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Nuclear Energy Enabling Technologies (NEET)

Advanced Sensors and Instrumentation (ASI) Annual Project Review

Advanced Human-System Interfaces

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Project Overview

Goal and Objectives

1. Investigate the state-of-the-art of HSI technologies, with the emphasis on their ability to provide error-tolerant and resilient operation, a superior degree of task performance, and user satisfaction with such systems.
2. Define measures of the efficiency, effectiveness, safety and reliability with which specific users can perform specific tasks in specific contexts with identified technologies. (ISO 9241-11 – Guidance on Usability)
3. Develop guidance for HSI technology selection and deployment in all nuclear application domains.

Participants

- INL project team: Jacques Hugo, David Gertman, Jeffrey Joe, Katya le Blanc

Other participants

- Utility collaborator for technology evaluation (FY 2014, 2015)

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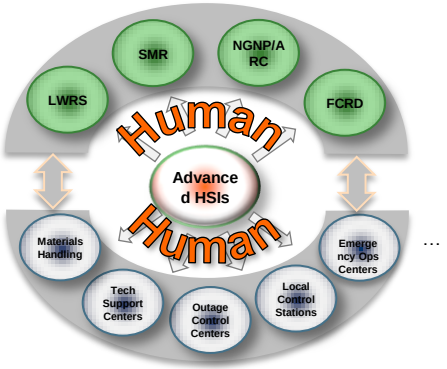
DOE R&D programs benefitting from this work

- **All areas and functions where humans interact with technology**
  - New plant designs
  - Modernized plants
- **Human factors aspects of new technology**
  - Control rooms, local control stations, materials and fuel handling, and laboratories:
    - Primary: LWRS, SMR, NGNP/ARC
    - Secondary: Materials handling and Fuel cycle applications - Advanced Fuels, MPACT, Separations and Waste Forms, Used Nuclear Fuel Disposition



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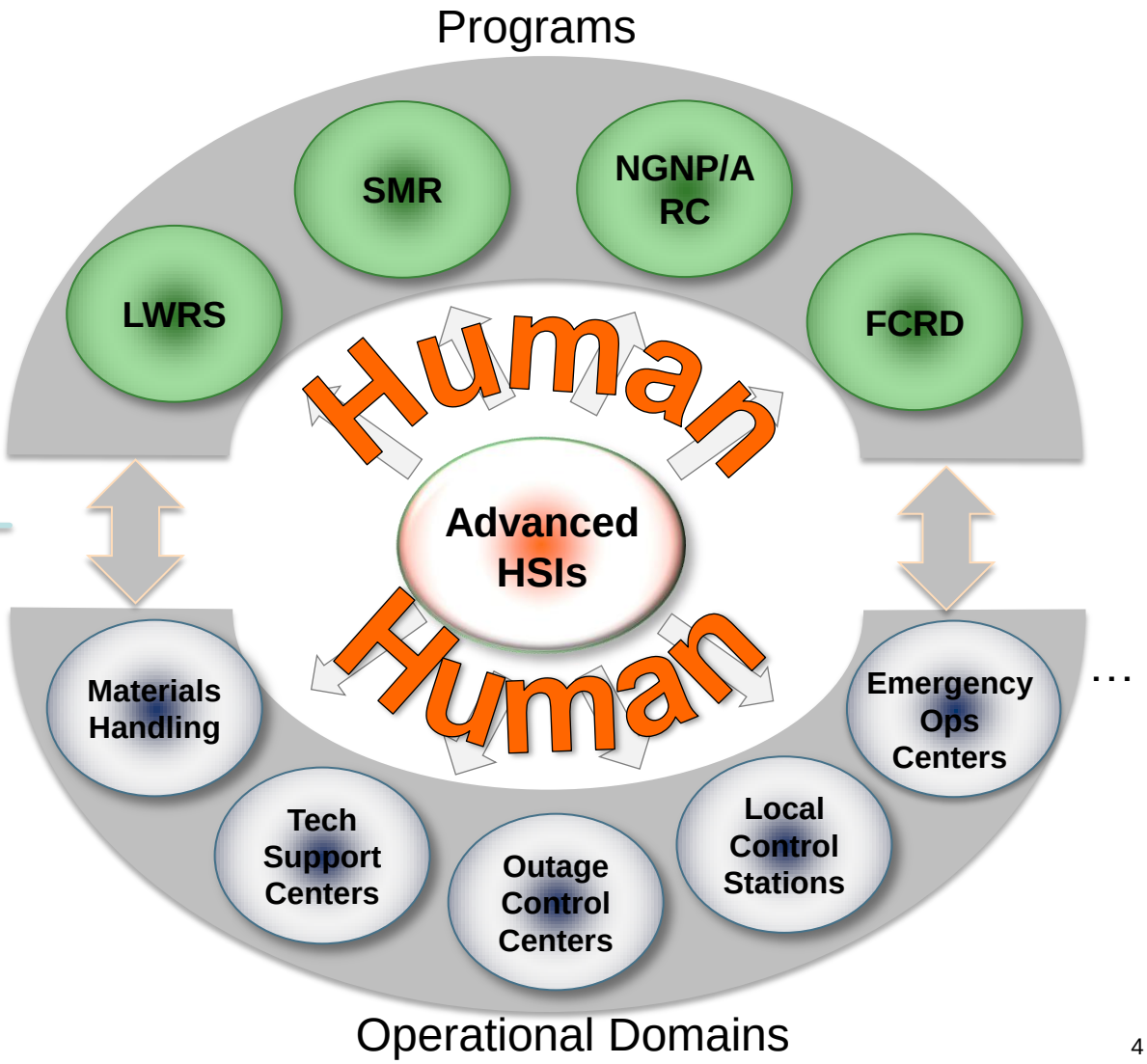
Benefit to other programs and operational domains

