation of Nuclear Power Plant Control Room Designs and Modifications. It was organized by the Nuclear Energy Agency's (NEA) Working Group for Human and Organizational Factors (WGHOF). NEA is an agency within the Organization for Economic Co-operation and Development (OECD). The workshop brought together over 30 international experts representing a cross section of industry stakeholders including designers, utilities, regulators, academics, and researchers.

The workshop's goal was identifying best practices, potential solutions to validation challenges, and areas where additional research is needed. Many of the participants prepared white papers describing their validation experiences, identifying issues, and, where possible, suggesting promising technical approaches to address them. The organizers made these white papers available to the participants prior to the workshop. In addition, participants were asked to identify papers and other materials that contained valuable technical information about validation. This provided an excellent technical basis for the workshop itself.

The workshop format was a combination of focused presentations followed by breakout sessions that provided an opportunity for participants to discuss various technical and practical aspects of validation. Key topics discussed included:

- defining the scope and objectives of a control room validation
- selecting measures and acceptance criteria
- constructing validation test scenarios and designing the tests
- analyzing results and drawing conclusions

HUMAN FACTORS FOCUS

A workshop report is currently being prepared. It will include the white papers and summaries of the breakout discussions, including recommendations for current practices, potential solutions to challenges, and areas in need of research.

The workshop report will make a valuable contribution to the validation literature. The results and information gained will help research organizations prioritize validation issues so that the most important can be addressed. It will also help inform the development of consensus standards and regulatory guidance for control room validation.

For additional information about the workshop, contact Dr. David Desaulniers at David.Desaulniers@nrc.gov.

—John O'Hara
Brookhaven National Laboratory

ICAPP 2015
MAY 3-6, 2015 • Nice, France

General Chairs, ICAPP 2015

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Kumiaki Moriya - Hitachi-GE - Japan
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Michaele Raap - PNNL - USA

http://fr.amiando.com/ICAPP-2015.html

The ICAPP Congress is a unique platform for experts from all over the world to share about the latest innovations in nuclear energy for safety, environment, reliability and efficiency. With more than 500 presentations and more than 40 nationalities, the ICAPP 2015 congress is a major opportunity for the international nuclear community to leverage its knowledge and know-how.

For the 2015 edition (3rd time in Nice), two new workshops addressing todays and tomorrows challenges of nuclear energy will enrich the traditional ICAPP program :

- Nuclear Power & Climate change: as a low-carbon energy, nuclear is a part of the solution to protect clean air and healthy communities. ICAPP 2015 is the opportunity to demonstrate the vital importance of nuclear to fight efficiently climate change.
- New & Rising Nuclear Countries: the increase of installed capacities in China, India, Korea, Russia and newcomers raises the question of conditions for success

For more information on the conference, please visit **http://fr.amiando.com/ICAPP-2015.html.**