

HUMAN SYSTEMS INTEGRATION: APPROACHES FOR DEVELOPMENTAL TESTING

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HSI in Developmental Testing

- Developmental Testing (DT) assesses technical progress against critical technical parameters and allows for early operational assessments
 - DT can include multiple phases / events
- DoD policy and guidance helps to direct HSI involvement
 - DoD 5000.02 mandates that Human System Integration (HSI) be included in the Engineering Manufacturing Development phase of the acquisition process, which includes DT
 - HSI test planning should verify that the system can be operated, maintained, and supported by users in its intended operational environment, with the planned level of operator training (DAU DAG, 2010)
- DT is a valuable environment for HSI assessments and user-centered testing
 - Early, multiple opportunities, system integration and functionality, and can support operational workflows
- However, there is limited guidance on how to include HSI in DT events, the scope of what to test during each event, and how those results impact overall system performance



HSI in Developmental Testing: Challenges

- HSI testing opportunities may only include components and subprocesses rather than total system performance
- Examples of traditional yet limited approaches to HSI testing:
 1. human performance evaluations on a mature or fielded system
 2. usability evaluations of discrete system functions without acknowledging their relationship to the larger, complex system – a “band-aid” approach
- While valid approaches, HSI testing in both instances is untimely because it is not aligned with the full sequence of planned engineering test activities
- Testing is rarely under the direction and control of HSI and therefore may limit opportunities for HSI tests
- HSI and DT processes require better integration so HSI results can contribute to development of early mitigation strategies
- There is a need to better define how HSI testing capabilities can support the test community
 - Process, procedures, products, and metrics



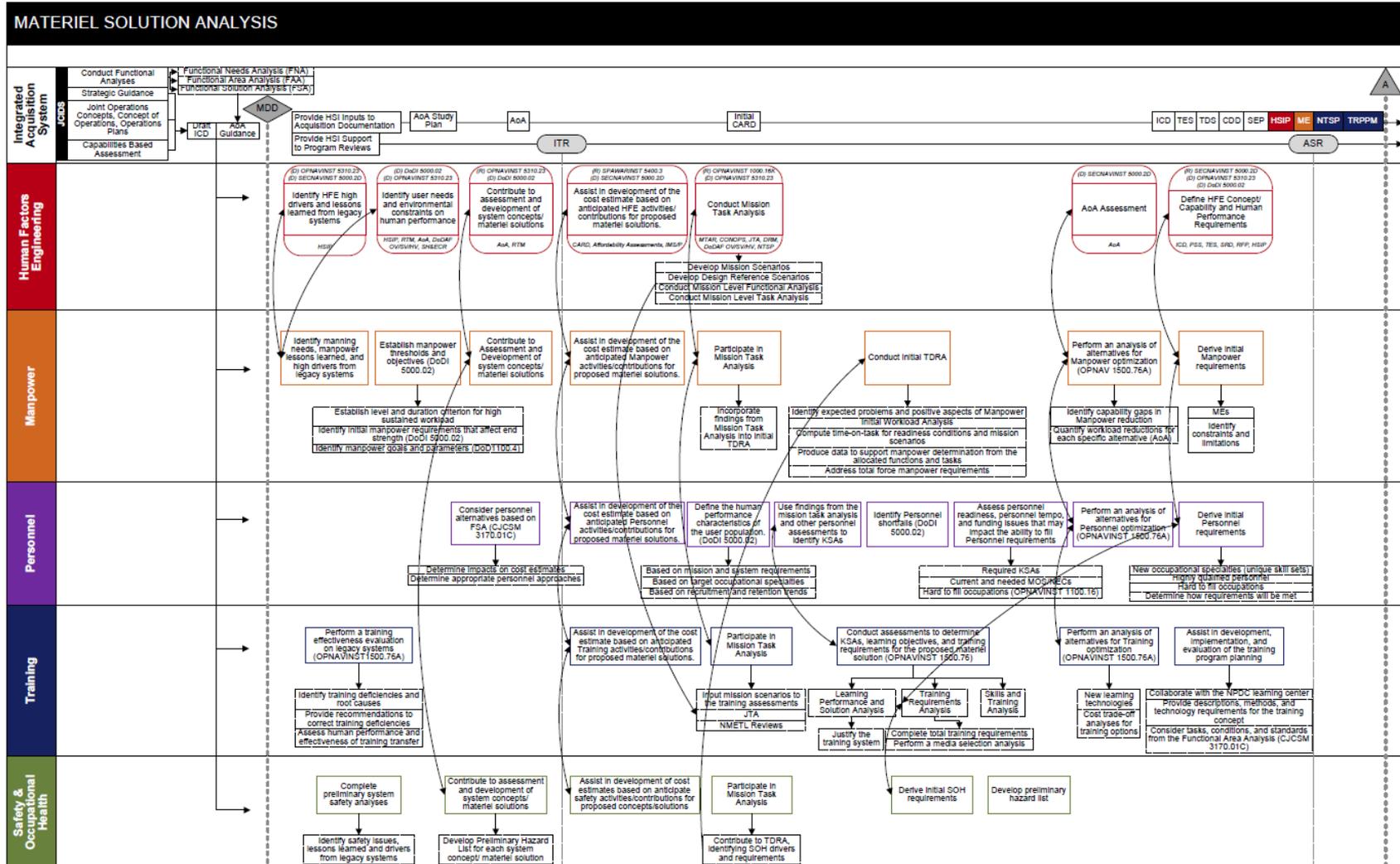
Defining a Process: HSI Support for Testing

