

# Human Factors Symposium Program

May 10–12 | Discovery Hall | Pacific Northwest National Laboratory

## Wednesday May 10

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**8:00 AM**    **Networking and Check In**

**8:30 AM**    **Bridging Human Factors Disciplines to Advance Energy and Security Goals**

Brett Jefferson and Michael Royer | *Pacific Northwest National Laboratory*

The Human Factors Symposium was born out of a desire for increased collaboration between human factors researchers in different fields. At PNNL, security and energy are two major research areas where human factors has great importance and is critical to achieve the goals of the Department of Energy, Homeland Security, and other federal agencies. This presentation will highlight important areas of intersection, opportunity, and possibility to set the stage for the rest of the symposium to follow.

### **Ethics in Human Factors Research**

Susan Varnum and Jesse Willett | *PNNL Institutional Review Board*

In this talk we will define human subjects research and the role in Institution Review Board (IRB) plays in protecting human subjects. Further, we will discuss the ethics of human subjects research as it relates to human factors research and present some study examples.

[Break for Refreshments]

**10:00 AM**    **Considerations for Successful Interdisciplinary Research on Human Factors of Energy Use in Buildings**

Jennifer Veitch | *National Research Council Canada*

To achieve societal goals for reducing carbon emissions and energy security will require different energy use behaviours from individuals, organizations, and governments. New building technologies may promise energy efficiencies, but need to be understood as part of systems that include building occupants in order to avoid unintended consequences, including failed adoption. Developing this understanding demands interdisciplinary research. Multidisciplinary research engages several different perspectives on one problem – for example, engineering, architecture, computer science, and psychology -- but there may be few direct points of contact to lead to a unified answer. Interdisciplinary research differs, by contrast, in that each party needs to absorb some aspects of the others' perspective, involving reciprocal and mutual interaction, in order for all the parts to fit together. This integration is vital to achieve our goals, but anyone who has worked in an interdisciplinary team knows that this is not easy. Success requires overcoming language and cultural barriers between disciplines, breaking down interpersonal barriers, and leaping institutional barriers. This presentation will illustrate the challenges and describe practices that can overcome them, using examples from a series of successful field trials of residential smart

technologies that my colleagues and I have undertaken with a utility company in eastern Canada. (Preview: Infrequent meetings are not one of the best practices!)

### **Modeling Occupant Behavior in Buildings to Support Building Decarbonization**

Tianzhen Hong | *Lawrence Berkeley National Laboratory*

Globally buildings consume more than one-third of primary energy and produce about 30% of GHG emissions. Decarbonizing the building sector is essential to achieving global carbon-neutral economy. Occupant behavior significantly influences building operation and energy use. Understanding and improving the two-way human-building interactions can help unlock the potentials of human dimensions in reducing resource use and carbon emissions, as well as maintaining occupant comfort and health. This talk covers methods, data, and tools of occupant modeling and analytics to support the design and operation of energy efficient, demand flexible, and climate resilient buildings. Challenges and research opportunities in occupant modeling will also be discussed.

### **Human Dimensions of Energy in Buildings**

Julia Day | *Washington State University*

Heather Burpee and Christopher Meek | *University of Washington*

The Integrated Design (and Construction) labs at UW and WSU will present several research projects related to human factors. First, our sister labs will introduce the Integrated Design Lab Network and present specific strengths of the UW and WSU labs. Then, we will present brief snapshots to illustrate research projects that explore the human dimensions of energy in buildings. Specifically, project snapshots include research on occupancy patterns post-covid, building interfaces, interactions with lighting controls (LLCs) and plug loads, tenant engagement efforts and more. We also explore the idea of using energy as a proxy for better understanding occupant building use-patterns and how new-use patterns might open new opportunities for efficiency.

#### **12:30 PM Human Factors at PNNL [Working Lunch]**

Bill Pike | *Chief Science and Technology Officer, PNNL National Security Directorate*

Karma Sawyer | *Director, PNNL Energy Infrastructure and Buildings Division*

#### **1:30 PM Human-Machine Communication in the era of Algorithmic Decision-Making**

Aritra Dasgupta | *New Jersey Institute of Technology*

Abstract pending.

