

# DHS SCIENCE AND TECHNOLOGY

## HSI T&E Methods and Metrics for Assessing User-Automation Interaction

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**Homeland  
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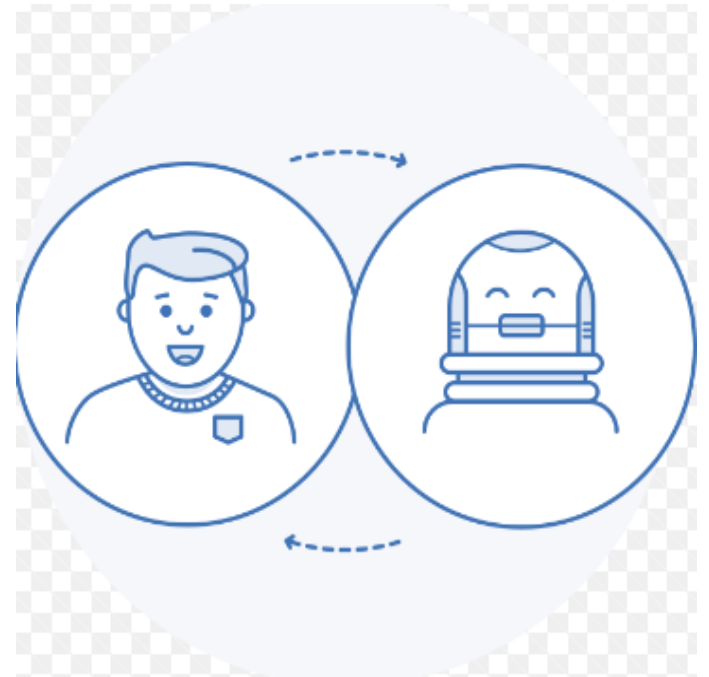
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# Agenda

- Definition of Automation
- Allocation of Functions
- Value of Early T&E
- Systems Engineering Life Cycle (SELC)



# Automation

*Technology by which a machine performs a process or procedure*

## Advantages



- Reduces human workload, fatigue, staffing
- Integrates large volumes of data
- Improves vigilance, surveillance, and detection
- Increases safety by removing the human from hazardous environments or situations
- Reduces human error
- Expands and extends human capabilities: strength, sensory abilities, and cognitive processes

## Disadvantages



- Uses different control strategies than operator
- Elicits the 'out of the loop syndrome'
- Leads to complacency
- Leads to loss of perishable skills
- Creates mode selection errors
- Interferes with operator situation awareness issues
- Interferes with team coordination

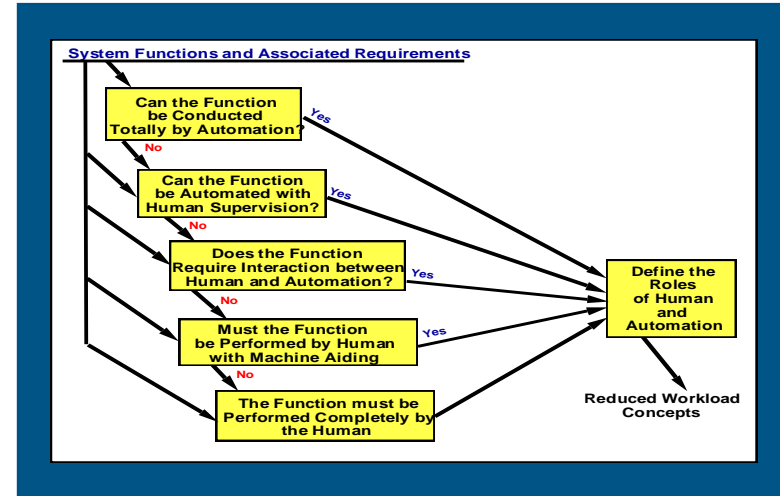
# Function Allocation in the system design process

## Decisions are made on functions:

- which ones are fully automated
- which ones are performed by a human only
- which ones are performed by a collaboration between automation and human