- An HSI Framework was developed to provide specific guidance on how to integrate HSI processes, products, and tools into the Defense Acquisition System.
- Using DoD guidance and policy documents as references, activities for all HSI domains were defined and mapped to each acquisition phase.
- The intent of the Framework is to provide a coordinating mechanism, aligned with the Acquisition Lifecycle, to support the Program Offices, program reviews, system engineering, and the HSI practitioner.
- It supports the consistent application of HSI processes, products, and tools within the acquisition community to mitigate human performance shortfalls and maximize system effectiveness.



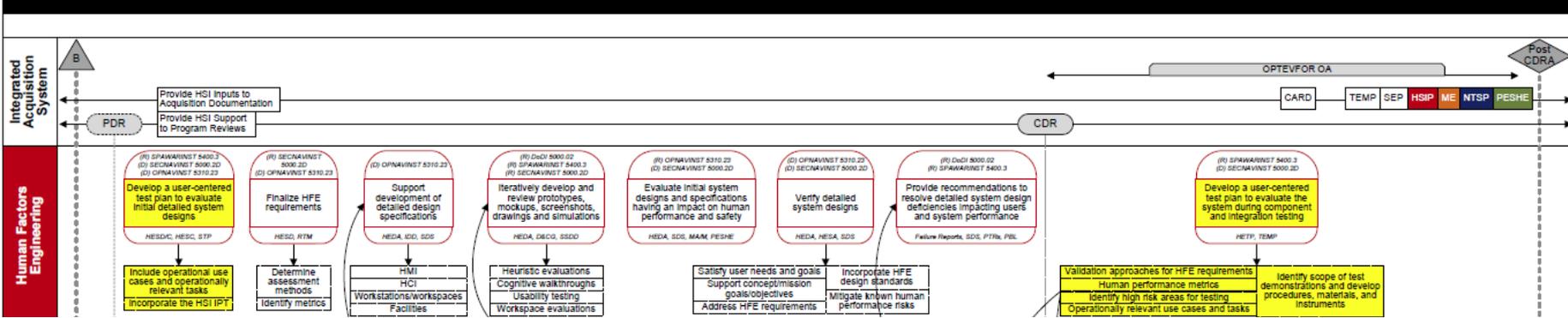
HSI Framework Example

Matériel Solution Analysis phase includes rows for each HSI domain and a row for integrated acquisition events and documents. Inputs and outputs have been mapped onto each HFE activity.