### **Human Factors in Technology Discovery**

Brett Jefferson and Jessica Baweja | *Pacific Northwest National Laboratory*

Artificial intelligence and machine learning (AI/ML) have presented new opportunities for humans to work with technology. With these opportunities come new challenges for leveraging that technology in helpful, appropriate ways that complement human judgment and expertise. To support the integration of machines into human work, human factors researchers have explored how human expertise can inform technology design and evaluation. For example, interaction with subject matter experts (SMEs) or end users can help to design and enhance a machine. The human factors of technology deployment can be divided into five steps: discovery, planning, development, evaluation, and deployment. This framework is a higher-level abstraction of the Human Readiness Levels for technology use and adoption (See, et al., 2018). In this presentation, I will discuss how human factors methodologies, principles, and practices can be realized in the first phase, Discovery, of the technology development process.

### **Assessing the Impact of Automated Document Classification Decisions on Human Decision-Making**

Mallory Stites | *Sandia National Laboratories*

As machine learning (ML) algorithms are incorporated into more high-consequence domains, it is important to understand their impact on human decision-making. This need becomes particularly apparent when the goal is to augment performance rather than replace a human analyst. The derivative classification (DC) document review process is an area that is ripe for the application of such ML algorithms. In this process, derivative classifiers (DCs), who are technical experts in specialized topic areas, make decisions about a document's classification level and category by comparing the document with a classification guide. As the volume of documents to be reviewed continues to increase, and text analytics and other types of models become more accessible, it may be possible to incorporate automated classification suggestions to increase DC efficiency and accuracy. However, care must be taken to ensure that model-generated suggestions do not introduce unacceptable errors into the process, which could lead to disastrous impacts for national security. In the current study, we assessed the impact of model-generated classification suggestions on DC accuracy, response time, and confidence while reviewing document snippets in a controlled environment and compared them to DC performance in the absence of a model (baseline). Across two assessments, we found that correct model suggestions improved human accuracy relative to baseline, and increased speed of response relative to baseline when full-length documents were used. Incorrect model suggestions produced a higher human error rate (for short but not full-length documents), especially when model explanations were provided. Incorrect suggestions also elicited longer responses for unclassified documents. DCs reported higher confidence when they complied with incorrect suggestions from an interactive model, relative to cases in which they correctly disagreed with them. These results highlight that although ML models can enhance performance when the output is accurate, they may impair analyst decision-making performance if inaccurate. This has the potential for negative impacts on national security. Findings have implications for the incorporation of ML or other automated suggestions not only in the derivative classification domain, but also in other high-consequence domains. The effects of model accuracy and amount of information displayed from the model should be taken into account when designing automated decision aids.

**Action Uncertainty and Expert Derived Confidence: Addressing Uncertainty During Interactions with Highly Autonomous Agents and Artificial Intelligence**

Corey Fallon | *Pacific Northwest National Laboratory*

This presentation will focus on two separate but related research areas. First, the presenter will introduce a type of uncertainty that should be considered when interacting with highly autonomous systems referred to as Action Uncertainty. Next, the presenter will discuss his latest research on developing a new type of confidence score for communicating uncertainty associated with AI classification decisions. Unlike traditional confidence scores that are generated by the AI, this confidence metric is generated by humans who have spent time studying the performance boundaries of the ML classifier. This metric is referred to as an Expert Derived Confidence score.

**4:30 PM**    **Open Problems Discussion** [Light Refreshments Provided]

**6:00 PM**    **No-Host Dinner: At Michelle's** (2323 Henderson Loop, Richland, WA 99354)

Thursday May 11

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**8:30 AM Individual Differences in Human-Machine Teaming**

Megan Morris | *Air Force Research Laboratory*

Human-machine teaming (HMT) is of growing importance as autonomous systems become more integrated into our everyday lives and workplaces, helping us execute critical decision-making. An area involved in HMT that has not garnered much focus is how individual differences in the human teammate affect perceptions of the team relationship and how these individual differences can be leveraged to create optimal team performance. In this talk I will first provide a brief overview of my background and research perspective regarding individual differences. I will then discuss some perspectives in the literature on HMT. Lastly, I will discuss where I see opportunities for individual differences to be leveraged in HMT, with examples from different focus areas. I hope this talk will spur interest in individual differences and emphasize the importance of these factors when working with autonomous technology.

