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Predicting Human Performance in Unexpected Events

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Alion Science and Technology
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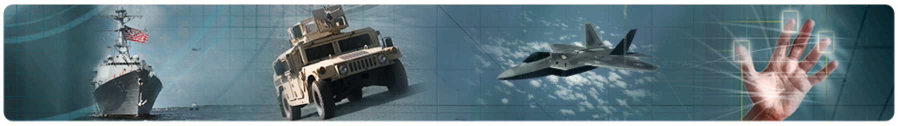


The Challenge and Approach

SLIDE 2

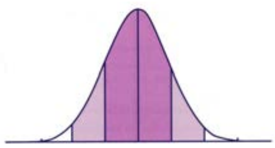
Challenge
- Things can – and do – go wrong
- We cannot possibly identify every potential situation ahead of time
- How can we predict how people will behave and respond in unexpected, off-nominal events?

Approach
- Using computational models to predict operator performance
- Basing these models on empirical research / operational data and conducting validation studies

Human Performance Modeling

SLIDE 3

- Provides tools for simulating and predicting operator performance in different conditions
- How it works
  - Based on task analyses and understanding of cognitive demands placed on operators
  - Includes data: task times, distributions, operator decisions and paths
  - Each run can take a different path, generating sets of predicted performance results
- Output
  - Mission time, success
  - Operator workload, utilization, staffing levels
  - Human error probabilities
  - Operator noticing, situation awareness
  - Productivity, throughput, optimization capabilities



Distributions of predicted performance across runs

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Human Performance Modeling Applications

SLIDE 4

Many industries use modeling to answer different questions

- Defense
- Aviation
- Healthcare
- Space
- Nuclear

Predict performance in situations that cannot readily be tested

- Never performed tasks / missions
- New operational concepts
- Dangerous scenarios / conditions
- When HITL is prohibitively expensive

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Case Study
Predicting Human Performance in Long Duration Space Missions

NASA Grant NNX12AE69G

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GRAs: Alex Vieane, Robert Gutzwiller
NASA POCs: Brian Gore, Sandra Whitmire

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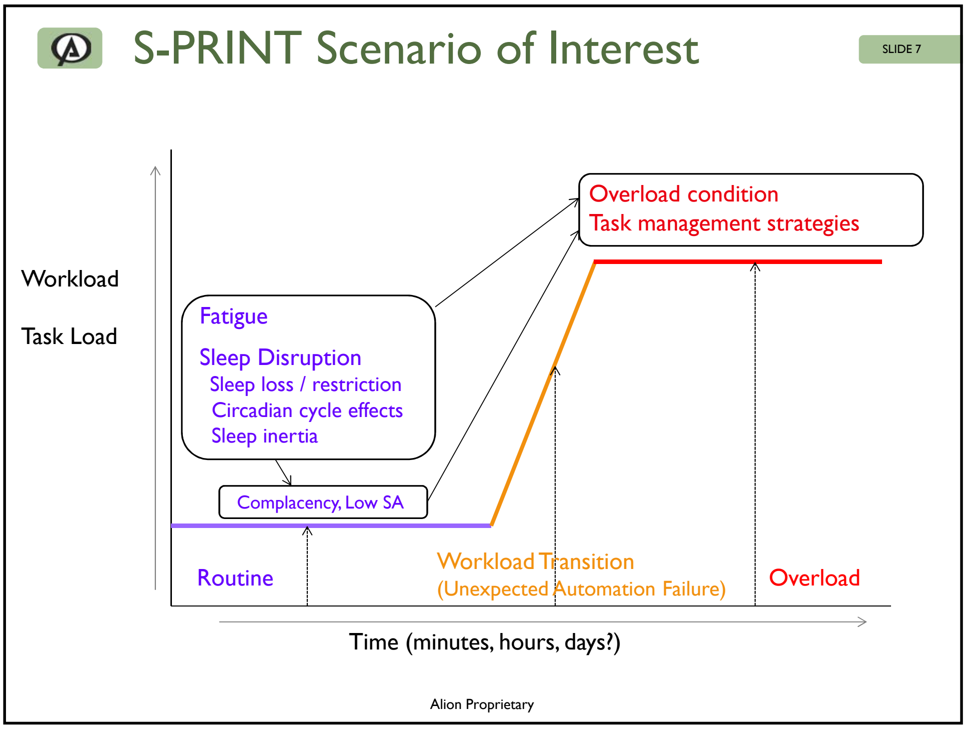
NASA

Purpose

SLIDE 6

- Identify vulnerable situations in long-duration missions
- Select a worst case scenario
- Characterize and research components
- Develop analytic models and a task-based model