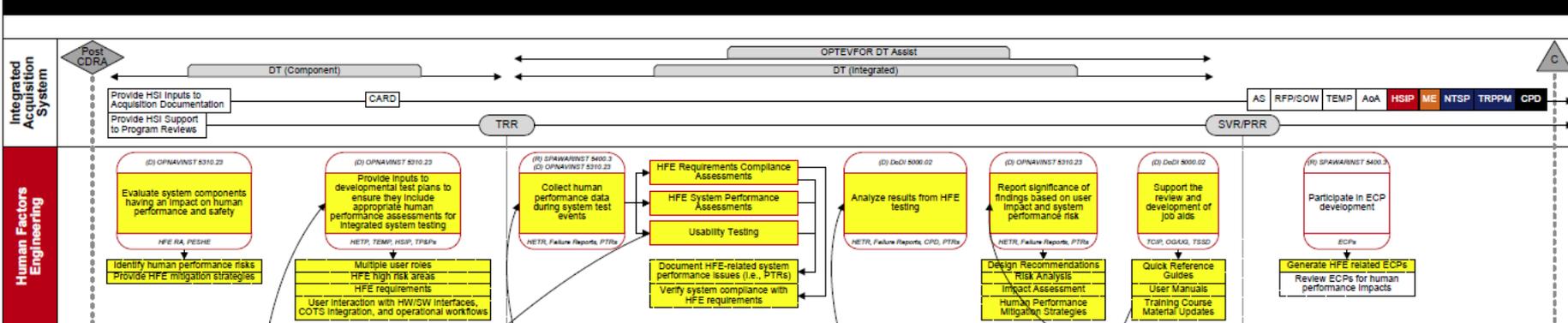


HSI Framework: Test Activities Identified

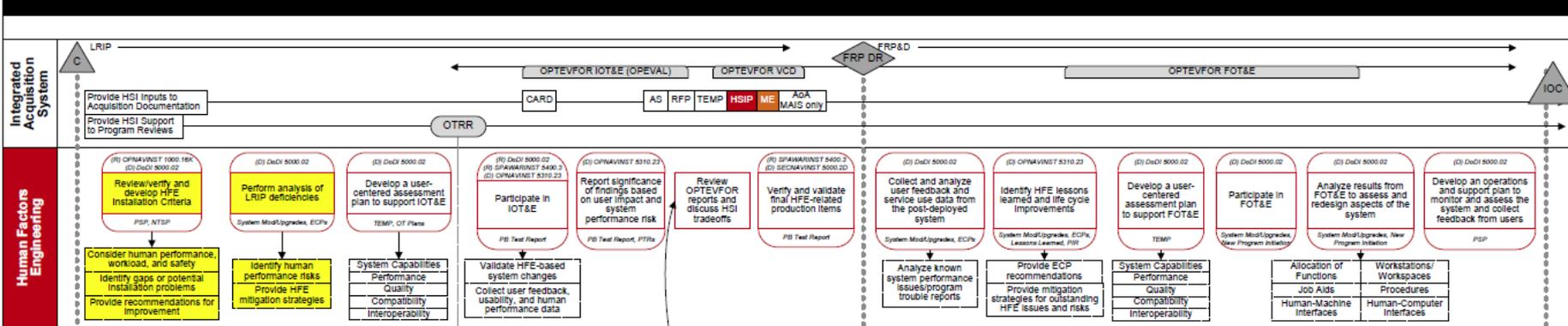
ENGINEERING & MANUFACTURING DEVELOPMENT: Integrated System Design



ENGINEERING & MANUFACTURING DEVELOPMENT: System Capability and Manufacturing Process Demonstration



PRODUCTION & DEPLOYMENT



HSI in Developmental Testing: Approaches

- Support the development of operationally based DT test plans and procedures
 - Directly supports subsequent Operational Testing (OT)
 - Resequencing traditional requirement-based test procedures can reveal system performance issues that would otherwise be discovered during OT and fielding
- Use a multi-phase and multi-source approach
 - Participate in multiple DT events and leverage findings to support each subsequent event
 - Leverage multiple data sources such as observations, interviews, expert assessments, performance measurements, analysis of logs, etc.
- Communicate HSI findings in a manner consistent with the engineering and test communities
- Perform expanded analyses to demonstrate impact on operational workflow and mission performance



HSI Role in Developmental Test Events

DT Event	HSI Role
Component Testing	HSI will observe engineering component/unit tests in order to obtain a more comprehensive understanding of the system and its individual components. Observations and HSI requirements validation results will be used to focus the scope of assessments for Functional Testing and develop/refine HSI test plans for System Integration and Developmental Testing. HSI-related issues uncovered by component testing will be documented and analyzed.
Functional Testing	HSI will observe tests of functionality with representative users . Observations of user performance and HSI requirements validation results will be used to refine test plans and materials for System Integration and Developmental Testing. HSI-related issues uncovered by functional testing will be documented and analyzed.
System Integration Testing	HSI will perform assessments with representative users to evaluate usability and user performance when using an integrated functional system. Recommendations for conducting DT/OT will be provided ensuring test plans include operational use cases, operationally relevant tasks/scenarios, and testable human performance metrics based on requirements. Any critical user performance and system functional issues identified will be noted and included in DT/OT assessments for further evaluation. In preparation for DT/OT, HSI will review the TEMP and provide inputs as needed.
Developmental / Operational Testing	HSI will perform assessments with operational users to evaluate user performance and operational suitability . HSI test plans and materials developed and refined based on findings from previous test events will be used to support user evaluations. Results from DT/OT will be reported and recommendations for Engineering Change Proposals (ECPs) will be provided.



Communicating HSI Results and Impact

- HSI-specific findings should be assessed for their relevance and tracking of HSI-related items at the program level
- Report significance of findings based on user impact and system performance risks
 - Analyze HSI issues based on Frequency and Consequence to prioritize human performance risks
 - Results should include prioritized design guidance, human performance mitigation strategies, and/or risk and impact assessments
- Coordination of HFE and Training domains
 - DT findings will contribute to the development and review of job aids such as quick reference guides, user manuals, and training course material updates
 - Training solutions can be revised based on findings from integrated system demonstrations and pilot courses

	CONSEQUENCE					Total
	1 Minimal	2 Minor	3 Moderate	4 Significant	5 Severe	
5 Very High: ~90%	Low 0	Moderate 1	High 0	High 0	High 0	1
4 High: ~70%	Low 2	Moderate 5	Moderate 2	High 5	High 0	14
3 Moderate: ~50%	Low 1	Low 6	Moderate 5	Moderate 3	High 2	17
2 Low: 30%	Low 10	Low 4	Low 5	Moderate 3	Moderate 0	22
1 Very Low: ~10%	Low 1	Low 0	Low 0	Low 0	Moderate 0	1
Total	14	16	12	11	2	55

FREQUENCY



ANALYSIS OF HSI PROBLEM TRACKING REPORT (PTR) DISTRIBUTIONS AND POTENTIAL IMPACT ON OPERATIONAL WORKFLOW



HSI PTR Analysis

- Problem Tracking Reports (PTRs) are issues identified through DT events, assigned a severity code, prioritized, and tracked over time for their resolution
- Many “system” PTRs have human performance implications
- Naturally, program mitigation strategies and resources place emphasis on higher priority items
- Many HSI items may be identified as lower priority because they do not meet higher priority criteria and often have workarounds
- Individually, each HSI item may not be a significant concern
- But what is the impact on overall system performance when an operator must accommodate several workarounds or “nuisances” while executing their tasks?



