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Framework for Operational Concepts and Human-Automation Collaboration

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Advanced Reactor Technologies
Advanced Materials R&D Program Review

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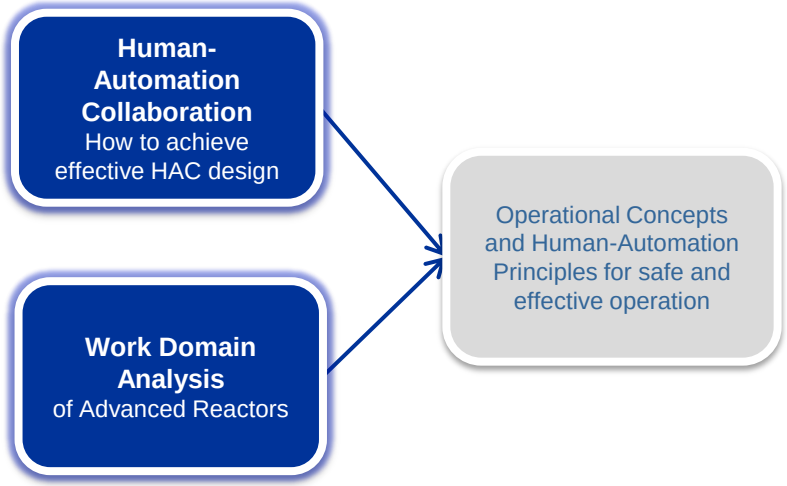
Framework for Operational Concepts and Human-Automation Collaboration

Task Relevancy

- ***Develop Operational Concepts (OpsCon) for Advanced Reactors to inform system, functional & operational design and licensing basis to ensure that operational requirements are included in system design.***
- ***Analyze Human-Automation Collaboration (HAC) to provide an understanding of how automation design impacts both human and system performance in advanced nuclear power plants.***



Technical Approach, Accomplishments/Results

- ***Conduct research to investigate the effect of automation on performance, efficiency, and safety.***
- ***Develop an Evaluation Framework for Human-Automation Collaboration.***
- ***Develop Work Domain Analysis (WDA) Methodology Framework for AdvRxs.***
- ***Develop Reference OpsCon for AdvRxs***

Expected Deliverable & Schedule

FY 15	1. WDA Framework for AdvRxs 2. Reference WDA for SFR 3. Reference OpsCon for AdvRxs 4. Process simulator experiments to investigate HAC impacts 5. Evaluation Framework for HAC
Opportunities for further R&D	**1. Study HF impact of non-electrical operating missions** **2. Develop AdvRx benchmarks and General Design Criteria for OpsCon and HAC** **3. Develop a tool to evaluate HAC design**

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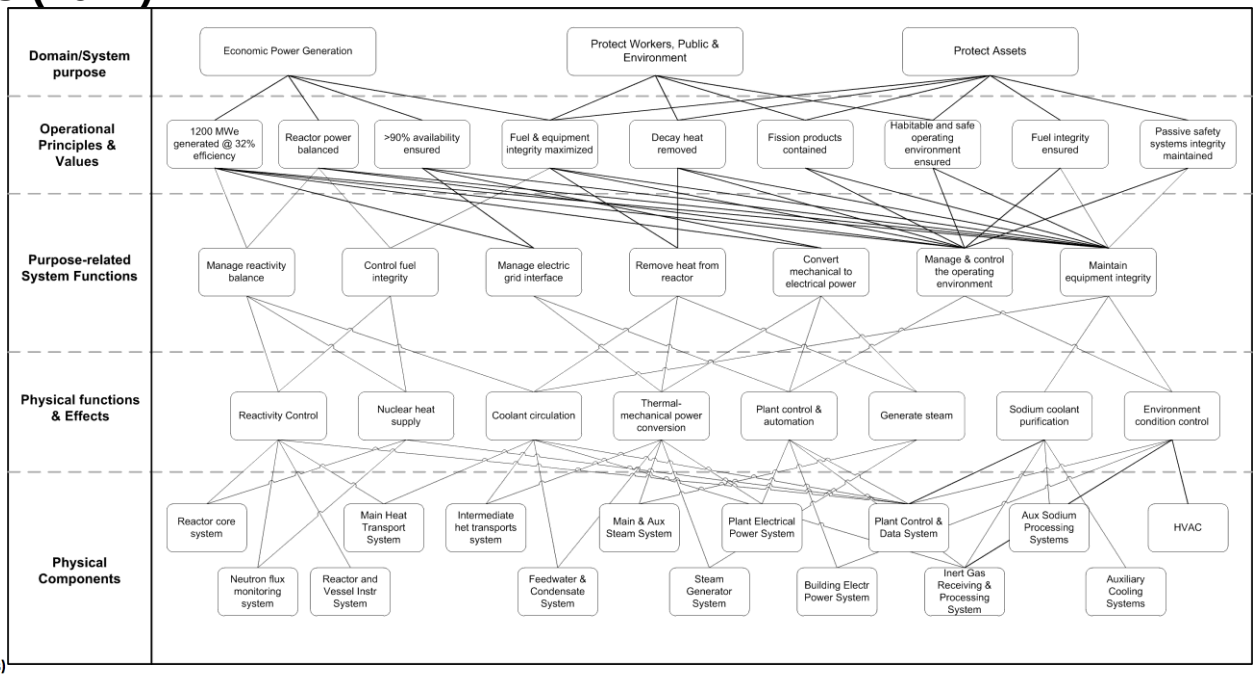
Operational Concepts Accomplishments (2)