- Conduct HITL studies for data gathering, model development, and validation purposes


S-PRINT Scenario of Interest
SLIDE 7
Workload
Task Load
Overload condition
Task management strategies
Fatigue
Sleep Disruption
Sleep loss / restriction
Circadian cycle effects
Sleep inertia
Complacency, Low SA
Routine
Workload Transition
(Unexpected Automation Failure)
Overload
Time (minutes, hours, days?)
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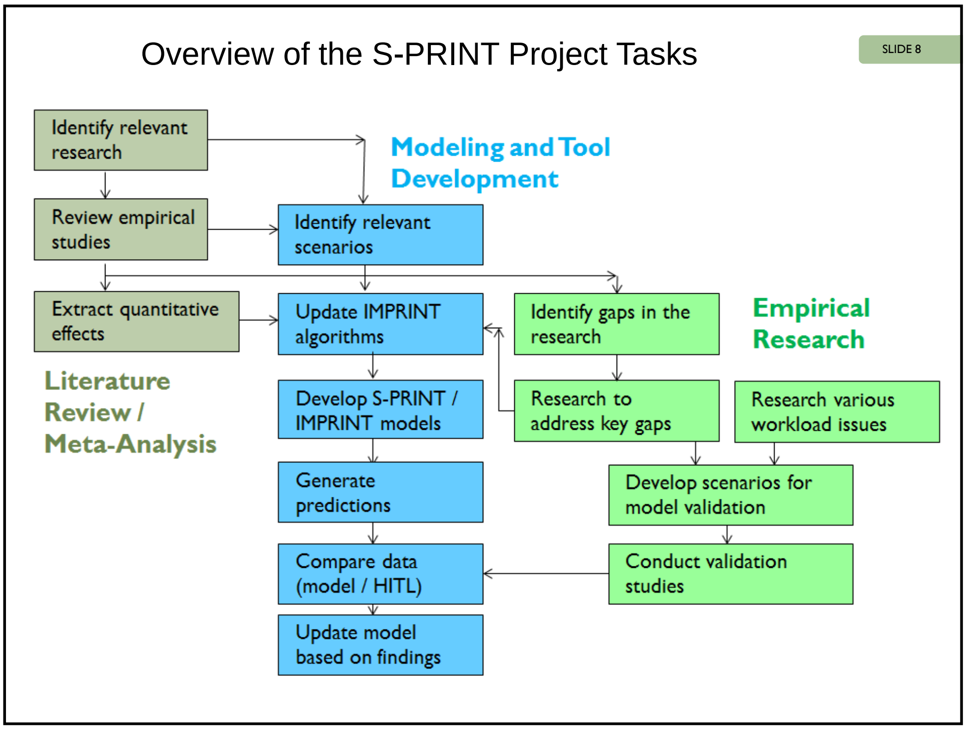
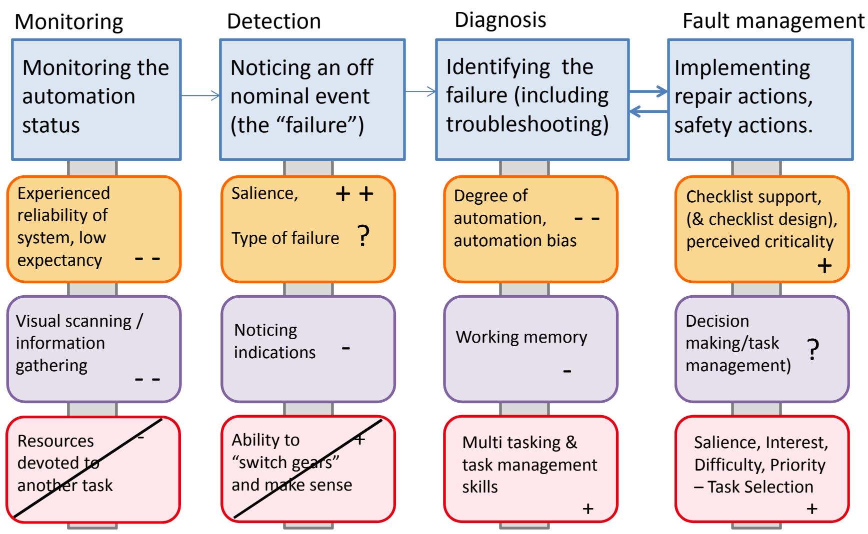

Overview of the S-PRINT Project Tasks
SLIDE 8
Identify relevant research
Review empirical studies
Extract quantitative effects
Literature Review / Meta-Analysis
Modeling and Tool Development
Identify relevant scenarios
Update IMPRINT algorithms
Develop S-PRINT / IMPRINT models
Generate predictions
Compare data (model / HITL)
Update model based on findings
Identify gaps in the research
Research to address key gaps
Empirical Research
Research various workload issues
Develop scenarios for model validation
Conduct validation studies