## Criteria for these decisions include:

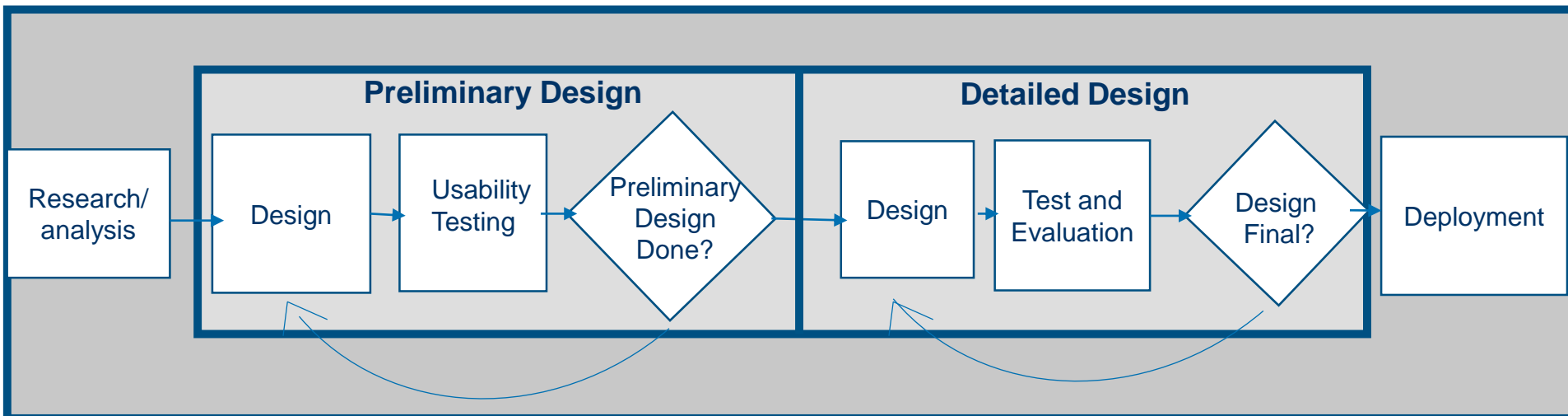
- technology maturation, technical risks, and automation feasibility
- command authority, mission risks, environmental, and operational contexts
- human safety, performance capabilities, and limitations



# Value of Early T&E

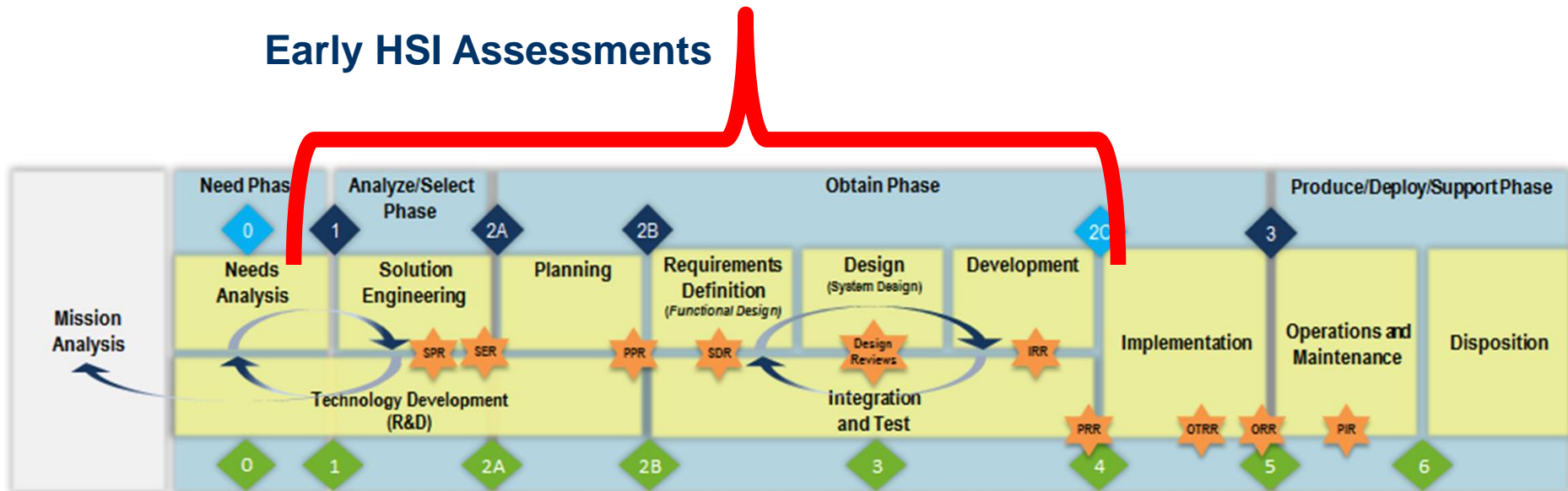
Initiating T&E efforts earlier in the process leads to:

- Successful T&E outcomes through early verification of HSI requirements;
- Early identification and implementation of mitigation strategies to reduce HSI risks;
- Earlier identification of problems that can impact system modifications;

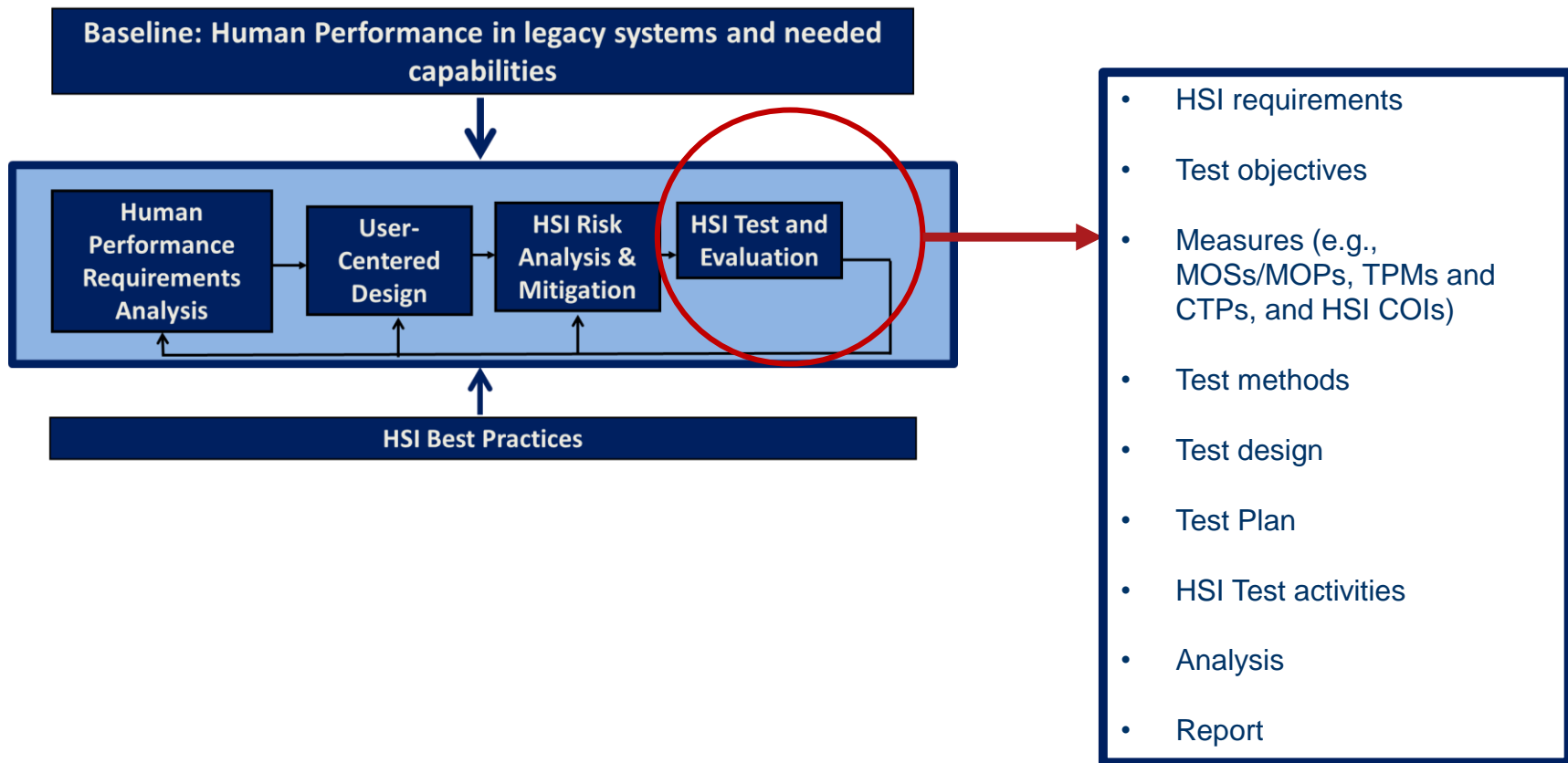


# DHS Systems Engineering Life Cycle

## Early HSI Assessments



# Key HSI Activities



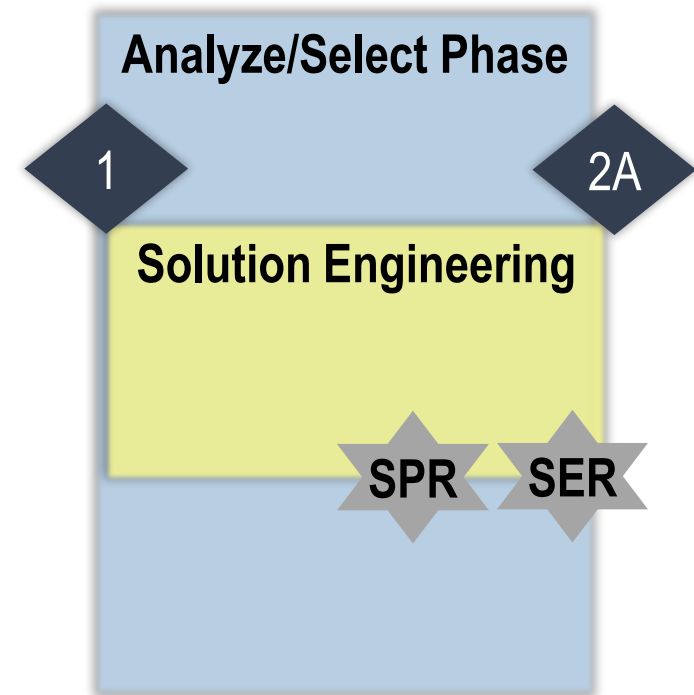
# Sample HSI Methods and Measures for Automation

Methods	Measures	Metrics
Direct observation and measurement	Usability	Completion rate, number of incorrect decisions/actions, duration of time to respond to a stimulus or complete a task, ratings of satisfaction/acceptance)
**Experimentation **Actual operations **Simulated Human-in-the-loop studies	Workload (e.g., task load/task engagement)	Number of instances where task load exceeds threshold, duration period of workload saturation, workload spikes/number of instances or timing situations where the overall workload drops below a set minimum threshold, ratings of perceived workload
Compliance with standards	Training (e.g., manual and automated tasks)	Time to train/number of training objectives met
Heuristic Evaluations	Mismatches between authority and responsibility	Number of mismatches between authority and responsibility
Checklists	Unpredictability	Number of Type 1 (i.e., human cannot predict the need to act in nominal operations)/Number of Type 2 (i.e., human can predict but the timing is uncertain regarding when the action needs to occur) unpredictable actions
Subjective rating scales	Coherency	Number of resource conflicts resulting in interdependent activities/significant coordination
Surveys/Questionnaires	Interruptions	Number of interruptions
	Automation boundary conditions	Number of instances/duration when automation is placed outside of boundary conditions, Number of instances where automation does not achieve targets while operating according to its spec
	Adaptation to context	Number of instances where there is an Inconsistent response/work-arounds to overly prescribed function allocation
	Automation reliability	Ratings of trust/degree of overreliance on automation/degree of disuse
	Transfer of control	Duration of time it take to move from a passive to an active state/# of errors
	Situation awareness	Mean Situation Awareness Global Assessment Technique (SAGAT) scores across a number of simulation trials
	Comprehension of system/automation logic	End user rating of the extent to which the automation meets expectations