Case Study: METMF(R) NEXGEN

- The Mobile Meteorological Facility (Replacement) Next Generation (METMF(R) NEXGEN) is a USMC mobile tactical meteorological system designed in a sheltered HMMWV
 - Up-armored sheltered HMMWV with tactical trailer
 - 4 modes of operation (Full, Limited, Remote, Stand-alone)
 - 3 racks of equipment, 3 displays, and 2 operator workstations
 - 5 major sensor systems with 25 cases
 - Multiple communication pathways
- HSI-related Key Performance Parameter (KPP): Full setup in 3-hours with 8 Marines and Limited setup in 1-hour with 2 Marines
- Sensors and components must be stored within a limited space and used safely and efficiently by operators and technicians within tight time constraints under various environmental conditions



HSI PTR Analysis: Rationale

- A series of HSI DT analyses identified 110 human performance-related PTRs
 - 12 High, 57 Moderate, and 41 Low risk HSI PTRs
 - Priority categories were 1's (18), 2's (13), 3's (63), and 4's (16)
- Most HSI-related PTRs were of lower priority because workarounds were identified (e.g. usability items)
- However, human errors and workload can be additive
 - Several smaller issues can equal one large issue
 - Workload increases with each issue
 - Errors can have cascading consequences
- Analyses needed to determine impact on operational performance to scope future efforts – 2 analyses were performed:
 - PTR Frequency and Risk Distribution Analysis
 - PTR Expanded Error Analysis