2. Work Domain Analysis (2014)

Functional Abstraction Framework



Contextual Activity Analysis

Generic SFR Operational Concepts
Contextual Activities: Anticipated Operational Occurrences (AOOs)

Functions \ Situations	Decrease of primary coolant flow	Decrease of intermed. coolant flow	Increase of primary coolant flow	Increase of intermed. coolant flow	Increase of feedwater flow	Decrease of feedwater flow	Loss of offsite power	Spurious control rod insertion	Spurious control rod withdrawal
Manage Reactivity Balance	✓	✓	✓	✓	✓	✓	⊘	⊘	
Remove Heat from Reactor	✓	✓	✓	✓	✓	✓	✓	?	
Convert Mechanical to Electrical Power	?	?	✓	✓	✓	✓	⊘	?	
Cool Plant Equipment	✓	?	✓	✓	✓	?	?	?	
Provide Personnel Comfort and Safety	✓	✓	✓	✓	✓	✓	✓	✓	

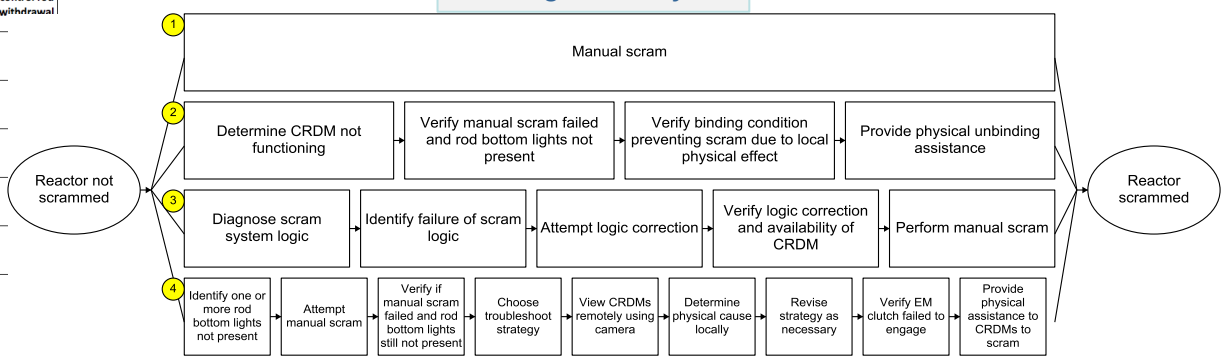
Symbol Explanation:

✓ The function can and typically does occur in this condition

? The function could occur in this condition, but typically does not

⊘ The function is not possible, or prohibited in this condition

Strategies Analysis



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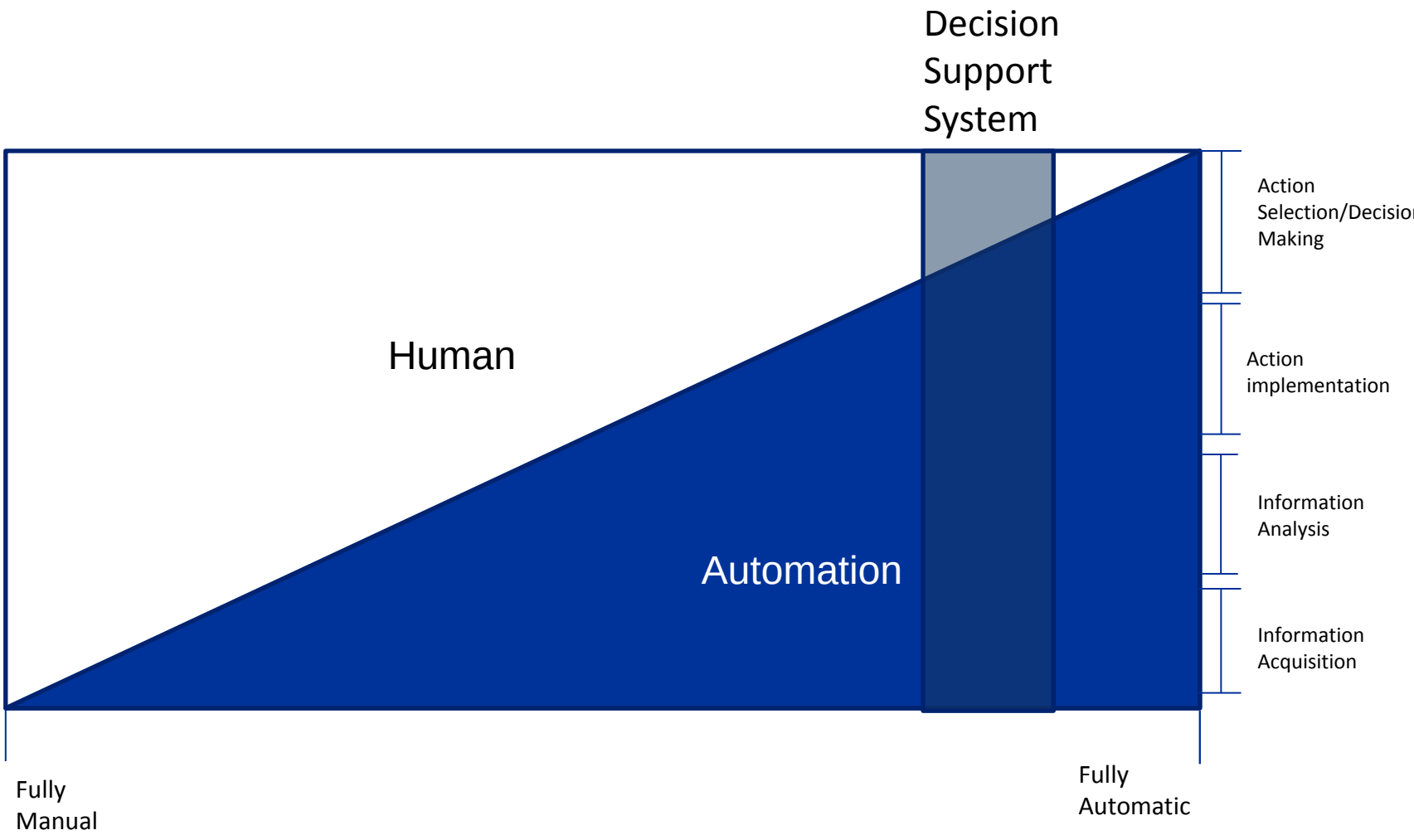
Conceptual Model Of Automation Characterizing Degree of automation