**Evaluating Human Systems Integration of AI-Enabled Systems: What should you consider in a Test and Evaluation Strategy?**

Jonathan Elliott | *Chief Digital and Artificial Intelligence Office*

Rachel Haga | *Institute for Defense Analyses*

The Chief Digital and AI Office (CDAO) and Institute for Defense Analyses (IDA) are developing a framework to support testers as they evaluate Human Systems Integration (HSI) of AI-enabled systems. This product is a short briefing that gives an overview of the framework, conveys a sense of what the fuller framework looks like, and ends with an example of how increased autonomy in aviation led to the loss of Air France 447. We are creating this framework because HSI expertise in the DOD Test & Evaluation workforce is rare and increasingly important with more automation in systems. This briefing focuses on the portion of the framework which introduces non-experts to core HSI concerns to help testers write and assess test and evaluation strategies (TES). This briefing covers a subset of HSI topics included in the framework, including mental models, trust, workload, and function allocation. HSI will continue to be a vital component of creating and adopting effective, suitable, and trustworthy AI enabled systems.

[Break for Refreshments]

**Operationalizing Relational Trust in Human-AI Teaming**

Erin Chiou | *Arizona State University*

In this talk I will motivate a theoretical perspective of “relational trust” to advance our understanding of system design considerations in human-AI teaming contexts. This perspective integrates past scholarship on trust in automation from an industrial and safety science perspective with more recent scholarship on trust in AI from a broader societal perspective. I will then describe how we have operationalized this perspective using examples from my lab. I will share insights learned from the past ten years of studying trust in complex decision contexts, trust measurement, and how related human-AI teaming

constructs like transparency and explainability may also benefit from this new perspective.

### **Human Teaming with Learning-Capable Agents: Examining Differences in Workload, Trust and Perceptions of the Agent**

Julia Wright | *Army Research Laboratory*

Advances in AI/ML have led to learning-capable agents (LCA), agents that can be ‘taught’ via a variety of methods besides traditional programming. These agents learn off-line, either prior to or following deployment, and this training requires large amounts of data, computer specialists, and the agent/system cannot be used during training. However, the world is dynamic and changeable, resulting in deployed agents that cannot respond to the evolving needs of their tasking. The ability to teach these agents during deployment, without interrupting tasking, would better address the needs of a dynamic, evolving environment. Learning from Intervention (Lfi) is one agent training method that promises to bridge this gap. I will present results from two studies examining human teaming with LCAs wherein the user is also teaching the agent new behaviors using Lfi methods. We then compare and discuss the results and examine future directions for the research.

### **Investigations of the Impact of Information about Uncertainty on Human Decision Making**

Laura Matzen | *Sandia National Laboratories*

People are frequently called upon to make decisions based on uncertain information, but they often struggle to understand and reason about uncertainty, even if it is well-characterized. There are many unresolved questions about when and how to show information about uncertainty to analysts or decision makers in order to support unbiased reasoning. The experiments presented in this talk address some of the gaps in the prior literature on this topic. Each experiment required participants to make decisions based on uncertain or probabilistic information and systematically manipulated the ways in which the information was presented. The results of these experiments demonstrate that different representations of uncertainty can lead to dramatically different patterns of decision making. It is crucial for us to gain a better understanding of the cognitive factors at play in order to support the development of effective human-computer or human-machine interactions.

#### **12:30 PM Generating Collaborations [Working Lunch]**

Topic Tables: Discussion of Challenges, Opportunities, and Collaboration

- Buildings
- Artificial Intelligence
- Safety and Security
- Human Machine Teaming

#### **1:30 PM Increasing Applicant Understanding and Response to Security Questions**

Callie Chandler | *Defense Personnel and Security Research Center*

Errors and incomplete information provided on the SF-86 can negatively impact investigative timeliness, increase costs, and delay when an applicant can begin doing the work for which they were hired.

In this session, the speaker will discuss how the Personnel Security Questionnaire evolved and whether it continues to be relevant. They will identify which questions cause the most discrepancies and examine the reasons why applicants do not provide accurate and complete information. Finally, the speaker will discuss technical and non-technical solutions for improving the quality and completeness of applicant responses.

### **Human Factors for International Nuclear Safeguards**

Zoe Gastelum | *Sandia National Laboratories*

International nuclear safeguards are measures implemented by the International Atomic Energy Agency (IAEA) via bilateral and multilateral agreements to verify the peaceful use of nuclear materials and facilities. IAEA safeguards inspectors are experts in their field, who are selected from a highly competitive pool of applicants and undergo months of in-depth training followed by mentoring from senior inspectors. With their global nuclear monitoring mandate, inspectors may face operational challenges such as jet lag, time pressures, working in their non-native languages, wearing personal protective equipment, and working in noisy or industrial environments. Tolerance for human error is incredibly low, as missing indicators of nuclear proliferation activities could result in regional or international security consequences. Within this context, Sandia National Laboratories has spent the past seven years investigating various aspects of human performance to support better information provision to IAEA safeguards inspectors and analysts. This presentation will present an overview of the international safeguards operating environment, Sandia's human performance factors capabilities, and a deep-dive on selected results and impacts.