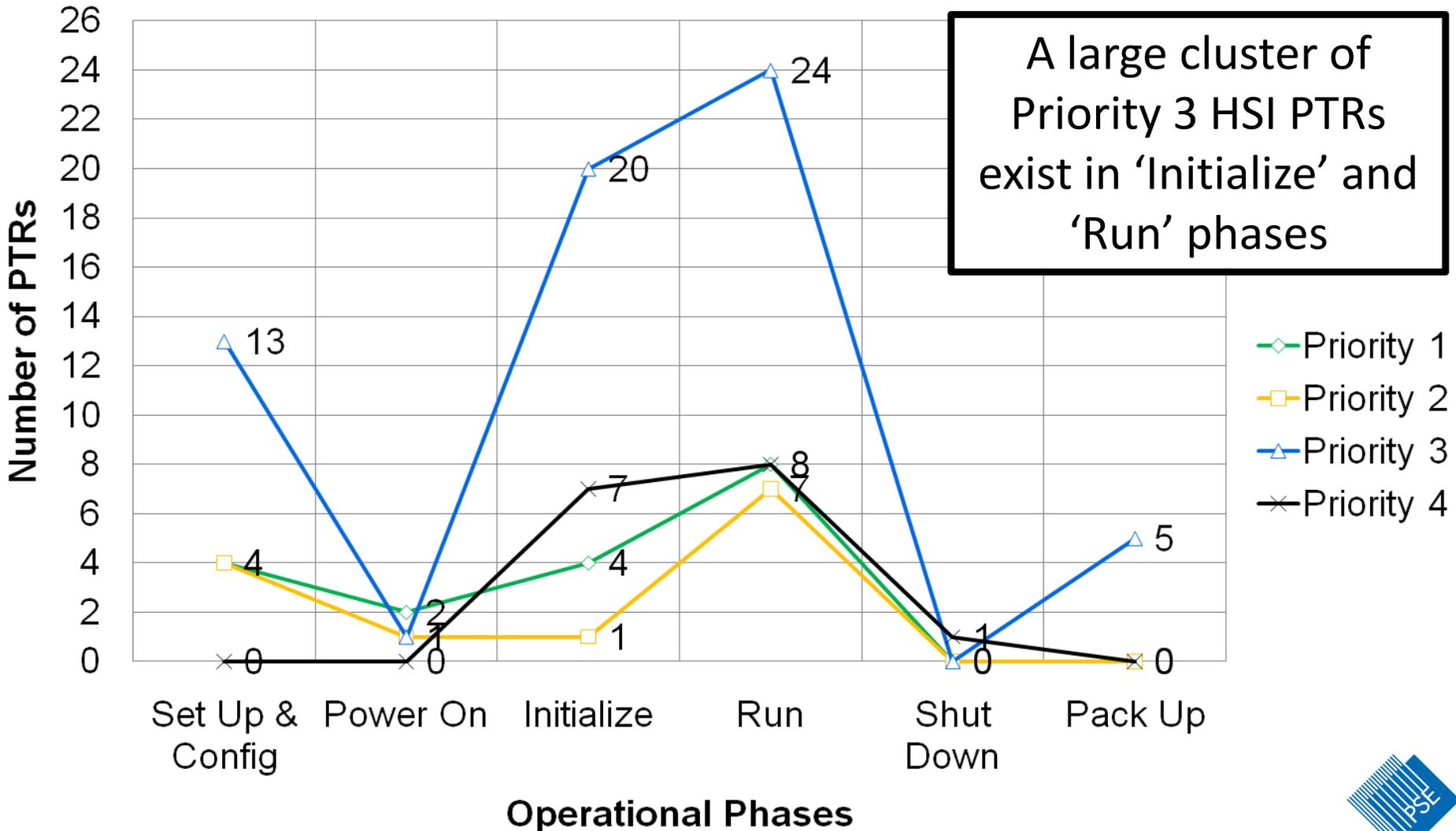
HSI PTR Distribution Analysis: Method

- Objectives:
 - Identify the impact of lower priority PTR clusters on operational phases
 - Determine the type and severity of human performance risks
 - Evaluate the distribution of HSI-related PTRs against operational workflow
 - Risk severity distribution (High, Medium, Low)
 - Risk type distribution (Error, Safety, Workload)
 - Identify the high-risk HSI PTRs based on the consequences of latent errors that may impact operational performance
- Method:
 1. Plotted HSI-related PTRs against operational workflow to identify low priority clusters
 2. Categorized HSI PTRs for type of risk (workload, safety, error)
 3. Based on analyses of Frequency and Consequence, derived and categorized HSI Severity (high, medium, low) using MIL-STD 882D risk matrix
 4. Matched HSI PTRs to System Operating Modes or other system components
 5. Plotted and analyzed clusters of risk type and severity within the operational workflow