# T&E Activities: Solution Engineering

- Identify applicable HSI MOSs and MOPs
- Evaluate alternative concepts
  - Develop test scenarios
  - Select HSI methods to assess function allocation approach and define roles of human and automation
- Identify HSI operational requirements and critical operational issues

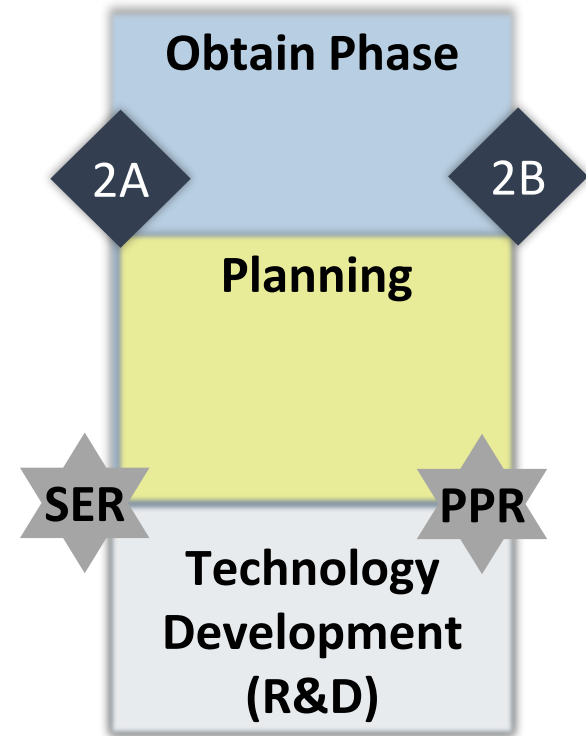


**Operational Requirement:** The solution shall enable users to successfully complete mission tasks with reduced workload (Threshold = X and Objective = X )

**COI:** Does the design of the automation coupled with user training support the users in successfully accomplishing mission tasks and minimize the deskilling of automated tasks?

# T&E Activities: Planning

- Provide HSI inputs to the TEMP (Test and Evaluation Master Plan).
  - HSI-specific tests
  - HSI tests as part of system-level testing
- Develop an HSI test strategy
- HSI participation in a T&E IPT
- Provide HSI Critical Technical Parameters (CTPs)



## HSI Measures:

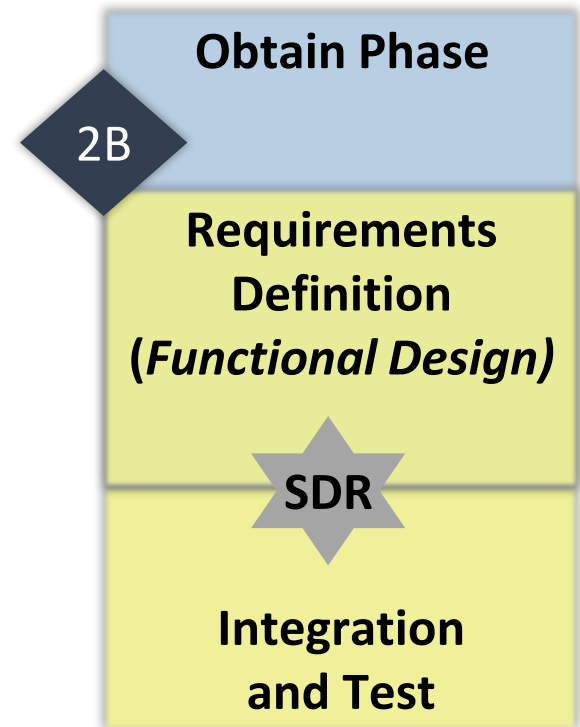
Usability  
Situation Awareness  
Coherency

