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Missile Captive Carry Monitoring

PNNL-SA-87314 Distribution Unlimited

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History of Asset Health Monitors at PNNL

1. PNNL has been developing Asset Health Monitors for more than 15 years
    1. Multiple army programs supporting missiles and munitions
    2. Pursuing new opportunities with Navy, Air Force, FAA
2. Conducting R&D supporting Advanced Health Monitor capabilities
3. Fielded thousands of units in Iraq
4. Flexible architecture allows configuration of custom health monitors on short timescales
    1. Shock, vibration, humidity, temperature, radiation, pressure, magnetism
    2. RF, WiFi, USB, cellular, RS485, Bluetooth®

PNNL Health Monitoring Systems

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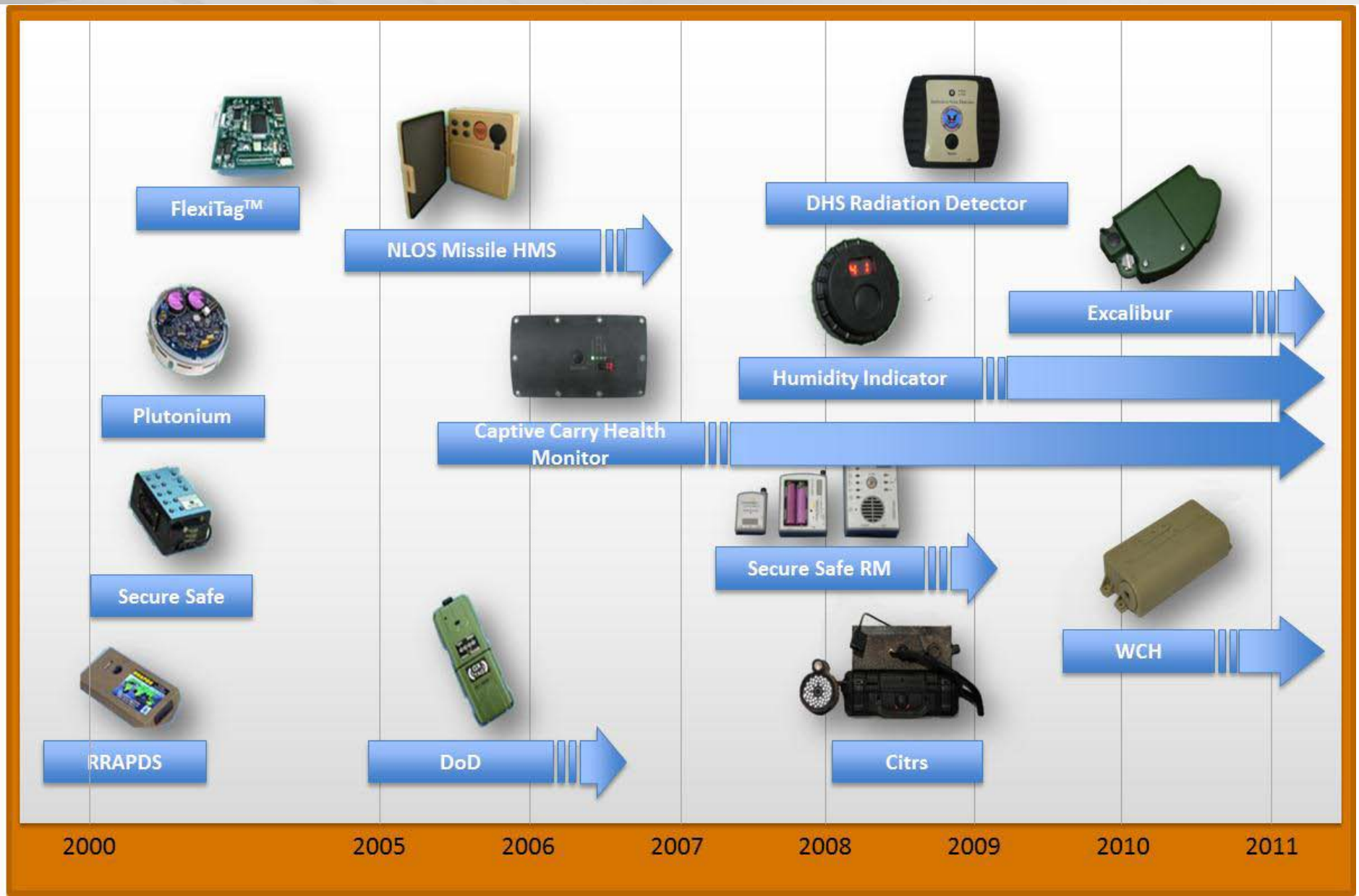

