Ammunition Stockpile and Service-life Reliability: 
*Improvement Efforts at US Army ARDEC*

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The Problem

• Testing for reliability through the life of a smart-munition is not financially feasible
  – Firing 100+ rounds from each strata
  – Every 3-5 years
  – For the life of the item

• Waiting until the item is bad does not provide enough time to buy more
  – 2 to 6 year cycle time from need to field
The Solution: Predictive Stockpile Management

Failure Mode and Mechanism + Sensors + Mode-Mechanism Model + CONOPS & Data Repository = Predictive Stockpile Management
An Example…

- Identify Failure Mode
  - What fails?

- Identify Failure Mechanism
  - What causes the failure?

- Determine rate of degradation
  - How long does it take to fail?

- Correlate and synthesize
  - When will it fail?
  - When should I produce more?
  - Which items are at risk?
  - Which items are not?
Elements of the ASRP:

- Design for Storage Life
  - Predictive Engineering
- Ammunition Surveillance Program
- Function (Reliability) Testing
- Laboratory testing program
Storage Life Predictions

- **Proactive (Development Items)**
  - Analogy based analysis to determine at risk, life limiting items
  - Accelerated life testing to predict storage life
    - Controlled
    - Uncontrolled
  - Determine design changes or mitigations to extend life

- **Reactive (Fielded Items)**
  - Perform function testing per ASRP Plan
  - Analysis of variance
    - Age
    - Lot
    - Manufacturer
    - Storage location/type
    - Design revisions
  - Detect reliability degradation trends
  - Predict breach of lower reliability threshold

*Predictive Technology (ALT) can be used for fielded items also*
Initiatives

• Policy – Army Regulations and local installation application policies

• Process – Lean Six Sigma Green Belt Project to refine methods

• Data - Predictive Summary Report and Benchmarking

• Application – Synergistic programs addressing multiple items or classes of items

Goal – Enable Predictive Stockpile Management
ASRP Policy

• Memo documenting policy requirements
  – Ammunition Stockpile Reliability Program
    • AR 702-6
  – Ammunition Surveillance
    • AR 740–1, AR 702–12, and AR 700-142
  – Required at time of MR

• Key responsibilities of PM and ARDEC
  – Baseline performance and reliability
  – Identify life-limiting components
  – Identify acceptable limits of degradation
  – Design and build unique inspection/test equipment
SSGB Project

Objectives:
- Develop process map for creation of ASRP Plan
- Improve timeliness and value of the ASRP Plan and its execution
  - Completed at time of MR
- Improve quality of plans to include:
  - Greater use of predictive engineering and accelerated life testing
  - More item and failure mode unique testing and inspections
  - Add Ammunition Peculiar Testing Equipment
  - Add detailed test procedures
- Institute Configuration Management
  - Approval routing
  - Revision Management
  - Document Maintenance
  - Define how ECP and MIF information is added to ASRP Plan

Approach:
- Define current process
- Measure and Analyze results of current process and adherence to AR
- Improve and Lean process to provide more value and synergy across ammo classes
- Institute Controls to ensure continual improvement
Unified ASRP Approach

Predictive Testing

Function Testing

Lab Testing

Ammunition Surveillance
Practical ALT

HALT → Define: Failure Mode

DoE based ALT → Measure: Sensitivity to Stresses

ANOVA → Analyze: Correlation to CI’s

FRACAS → Improve: Design out if possible

Sensor & Lab test → Control: Monitor stresses & CI’s

CBM for Ammo

Predictive Testing

Function Testing

Lab Testing

Ammunition Surveillance

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.
• Compilation and update of tests and analyses capturing environmentally susceptible items and components

• Sources:
  – ASRP function testing
  – ASRP surveillance inspections
  – DIF/MIF reports
  – FAT/LAT results
  – Predictive Engineering/Aging Studies

• Motivation
  – Identify common causes and risk for LCMC managed items
  – Provide repository of data to expedite MR process and avoid duplication of effort
  – Determine candidates for further investment and investigation
    • Aging program
    • In-situ sensing
    • Telemetry
    • Additional functional, lab, or surveillance sampling
Sensor and Database Project

- Investigate COTS sensors
  - Literature review and continued work with UMD Consortium
  - Identify customer requirements (cost, size, IO, resolution)
  - Classes of sensors
    - Cheap and simple for cheap and simple
    - Ensure CBA/ROI is favorable

- Qualify one or more from each class
  - Durability - Sensor can’t fail before round
  - Accuracy – Sensor data can’t drift with time
  - Interoperability (E3) – Eliminate interference/safety concerns

- Data Analysis and Warehouse
  - Open Architecture
  - Tailorable
  - Self-definable models

- Application guidance
  - Common I/O and data collection methods
  - Coordination with JMC QASAS
Value of Temperature Data

Life Estimate between 2 and 22 years

Hand Held Signal Device

Failure Predictable with Only 1.7% escapes
- Reliability Characterization of SMT components in temperature cycling environment
- Predictive algorithm development to identify incipient failures
- Demonstration sensor(s) from Low Cost sensor program (if funded)
Questions?