## Critical Technical Parameter:

Task completion/error rates for task work/teamwork,  
Mean SAGAT scores  
Number of resource conflicts due to overlap in functions

# T&E Activities: Requirements Definition

- Determine how HSI T&E activities will refine requirements.
- Determine how HSI T&E is used to assess the adequacy of commercial or COTS products.
- Refine requirements through experimentation and modeling and simulation.



**Requirement:** System function allocation concept shall support the dynamics of the work

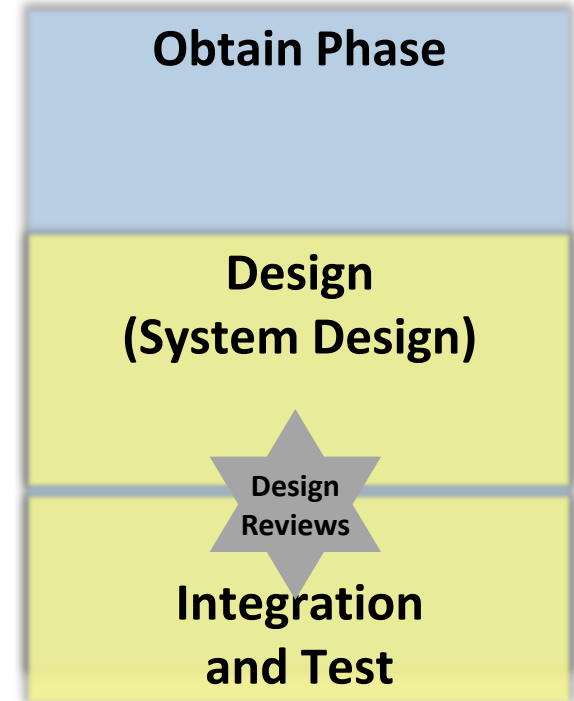
**Experimental Design:** 2 X 2 X 3 (12 conditions)

IVs: allocation concept, experience level, task demands

DVs: time spent in cognitive control modes and transitions between control modes

# T&E Activities: Design

- Develop HSI inputs to the DT&E test plan
- Common methods (analysis, test, demonstration, inspection)
- Iterative testing and evaluation to assess user performance of human-automation interaction
  - Usability, situation awareness, workload, function allocation concepts



## Requirements:

System shall provide adequate early warning notification

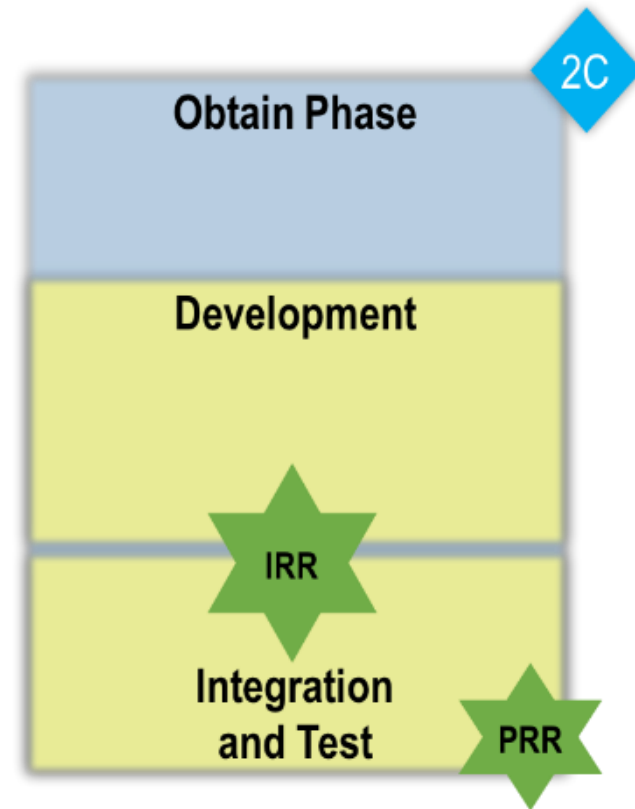
System shall not interrupt at inappropriate times (e.g., periods of high workload)