- Situation Awareness
- Workload
- Reliability
- Accuracy
- Workplace ergonomics
- Procedures
- Training
- Cooperative work
- Information
- Error reduction
- Device usability



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Technology Impact

Advances in NPP I&C Technology

- Change nature of interaction between operators and the system
- Affect human reliability and control room safety

Upgrades and New Designs

- Rely on digital technologies and higher levels of automation
- Technology-neutral, decision-centered and performance-based approaches criteria for technology selection

Project Results

- Criteria for selecting and deploying most suitable technologies
- Upgrade & replacement strategies, to meet industry standards and regulatory guidance

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Research Plan

- **FY2012: $450K (completed)**
  - Review State-of-the-Art in HSIs for nuclear application domains
  - Visualization study of plant performance data
- **FY2013: $210K**
  - Develop selection criteria for HSI for control rooms
  - Develop technology classification and definition of interaction modalities
  - Industry gap analysis of technology adoption and best practice
  - Limited HSI technology evaluation for human performance
- **Transition to Competitive R&D (plan for FY2014 – FY2017)**
  - Empirical study of human performance with new technology
  - Develop measures of process maturity, common technology features and best practices
  - Develop decision-support methodology and technical basis

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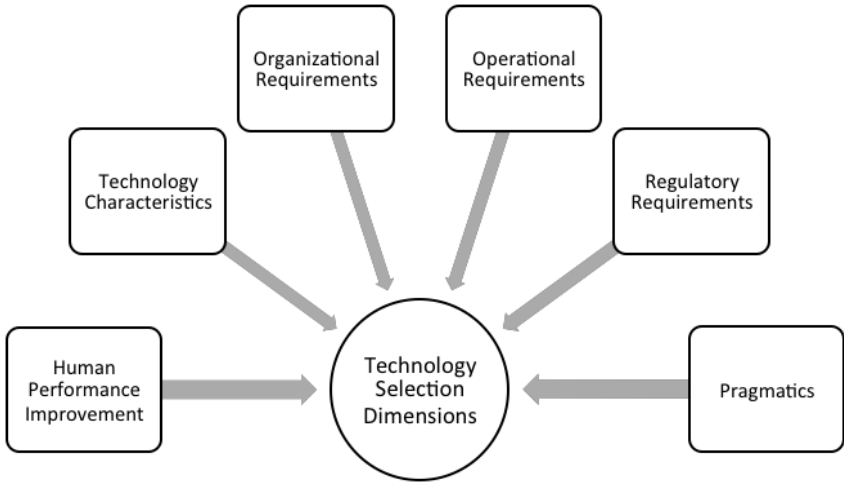
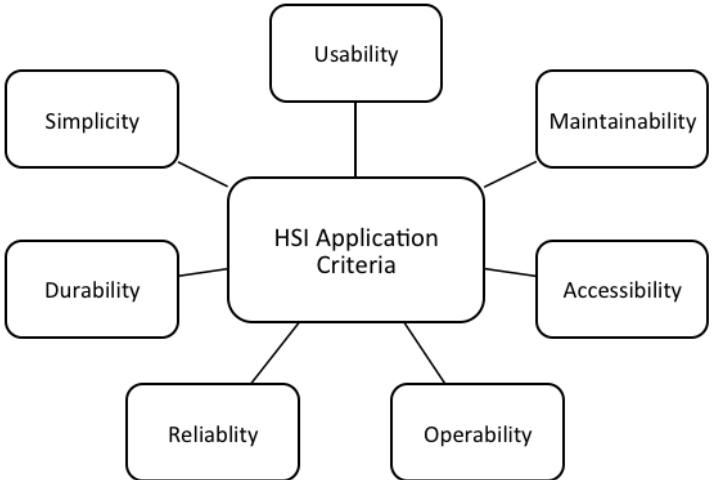
Accomplishments (FY-12)