### **Human Factors Engineering in Organizational Design**

Atithi Bharth | *Pacific Northwest National Laboratory*

While other topics during this symposium may focus on research and practical aspect of human factors engineering, this session focuses on the impact on the overall organization due to minimal and/or no consideration to human factors principles when developing and implementing new policies and procedures, integrating new technology, or when investigating mishaps. During this session, we will also discuss consequences of over-reliance on technological solutions. Furthermore, we will discuss how human factors principles can be used to inform procedures and operations and discuss how changes made with those principles in mind could lead to a positive organizational impact.

### **It's What's Inside That Counts: Personality Factors as Predictors of Both Positive and Negative Cybersecurity Behaviors**

Peter Harms | *University of Alabama*

Personality traits have proven to be robust predictors of workplace behaviors in a variety of settings and industries. This talk will briefly review major models of normal personality traits and personality disorders and how they impact a number of workplace outcomes including job performance, workplace deviance, job stress, and leadership. It will then highlight how these factors may be better used to understand human behaviors as it pertains to the performance and well-being of cybersecurity personnel as well as how personality

assessments can be used as preventative screens or warnings for potential insider threats. Finally, it will introduce new avenues for personality research concerning how to assess and train cybersecurity teams.

**4:30 PM**    **Open Problems Discussion** [Light Refreshments Provided]

**6:00 PM**    **No-Host Happy Hour: Bombing Range Brewing** (2000 Logston Blvd #126, Richland, WA 99354)



Friday May 12

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**8:30 AM Advancing Residential Building Decarbonization: Understanding Home Occupant Decision-Making Dynamics**

Chrissi Antonopoulos | *Pacific Northwest National Laboratory*

Fossil fuel combustion in buildings leads to roughly 30% of total greenhouse gas emissions in the United States, and residential buildings consume approximately 21% of total primary energy. Decarbonizing the electricity grid will not be enough to meet emission targets; electrification of residences will be a key factor in realizing community-scale sustainability goals. However, not all residents are willing or able to make changes to lower their fossil fuel use due to a myriad of economic, social, and cultural factors. Furthermore, the complexity of human behavior and decision-making makes the task of designing policies, programs, and messaging for uptake of green technologies difficult. Using findings from 121 interviews and a survey of 10,000 U.S. households, this presentation discusses how residents make decisions related to home energy efficiency. Key decision influencers emerge about buying and using appliances and other technologies relevant to residential electrification, such as heat pumps and kitchen appliances. Funded by the U.S. Department of Energy, this human-factors research was led by Pacific Northwest National Laboratory with support from Illume Advising. The large-scale survey reached owner-occupied and renter households in every U.S. state and is reflective of the country's diverse demographic composition. Outcomes of the study help determine links between resident preferences, values, and decision-making processes related to home energy use. Key take-aways can help inform industry and policymakers on overcoming barriers in the way of home electrification and leveraging opportunities to motivate or enable residents to choose electric versus gas appliances and equipment. Among preliminary results, residents highlight the importance of comfort and safety, and indicate a willingness to invest in high-efficiency electric technologies, with greater preference given to appliances that are visible or enhance the home's appearance.

**Heeding the Call: Operator and Worker Preferences Regarding Load Flexibility**

Margaret Taylor | *Lawrence Berkeley National Laboratory*

Load flexibility in buildings is increasingly recognized as a key resource for electricity cost containment and renewables integration. Further leveraging this resource requires an understanding of building occupant tolerance for service losses that may accompany curtailment of electricity use during times of high demand. We implement stated preference discrete choice experiments (DCE) that elicit preferences regarding tolerance for these service losses from building operator and workers dislike during-event temperature increases (in summer events) but at least tolerate and perhaps welcome pre-cooling strategies prior to events. Preferences for lighting reductions depend on the level of daylighting in the building. When and where daylighting is minimal, respondents disfavor lighting reductions; however, with more daylighting, respondents were much more tolerant or even welcoming of lighting reductions. Both operators and workers attach value to the economic benefits their organizations receive, indicating that larger incentives can to some extent increase willingness to accept service losses. In general, operator preferences are "sharper" than worker preferences - stronger preferences for economic benefits and stronger disamenities due to service loss reductions - and operators may tend to be more

conservative in their actions than worker preferences require them to be. Our DCE coefficients quantify these preferences and could be incorporated into simulation or algorithmic approaches for selecting event response strategies in specific buildings.