System shall enable the user to determine asset health, status, and place in a procedural sequence

# T&E Activities: Development

HSI testing of components, products, and functionality that make up the system

- Evaluate human performance against TPMs to assess progress towards meeting system performance requirements
- Identify HSI risks and mitigation strategies



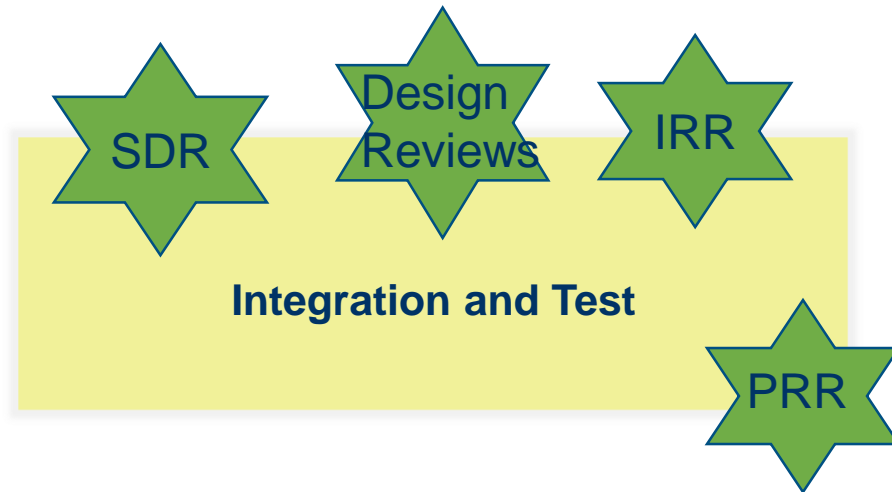
## HSI Risks:

- If automation overly prescribes a course of action or sequence of activities, then users may establish work-arounds or stop using automation
- If authority for task execution and responsibility for the outcome are not assigned to the same “agent”, then increased workload due to monitoring associated with the mismatch may occur

# T&E Activities: Integration and Test

Determine if integrated system, subsystems, and components satisfy HSI requirements (DT and OT):

- Coordinate with OTA so that Early Operational Assessments address progress toward meeting HSI COIs
- Assess system risks and maturity
- Identify and implement risk mitigation plans and corrective actions



Assess human-automation collaboration effectiveness & efficiency in the completion of mission tasks in representative environments using engineering simulations with prototypes and actual systems

# In closing...

- There are benefits to “shifting left” and assessing HSI considerations earlier in the acquisition process.
- T&E must evaluate decisions concerning verification of type/level of automation.
- Modern DHS systems increasingly exhibit automated processes (security network monitoring, revenue collection systems, explosive threat detection systems, remote video surveillance systems, etc.)
- Unique opportunities exist for designing automated technology and systems that facilitate teamwork and cooperation



Questions?



# Homeland Security

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Science and Technology



# HSI T&E – Typical Measures

- MOEs (Measures of Effectiveness) are derived through an analysis of the mission by initially defining the top-level mission tasks (capabilities) required to be performed, regardless of the potential solutions. Typically, human performance is not addressed in MOEs.
- MOSs (Measures of Suitability) are critical operational measures of success that define whether the alternative is a suitable solution. MOSs include items such as the impact of the alternative on the users (e.g., human system integration, accessibility, compliance, privacy, tactics, training) or the public (e.g., flow of commerce, environmental impact) as well as sustainability and support requirements.
- MOPs (Measures of Performance) are specific, technical performance parameters that can be measured and contribute to the MOEs/MOSs.