- **Preliminary results of technology classification**
  - Taxonomy of Human-System Interaction
  - Dimensions of technology selection
- **Visualization and Interaction study for technology criteria definition**
- **Preliminary Human Performance criteria identified**





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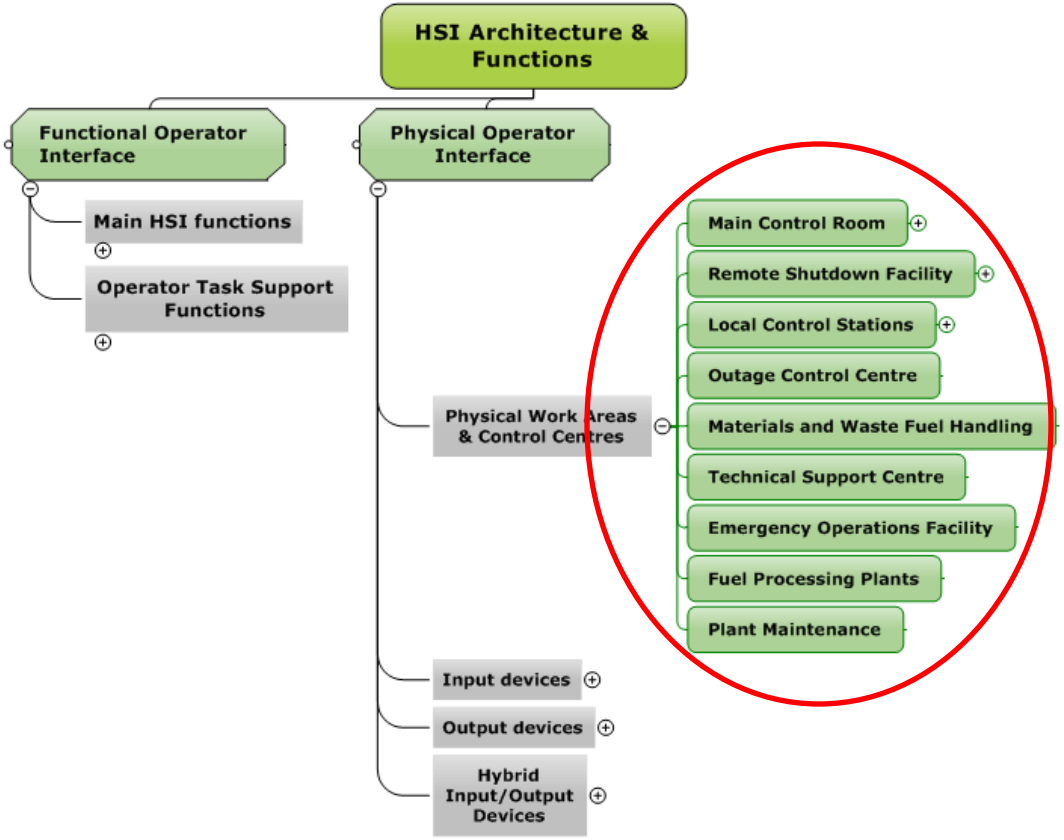
Accomplishments (FY-13)