### **The Influence of Dynamic Occupant Behavior on Predicting Non-visual Health in Buildings**

Siobhan Rockcastle | *University of Oregon*

This presentation will introduce novel simulation-based workflows to evaluate dynamic light exposure profiles for building occupants to better understand the impact of architectural design, shading and lighting controls, and behavior on non-visual health in buildings. In recent years, research has revealed the importance of eye-level light exposure for aligning sleep-wake cycles with the solar day and promoting circadian health in day active people. Over the past few centuries, humans have shifted the composition of their daily eye-level light exposure profile as they've moved from outdoor work environments to indoor office spaces. Compared to the intensity of outdoor illumination, light exposure in the indoor workplace is most often characterized by a brighter, daylight perimeter and a dimmer, electrically lit core. This spatial discrepancy in luminous conditions creates the potential for inequities in eye-level light exposure between occupants who populate the building perimeter and the building core. Electric lighting systems can help supplement deficient exposure levels, but ceiling mounted and suspended lighting systems typical to offices often still fall short of meeting recommended exposure levels for many building occupants, even when they meet recommended horizontal task illuminance thresholds. This presentation will introduce recent work in the Baker Lighting Lab to model dynamic occupant behavior and predict the non-visual health across a population. Current efforts at modelling the energy demand to supplement deficient exposure levels using electric light will also be presented.

### **Observational Research Methods for Evaluating Emerging Technologies for the Built Environment**

Ruth Taylor | *Pacific Northwest National Laboratory*

For years, energy efficiency programs have focused on the installation of energy efficient technologies, with anticipated savings typically determined through modeling, engineering calculations or controlled field experiments. Yet measurement and evaluation completed after the fact have frequently found that the technologies are not delivering the anticipated savings. What happens in the real world when these technologies are installed, configured and operated that leads to this disconnect?

To find out, PNNL staff managed DOE's Next Generation Lighting Systems (NGLS) program to pioneer the use of Observational Research for evaluating energy efficient technologies in the built environment. NGLS uses non-participant, real-time observational research in conjunction with technology performance evaluations and traditional surveys and interviews to discover and document challenging human and technology interactions.

Using results from the NGLS Living Lab in NYC and other DOE field demonstrations, this presentation describes the observational research rationale and approach as well as recommendations for applying observational research to other building energy efficiency

technologies. Understanding and addressing the human factors issues related to energy efficiency is critical to ensuring savings potential is realized and adoption is persistent.

**11:45 AM MARS Lunch Talks [Working Lunch]**

**Inferring Technology-Directed Research Behavior of Authors from Publication State Sequences**

Dennis Thomas | *Pacific Northwest National Laboratory*

Using nuclear research articles to provide valuable information about a country's intent to utilize or build nuclear technology is an active area of research and this information is relevant for assessing the country's nuclear expertise level in building nuclear weapons. In general, early detection of nuclear technology development indicators from data is challenging due to partial observability, sparse and unlabeled information, and confounding signals from multiple concurrent activities. This talk will present the early detection problem as a sequential decision-making and early goal inference problem, where the objective is to characterize and predict an entity's (individual's, organization's, or country's) intent to develop a nuclear capability (e.g., building a reactor) from author publication data using inverse reinforcement learning and Bayesian goal inference methods. A computational framework for early goal inference will be presented and its application demonstrated for a use case related to a civil nuclear capability.

**Human Factors for Model-driven Cyber Deception on Operation Technology**

Burhan Hyder | *Pacific Northwest National Laboratory*

Modeling the physical process of Operation Technology (OT) and Industrial Control Systems (ICS) provides a forecasting engine to feed decoy devices exposed on a cyber network. These decoy devices provide a high fidelity, low impact, and low false positive rate, deception defense solution to the cyber security of these systems. However, when modeling these physical processes, there are human factors that can be considered. This talk will outline an effort to create OT/ICS SME derived equations for OT/ICS systems and incorporate them into the validation on the quality of Machine Learned equations for the same types of systems. By incorporating OT/ICS SME input into the validation of the ML modeling we gain confidence in the model and can begin to develop recommended deception strategies for cyber professionals. Additionally, we can incorporate ICS specific attack strategies into the validation of the ML models. By validating that the ML model represents the outcome of cyber-attacks realistically and accurately, we can provide a better deception.

**1:00 PM Wrap-up**

**2:00 PM Adjourn**