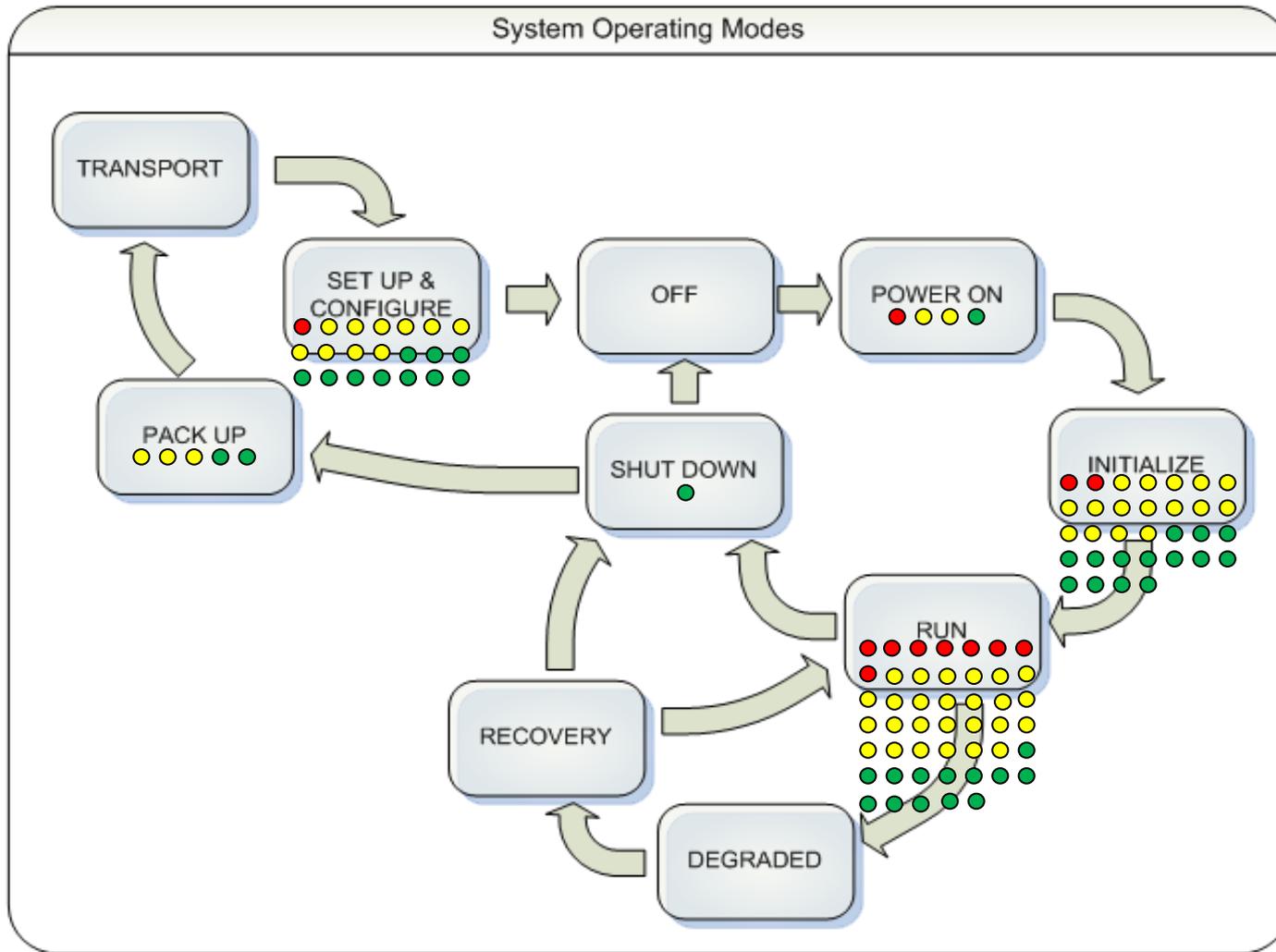


HSI PTR Analysis: HSI Priority Distribution

PTR Priority Distribution Across Operational Phases



HSI PTR Analysis: HSI Severity Distribution

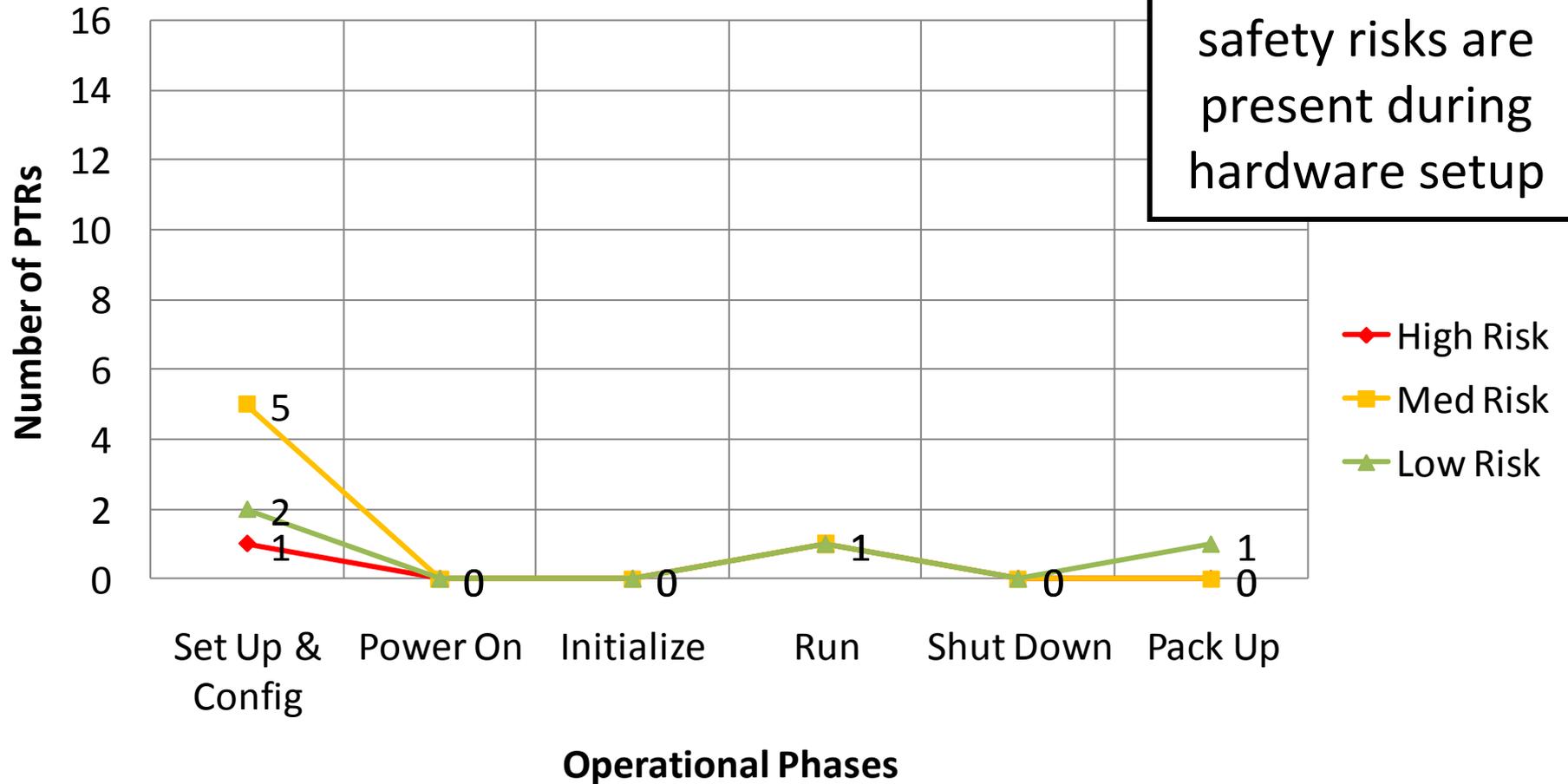


HSI risk severity plotted against workflow demonstrates significant clusters of low risk items during 'Initialize' and 'Run' – consistent with the PTR priority distribution