S-PRINT Conceptual Model

SLIDE 9



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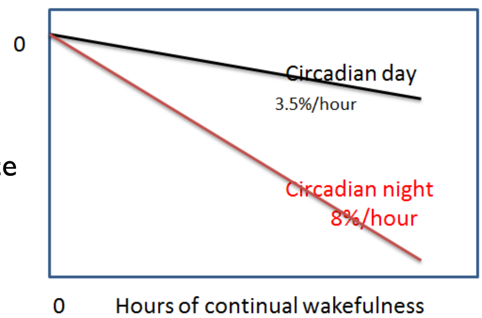
S-PRINT: Fatigue Algorithms

SLIDE 10

- Fatigue overview
  - Determine and quantify the effects of sleep-related factors on task completion time and accuracy
    - Sleep deprivation, sleep restriction, circadian cycle, sleep inertia
  - Important points:
    - Quantifying the effects
    - Identifying the effects on *complex* task performance



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S-PRINT HAI Model

SLIDE 11

- Challenge: HAI research is diverse and automated systems differ tremendously
- Approach: To develop a model of HAI that applies across systems, yet is specific enough to accurately model the actual system
- Result: Used two complementary approaches
  - A generic automation "performance shaping factor" that applies benefits or penalties to task performance
  - A custom-built task network model to capture the differences in tasks and operator performance paths

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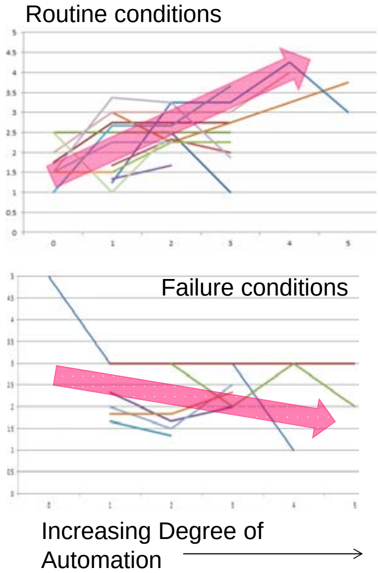
S-PRINT HAI: Performance Shaping Factor

SLIDE 12

- Developed based on studies that evaluate human performance across a variety of automation types
- Factors that the PSF includes
  - Increasing *degree of automation*
    - Improves performance in routine conditions
    - Degrades performance in failure conditions
  - Increasing *reliability of automation*
    - Improves performance in routine conditions
    - Degrades performance in failure conditions
  - Alert absence penalty (failure type and salience)

Onnasch, Wickens, Li & Manzey, 2013



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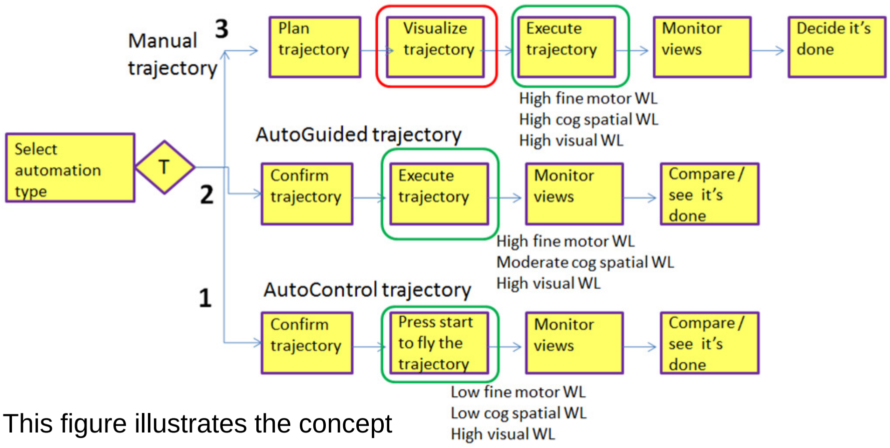
S-PRINT HAI: Task Network Model

SLIDE 13

- Automated systems differ tremendously
- Different modes and failures require that the operators perform unique tasks
- These paths (tasks, feedback, decisions) are included in the task network models