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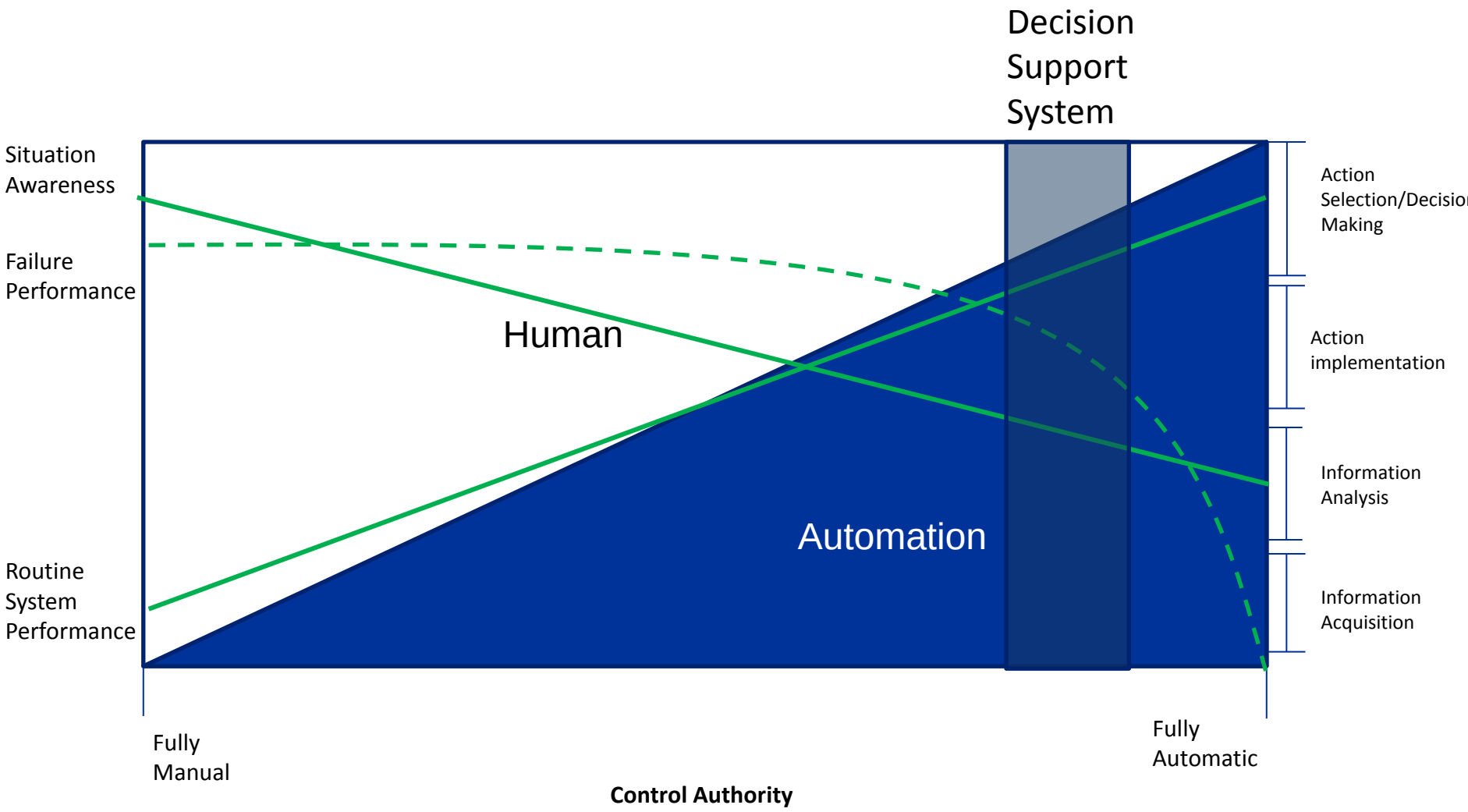
Characterizing Performance Consequences of Degree of Automation