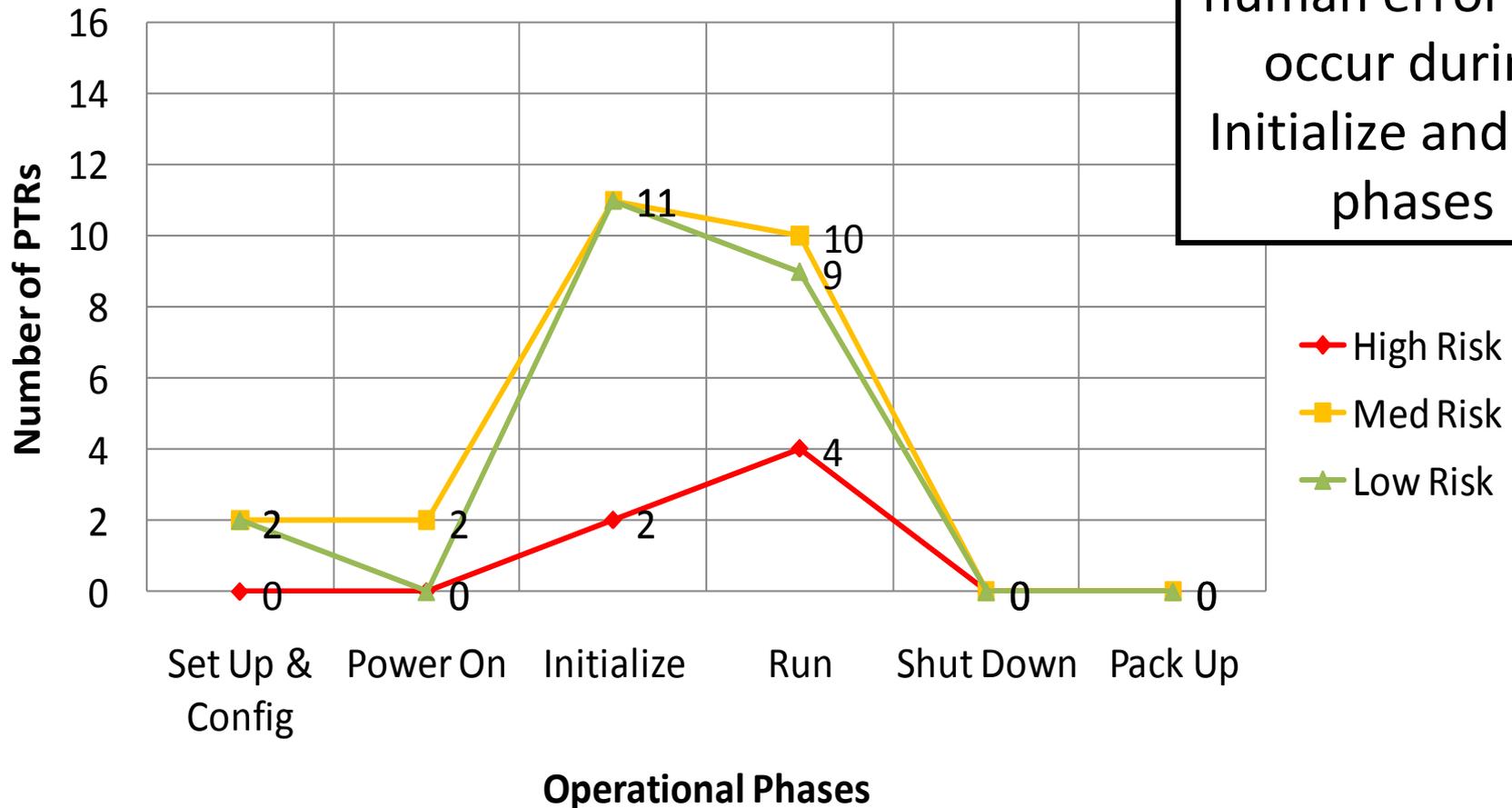
HSI PTR Analysis: Safety Distribution

**HSI PTRs Across Operational Phases:
*Safety Risk Distribution***



HSI PTR Analysis: Human Error Distribution

**HSI PTRs Across Operational Phases:
*Human Error Risk Distribution***

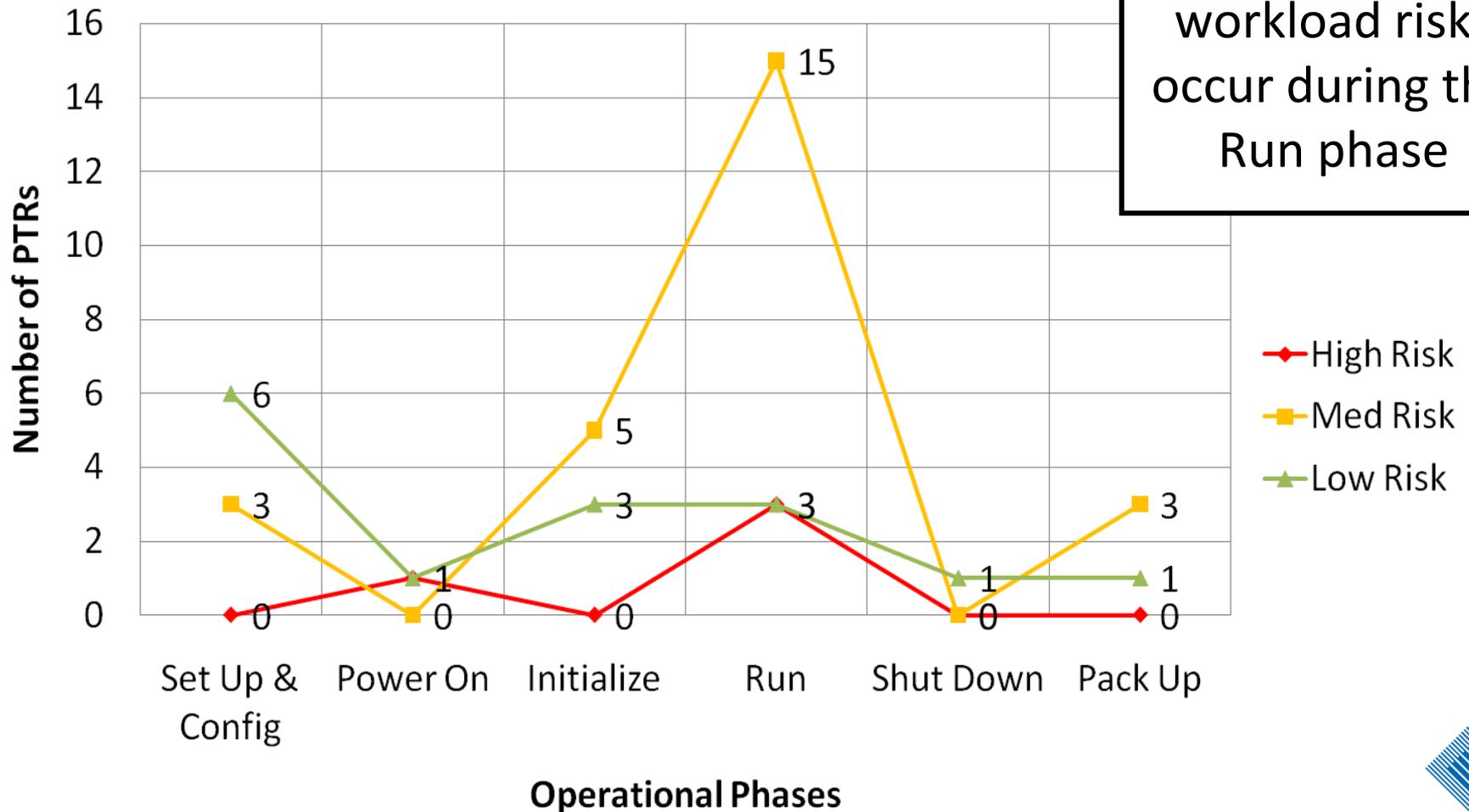


The majority of low and medium human error risks occur during Initialize and Run phases

HSI PTR Analysis: Workload Distribution

HSI PTRs Across Operational Phases:
Workload Risk Distribution

The majority of medium workload risks occur during the Run phase



Expanded Error Analysis: Method

- The 110 human performance-related PTRs were then analyzed in detail to estimate:
 - Whether the problem described was related to workload, performance (human error), or safety
 - The factors contributing to the problem
 - The likelihood the problem would occur
 - The probability the problem would be detected and corrected
- The time required to detect and correct each problem was also estimated.
- Issues in each category were then re-analyzed to identify a smaller set of those that could have significant consequences:
 - Delayed consequences – those that occur should the problem not be detected and corrected immediately
 - Cascading consequences – those that could generate additional error, safety, or workload issues



Expanded Error Analysis: Results

- Many PTRs were of lower priority because they were of low risk, easy to detect, and simple to correct.
- The analysis revealed 17 PTRs that may have delayed or cascading consequences
- Some (15) were of concern because they were associated with consequences that were difficult to detect or time-consuming to correct.
- A few (2) were of concern because they were associated with potential safety issues



HSI PTR Distribution Analysis Summary

- **Conclusions:**
 - This analysis method demonstrated that there may be increased human performance risks during specific phases in operational workflow