This figure illustrates the concept

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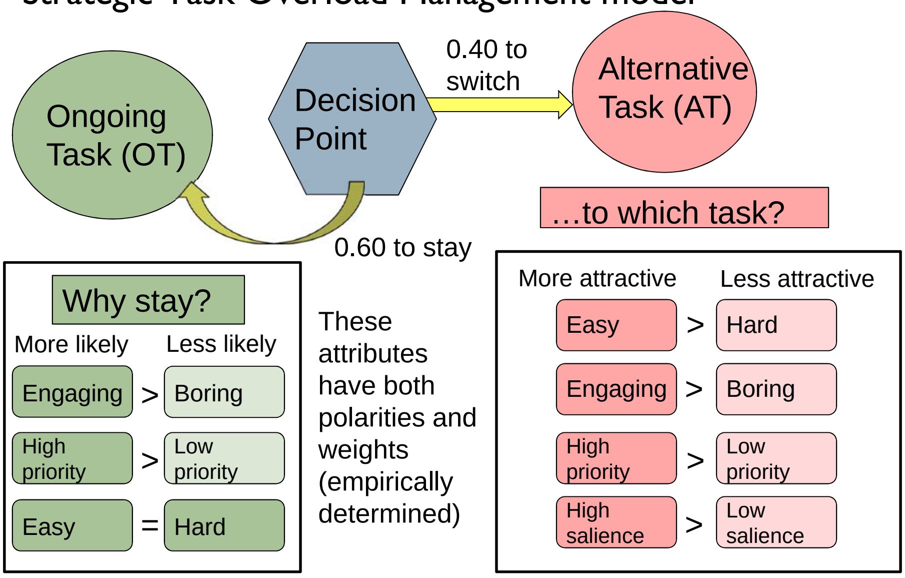
S-PRINT: Overload

SLIDE 14

Strategic Task Overload Management model



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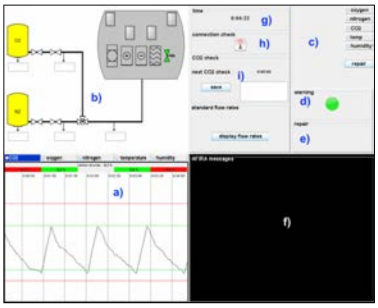
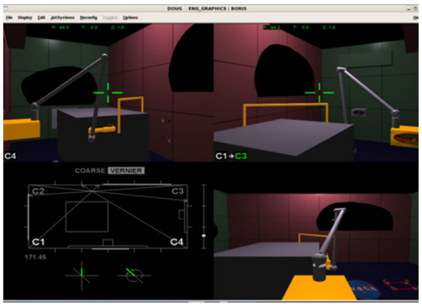
S-PRINT Scenario and Task Network Model

SLIDE 15

- Environmental process control
- Robotic arm control
- Predicts time, workload, mission success, tasks performed
  - Two modes of operation for each system
  - Different types of failures
  - Different fatigue scenarios (sleep histories)





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S-PRINT Experiments

SLIDE 16

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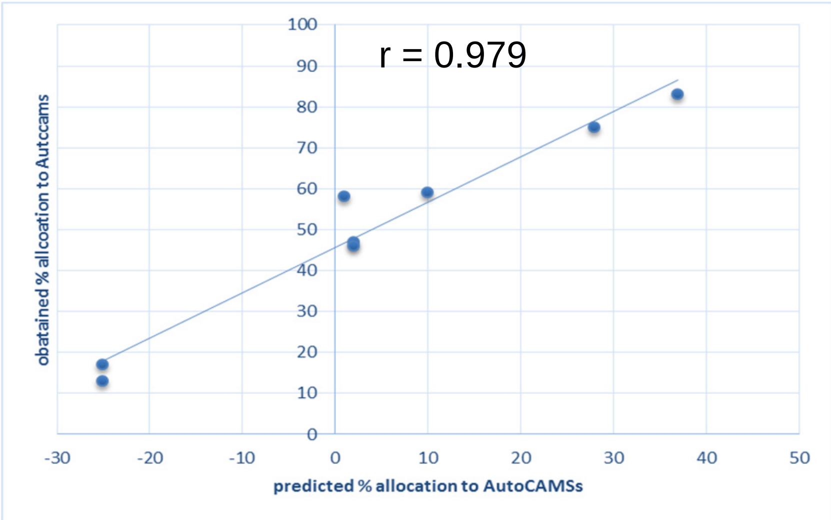
STOM Validation: Percent visual attention allocation to AutoCAMS

SLIDE 17



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Summary

SLIDE 18

- Modeling to predict human performance in unexpected situations
  - Identify potential worst case conditions
  - Characterize the situation – factors?
  - Conduct / review research to describe performance effects
  - Develop models (analytic / descriptive and task-based)
  - Perform data gathering and validation experiments
- Can be adapted to different industries, work situations, and environments
- Can run the model under a variety of conditions to gather data / identify those combinations of factors that impact performance
- Can identify and evaluate potential mitigation strategies

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