Using Non-Traditional Reliability Data to Achieve Evaluation Adequacy in Resource-Constrained Test and Evaluation

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Approved for Public Release

Definition of Reliability

Definition: "The probability that an item will perform a required function without failure under stated conditions for a stated period of time."

Source: P.D.T. O'Connor and A. Kleyner, *Practical Reliability Engineering*, Chichester: Wiley, ed. 5, 2012.

- **Repairable systems**
  - Not replaced following occurrence of failure; generally repaired and put back into operation
  - Mean Time Between Failure (MTBF)
- **Non-repairable systems**
  - Discarded and replaced with new ones following occurrence of failure (e.g. light bulbs, transistors, small appliances)
  - Mean Time To Failure (MTTF)

Qualitative and Quantitative Aspects of Reliability

- Qualitative
  - Failure types/modes, impact on Soldiers, impact on mission accomplishment; impacts on interoperating systems
  - Soldiers' trust in the system, willingness to use the system, willingness to work through troubleshooting steps instead of using a workaround
  - Insights versus estimates
- Quantitative
  - Mean Time Between Failure (e.g., system abort)
  - Operating time (hours, miles, rounds, trials, cycles, etc.)

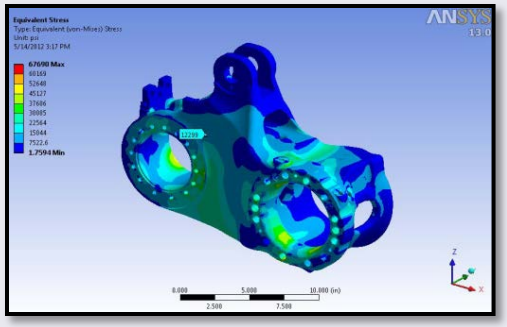
Elements of Operational Relevance

- Shocks and Vibrations
- Soldier Interactions
- Environmental Stressors (temperature, thermal cycling, sand & dust, rain, humidity, solar loading, saltwater spray, etc.)
- Loading (strain, network traffic, etc.)
- Duration & Tempo of Operations

Examples of Reliability Information Sources

- System-Level Developmental and Operational Test Events
- Subsystem- or Component-Level Testing
- Modeling and Simulation
- Training Events
- Historical Data
- Accelerated Test Methods
  - Highly Accelerated Life Testing, Accelerated Life Testing, Highly Accelerated Stress Screening, etc.
- Structured Interviews, Focus Groups, After Action Reviews
- Manpower and Personnel Integration (MANPRINT) assessments

Failure Mode Investigation via M&S

SYSTEM DESCRIPTION: Combat Vehicle Armor Kit and Suspension Upgrade	
T&E Need: Determine if the new components introduce any critical failure modes (system aborts).	**Opportunity:** Leverage existing finite element models and system instrumentation to estimate impact on suspension components.
Insights Gained: Able to estimate part life and durability for upgraded components. 	**Lessons-Learned:** Modifying an existing model is much quicker than building one from scratch. If you are going to invest in M&S and instrumentation, ensure that the two are integrated for maximum return on investment.
Impact: Reduced endurance testing by 20,000 miles.	

Leveraging Field Assets (1/2)

SYSTEM DESCRIPTION: Long Haul Vehicle Upgrade Kit	
T&E Need: Determine impact of upgrade kit (consisted of “A-Kit” and “B-Kit”) on vehicle reliability.	**Opportunity:** Leverage data from fielded systems with A-Kit. Added: Data Collectors
Insights Gained: Identified severe failure mode that did not appear until 9K miles. Finding these issues in a DT setting would have required tripling the size of the test scope, which was cost prohibitive.	**Lessons-Learned:** Use all available opportunities, including field use, to surface failure modes. Correcting failure modes prior to OT is the best way to ensure a successful demonstration of reliability requirements at OT.
Impact: Successful OT due to corrective actions made before OT.	

DT = Developmental Test
OT = Operational Test

Leveraging Field Assets (2/2)

SYSTEM DESCRIPTION: System of Sensor Systems	
T&E Need: Identify dominant failure modes and potential impact to Army operations.	**Opportunity:** Leverage field maintenance records from SoS employed by another government organization.
Insights Gained: Identified dominant failure modes and associated downtime. Led to documentation of preventative measures to be used by operators.	**Lessons-Learned:** Data from actual employment of a system in its intended operational environment may not be as precise as a formal test events, but insights into the dominant failure modes may be more valuable than a reliability estimate if they lead to corrective actions that improve the system.
Impact: Expedited reliability growth	

Bench Testing

SYSTEM DESCRIPTION: Network System	
T&E Need: Obtain additional operational hours to supplement user test.	**Opportunity:** Leverage bench testing.
Insights Gained: The loads and stresses of an operational setting differed significantly from the bench test. The data sets could not be pooled due to statistically different failure rates.	**Lessons-Learned:** It is critical to understand the loads and stresses of the operational environment. Any excursion that contributes to that body of knowledge aids design-for-reliability and reliability growth efforts and reduces risk in future testing.
Impact: The entire T&E planning process benefited from the improved understanding of the difference between the S&T environment and the operational environment, which served a T&E risk reduction function.	

Concluding Remarks

- Look for opportunities to quantify operational loads and stresses early in the system design process.
- Plan events(or plan to leverage events) that incorporate operationally relevant parameters such as representative users.
- Plan to monitor non-reliability testing to capture potential failure modes.
- Ensure that insights from all sources are included in the program's closed-loop failure tracking and mitigation system.
- Use consistent methods for data acquisition throughout the program.
- If investing in M&S, invest in flexible models that can be modified for other purposes and can be used in conjunction with the planned instrumentation.

Challenge the Existing Paradigm and Innovate!

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