 - Lower priority PTRs were related to type of human performance risks (e.g., error and workload)
 - Clustering of lower priority PTRs can be additive – leading to a decrease in human performance, and increase operational performance risks
- **Recommendations:**
 - While its important to address high-priority items, some attention should be given to resolving clusters of lower priority human performance risk items that can have additive or cascading impacts on operational workflow
 - Priority should be given to the HSI-related PTRs (error and workload) that are difficult to detect and correct operationally
 - Use PTR clusters to generate cost effective ECPs (i.e., fix related items)
- **Impact –** The program successfully reassessed the PTR clusters to develop mitigation strategies



HSI in Developmental Testing: Summary

- HSI objectives during DT should ensure:
 - HSI tests and metrics adequately verify compliance with HSI domain requirements
 - HSI-related system and functional requirements, user needs, and operational mission objectives are met and training plans are adequate
- HSI should take a multi-phase and multi-source approach to align with existing test processes
- HSI testing should also identify any outstanding human performance risks (e.g. human error, increased workload, safety) that would negatively impact system reliability and operational performance
- Findings should be analyzed and prioritized to communicate specific human performance and operational impacts:
 - Low priority / severity issues can cluster to have additive or cascading impacts on operational workflow
 - Issues that are difficult detect or correct
- Results can be used to make trade-off decisions about risk acceptance versus engineering modifications proposed to improve the system prior to Operational Testing and fielding



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