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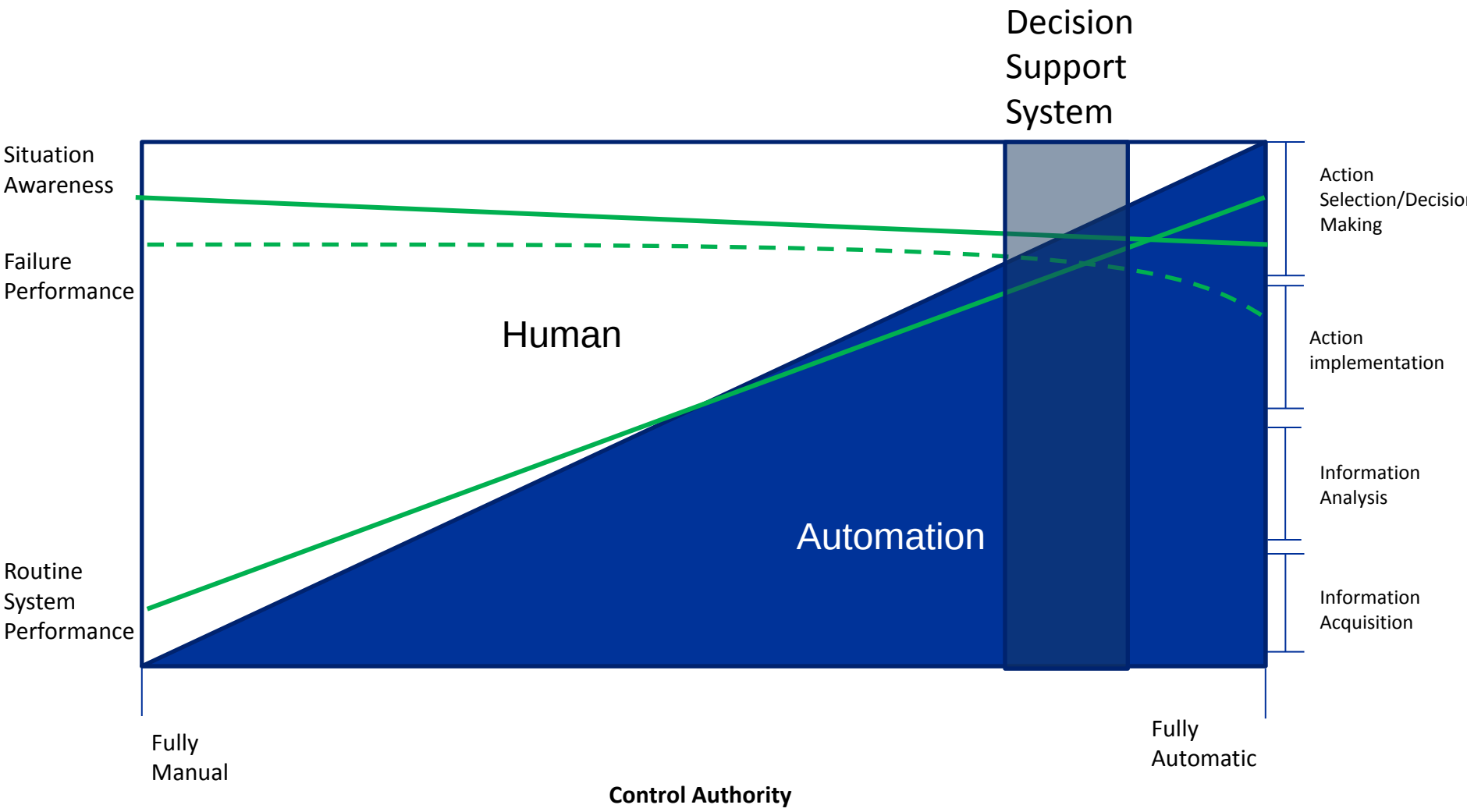
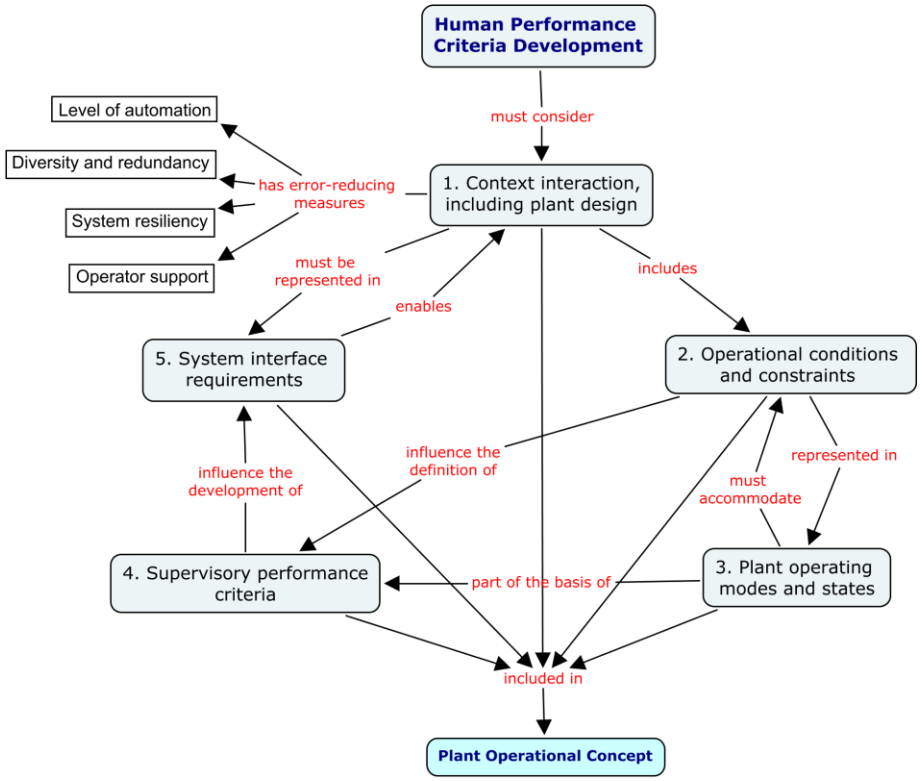
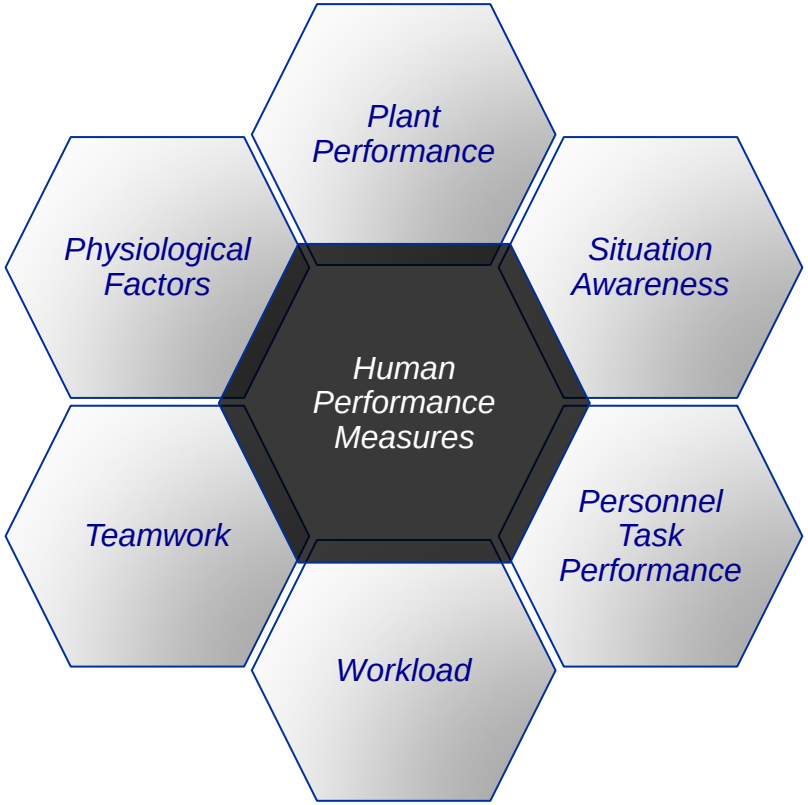
Hypothesized Performance Consequences of Degree of Automation



