Vehicle Reliability
The Quest for Affordable Performance

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Agenda

- Introduction
- Achieving Reliability on Tactical Vehicles
- JLTV Case Study
- FMTV Example
- Discussion
Introduction

- What is all this chatter about affordability?
- Tactical Vehicles and Combat Vehicles are both extreme examples of opportunities to exploit
- The Department will always be smarter when it decides what the right data is and really manages to value metrics!
- Processes and behaviors are at least as important as design.
• Fact - Tremendous improvements in reliability across the tactical wheeled vehicle fleet continue – doing the right things the right way yields results.

• Designed-In (JLTV Example)
  • JLTV Design For Reliability Evaluation
  • EMD Reliability Growth Plan
  • Testing

• Evolving Fielding Systems (FMTV Example)
  • Managing quality on the line is job #1
  • Engineering in reliability during the lifecycle

• Lessons learned
• Original user requirement for high reliability (11,700 MMBOMF)
  • Limited analytical underpinnings for the threshold
  • Significant number of miles to demonstrate high reliability with sufficient confidence
• Difficulty in Technology Development Phase
  • Low maturity designs
  • Change in OMSMP to significantly more challenging off road requirement
• User reduced reliability threshold reduced based on analysis - down to 2400 MMBOMF
  • Minimal impact on statistical likelihood of mission accomplishment
  • Still substantially better than systems it replaces (UAH w/FK and MATV)
• JPO committed to continued reliability growth beyond EMD phase – Consistent with all other tactical vehicles
• No development phase. Design must already take reliability into account
• **System Reliability & Maintainability (R&M) Maturity**
  • **Level 1: Requirements Analysis**
    • R&M Case Report completed.
    • Reliability (Mean Miles between Hardware Mission Failure) and Maintainability (Maintenance Ratio, Mean Time to repair, Max-Time to Repair) Allocations completed down to the Line Replaceable Unit (LRU) level.
  • **Level 2: Preliminary Design Analysis**
    • Design Failure Mode Effects and Analysis (DFMEA) completed with the JLTV FDSC and OMS/MP for the following sub-systems (Hull / Structure / Frame, Suspension, Braking, B-Kit Protection, Power Generation and Distribution, Engine / Transmission / Transfer Case, Electronics Architecture / Software, Steering).
    • Fault Tree Analysis (FTA) completed in accordance with the JLTV FDSC and OMS/MP for all Mission Essential Functions (MEFs).
    • Critical Items List (CIL) has been developed. CIL includes items whose failure would result in a hardware mission failure or Category III or higher Hazard Severity Rating as defined in MIL-STD-882D.
    • Reliability (Mean Miles between Hardware Mission Failure) and Maintainability (Maintenance Ratio, Mean Time to repair, Max-Time to Repair) Predictions are updated with complete Level 2 preliminary design analysis at the LRU level.
    • Predictions have been adjusted using the JLTV FDSC and OMS/MP.
    • R&M predictions include failure rates for each LRU, failure rates are individually identified as estimated (E), calculated (C), or measured (M).
    • Predictions have been rolled up to the system level.
    • Reliability Growth Plan and Reliability Growth Curves are IAW AMSAA Projection Maturity Model (PM2) and are updated with complete Level 2 preliminary design analysis.
• Reliability (RAM) testing
  • 20K miles per test asset
  • Reliability testing will be conducted at Curb Weight (CW) for 25% of the time and Gross Vehicle Weight (GVW) for 75% of the time per the chart below

<table>
<thead>
<tr>
<th>JLTV Vehicle and Trailer Percent Payload for RAM Testing</th>
<th>Payload On-board the JLTV Trailer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Payload On-board the JLTV FoV</td>
<td>No Trailer</td>
</tr>
<tr>
<td>Empty JLTV (CW+Crew)</td>
<td>19%</td>
</tr>
<tr>
<td>Fully Loaded JLTV (GVW)</td>
<td>41%</td>
</tr>
</tbody>
</table>

• Corrective Action Periods (CAPs) are planned for implementing design changes and corrective actions
• RAM testing will include three growth periods preceded by a CAP
• Additional Follow-on Reliability growth opportunities:
  • 50,000 miles of reliability testing in early LRIP to validate corrective actions from CAP 3.
  • 200,000 miles of RQT aimed at increasing reliability up towards objective requirements.
  • 150,000 miles in PVT aimed at increasing reliability up to objective requirements.
- EMD Reliability Growth testing consists of 8 Vehicles
  - 4 CTV mission role variants
  - 4 CSV mission role variants
- 160,000 miles across the FOV (20,000 miles/vehicle)
- Initial Reliability set at 1,475 MMBHMF
  - As demonstrated by vehicle C6 during TD RAM testing.
  - Includes Failures charged to Contractor-furnished HW, SW & Tech Manuals
  - Deemed as low risk given assessed reliability of 2,433 MMBHMF.
- An 80% Lower Confidence Bound ensures high statistical confidence in successfully completing MOT&E testing.
- 60% probability of acceptance, represents a 40% risk that an adequate design will be rejected.
  - Represents the lowest acceptable level of risk.
- Management strategy set at .95
  - 95% of the failure intensity will be addressed with corrective actions.
- Fix effectiveness set at .73
  - Derived from historical figures.
- Degradation factor of 10% applied for increase of operationally induced mission failures.
  - Derived historically from TWV fleet.
Reliability Won’t Happen Without Quality

- Implemented Best Quality Practices from Industry
- Automotive Quality Requirement’s
  - Advance Product Quality Planning (APQP)
    - Production Part Approval Process (PPAP)
    - Statistical Process Control (SPC)
    - Supplier Quality Assurance Program
  - Special Process Requirements and Approval
    - Qualification and Continuing Conformance of Electrocoating (E-COAT) process
    - Advance Quality, E-COAT, SPC, and Welding IPT’s weekly
    - Stringent Welding Requirements
• Close working relationship with Contractor and DCMA
• Stringent enforcement of contract requirements
• Continuous Improvement/Defect Reduction Incentive
• Focus on process not just product
• Focus on BIQ (Built In Quality)
  • Build it right the first time (minimal rework)
• Strong Leadership Support of QA Objectives
# LTAS Reliability Testing Results

<table>
<thead>
<tr>
<th></th>
<th>Prior Contract PVT/FPT Demonstrated Reliability</th>
<th>Prior Contract PVT/FPT Assessed Reliability</th>
<th>Oshkosh PVT Demonstrated Reliability</th>
<th>Oshkosh PVT Assessed Reliability</th>
<th>Final Requirement</th>
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<tbody>
<tr>
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<td>10,042</td>
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</tr>
</tbody>
</table>

* Limited testing of unchanged subsystems was conducted to reduce test duration.

Wrecker - Reduced Winch Cycles  
Dump - Reduced Cycles of dump body  
LHS - Reduced Load/Unload Cycles
Key Findings

• Communication between all team members (Government & Contractor) is critical for rapid resolution of failures. No program will be without its surprises, but good lines of communications limit the disruption of unforeseen events.

• Preparation for Corrective Action Review Boards (CARBs) to resolve FACARs must begin even before a FACAR is released. In most cases, it should begin as soon as the failure occurs.

• Preparation for RAM Assessment must begin with the failure. Like the FACAR process, it needs to be attacked as soon as possible.
Discussion