- **Preliminary results of the review of emerging state of the art of HSIs for NPPs and human performance-based evaluation of selected HSI technologies (September 2013)**



Device Categories	Performance
Static Display	Speed
Mobile/Wearable Devices	Accuracy
Haptic Devices	Consistency
Augmentative Systems	Situation Awareness

Interaction Modalities
Discrete 2 DoF
Continuous 6 DoF
Gesture
Voice

etc…

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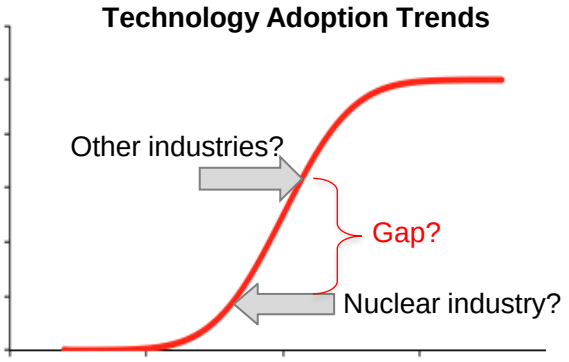
FY 2013 Activities

- **Gap analysis of the current state of technologies in the nuclear industry, compared to current best practice in other industries. Includes:**
  - Selection and prioritization of key issues
  - Attributes of the state-of-the-art in HSIs
  - Identification of issues not addressed by NUREG-0700
  - Review of their potential impact for NPP control rooms.



- **Develop preliminary human-centered selection criteria for HSI for different application domains**
- **Develop HSI Capability Maturity Model ("CMM-HSI") for HSI selection process based on DOE Technology Readiness Levels and analysis of market trends**
- **Develop human performance criteria for technology selection**

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Planned Accomplishments

- **Apply operator models and selection criteria to acquire selected technologies for evaluation, verification and field study with utility collaborator (July 2014)**
- **Develop technical basis and guidance for HSI selection (September 2015)**

Nonintrusive wearable displays

Virtual Reality

Multi-touch displays

Wearable Computers

Handheld devices

Touchless Gesture Control

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Crosscutting Benefits

- **DOE-R&D programs benefitting from this work**
  - All applications of HSIs in LWRS, SMR, NGNP/ARC and FCRD
- **How…**
  - Provide capabilities for highly automated, integrated control rooms, local control stations, materials, fuel handling, and laboratories, that minimize human error, workload, and staffing demands.
- **Validation and coordination**
  - Share project objectives, key outcomes, and timelines with other projects to elicit feedback from POCs on potential human factors elements in each project.
- **Outcomes and measures of success**
  - Projects address common human factors issues, requirements, potential overlaps and duplications.
  - All project results incorporate human factors principles where appropriate.

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Transition to Competitive Research

- **Leverage R&D results to date and previous investments in HSI and measurement technology:**
  - Perform gap analysis in specific operational contexts.
  - Refine model of human performance with new technologies in the Human System Simulation Laboratory.
  - Verify measures of process maturity, common technology features and best practices for safe and effective HSI development for nuclear energy and fuel cycle systems.
- **FY2014-2015: $900K**
  - Develop simulator-based predictive and system-oriented HSI assessment methods and metrics.
- **FY2016-2017: $1 M**
  - Develop decision-support methodology and technical basis for selection and deployment of new technologies.
  - Complete transition of technical results to industry

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Conclusion

- **Legacy I&C and HSI technology not human-centered – led to performance challenges, error, high cost.**
- **New concepts of operation, new control architectures and new HSI technologies lack guidance for selection, deployment, safety, resilience and human performance.**
- **Vision: Project results will:**
  - Address the critical HSI technology gap in the industry.
  - Help to ensure that new technologies selected are human-centered and will provide error-tolerant and resilient operation in all modernization and new-build projects.
  - Selection criteria will guide designers and inform the transition from old analog control room technologies to modern and more sustainable digital controls and display technologies in new as well as existing systems.