Operational Concepts Accomplishments (3)

3. Framework for Human Performance Criteria for AdvNPP Operational Concepts (2014)





Summary

- **Main research aims:**
  1. Investigate how to best design the collaboration between the operators and automated systems in a manner that has the greatest positive impact on overall plant performance and reliability.
  2. Investigate and describe the operational characteristics of reactors employing FOAK technologies and non-water coolants (HTGR, SFR, LMR).
- **Significance**
  - Conventional control system technologies unavailable and expensive - new plant designs will use emerging technologies.
  - Advanced designs must support operator/system collaboration. Bad design will limit overall performance and impact safety.
  - Operational Concepts vital to ensure system designs meet operational requirements. Must be developed as early as possible in the project life cycle include operational requirements in system design.
- **Benefits:**
  - OpsCon: improve ability to plan for the challenges of operating advanced reactors, align all engineering disciplines, ensure traceability of design decisions, help assure effective, efficient, safe operations.
  - HAC: provide an understanding of how automation design impacts both human and system performance in advanced nuclear power plants.

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Project Milestone Reports

- **HAC**
  - Effects of Levels of Automation for Advanced Small Modular Reactors: Impacts on Performance, Workload and Situation Awareness, INL/EXT-14-32639/SMR/ICHMI/INL/TR-2014/03, Rev 1.
  - Framework for Human-Automation Collaboration: Conclusions from Four Studies, INL/EXT-13-30570/SMR/ICHMI/INL/TR-2013/05, Rev 1.
  - Development of an Initial Model of Human-Automation Collaboration: Results from a Needs Analysis, INL/EXT-13-28682 /SMR/ICHMI/INL/TR-2013/01*, Rev 0*
- **OpsCon**
  - Work Domain Analysis of a Predecessor Sodium-cooled Reactor as Baseline for AdvSMR Operational Concepts , INL/EXT-14-31562/SMR/ICHMI/INL/TR-2014/022, Rev 0.
  - Development of a Technical Basis and Guidance for Advanced SMR Function Allocation INL/EXT-13-30117/SMR/ICHMI/INL/TR-2013/04, Rev 0.
  - Draft Function Allocation Framework and Preliminary Technical Basis for Advanced SMR Concept of Operations. INL/EXT-13-28601/SMR/ICHMI/INL/TR-2013/02, Rev 1.