Captive Carry Monitoring of External Stores

- Missiles are subjected to many mechanical effects during captive carriage:
  - Vibration from rotating blades, power systems
  - Shock from adjacent store releases, adjacent weapon firings, maneuvering, and landings
- Captive Carry Monitoring of each missile provides the warfighter with actionable information:
  - Actual captive carry can be compared to qualified life cycle exposure to determine when a munition is approaching the end of its life so that it can be removed from service or reworked.
  - Missile allocation to missions could be based on prior use to avoid overusing individual missiles.
  - Predictive maintenance and resource management programs can be based on actual field data.
- Logistical complexities make manual tracking and logging of captive carry exposure difficult.

Contract Team

- The U. S. Army Aviation and Missile Research Development and Engineering Center (AMRDEC)*, in conjunction with the Joint Attack Munitions Systems Project Office, have sponsored PNNL to develop the Captive Carry Health Monitor, or CCHM.
- This technology enables the Army to understand and sustain operational readiness levels of fielded missiles and greatly reduce the warfighter maintenance burden by eliminating manual methods of data collection.

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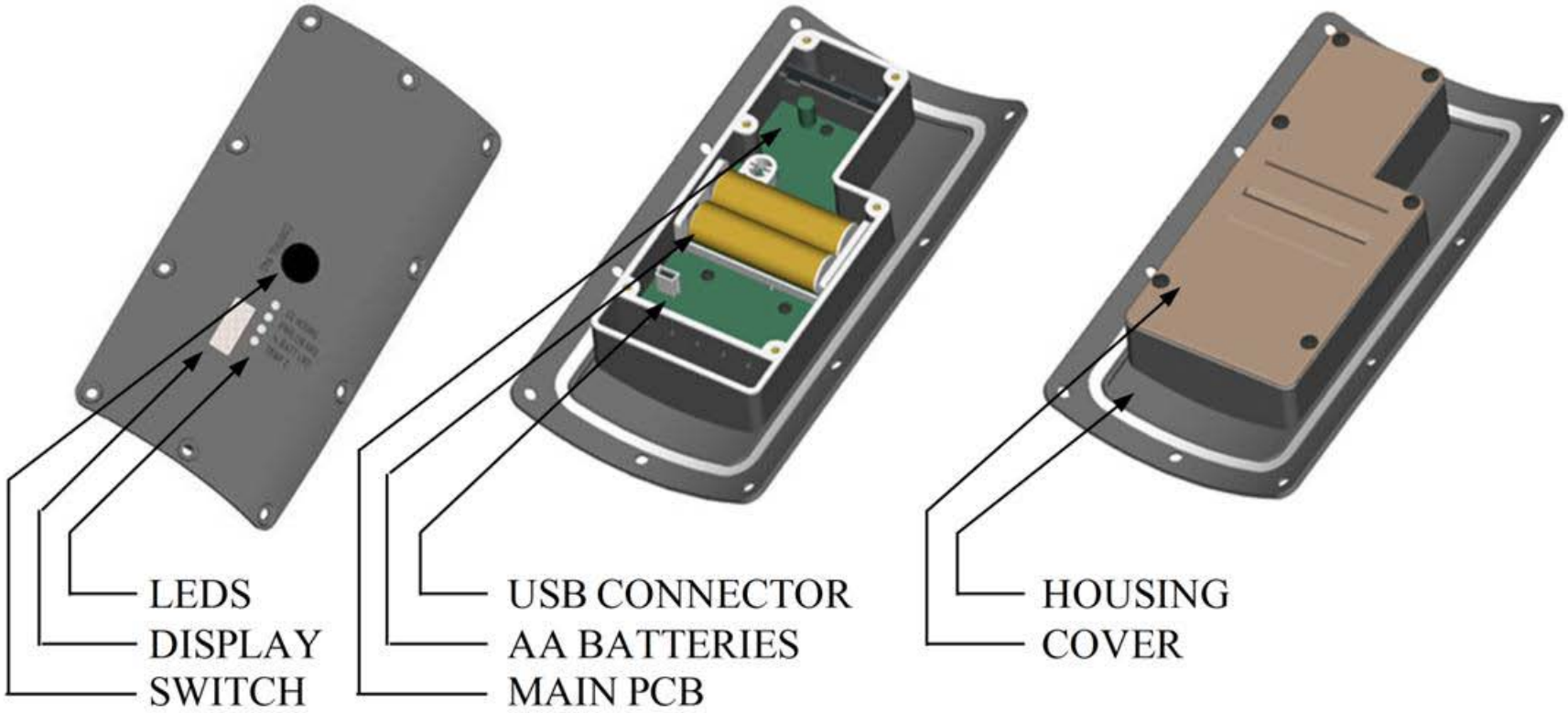
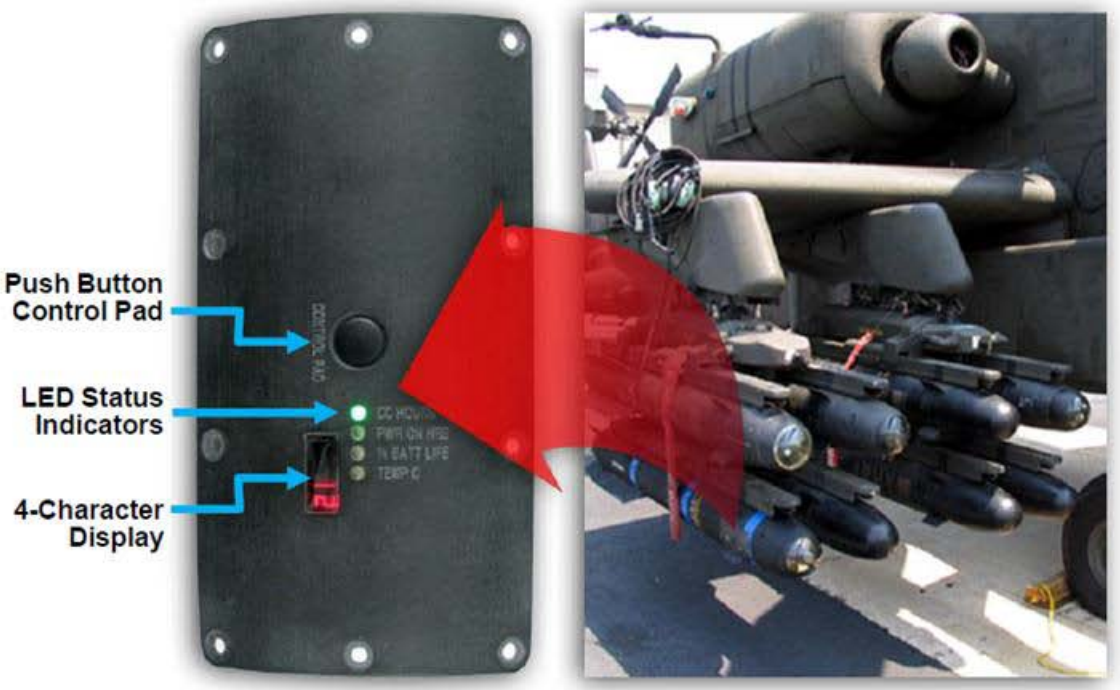
* -Engineering Directorate, Reliability, Availability, and Maintainability Engineering and System Assessment Division

Captive Carry Health Monitor



- The CCHM includes an accelerometer, environmental sensors, microprocessor, batteries, pushbuttons, and status display. Vibration signatures are acquired with a low power triaxial MEMS accelerometer.

Hardware Status



Production Status:

- Qualification Testing and AWR Complete
- 99 Version 1 Units Fielded to Afghanistan
- 675 Version 2 Produced
- Version 3 First Article Testing Underway

Simple GUI

Vibration exposure = 520 hours
Green = within acceptable range

Power On = 20 hours
Green = within acceptable range

Battery Charge = 5%
Red = out of acceptable range

CCHM System Evolution

- Version 1: Recorded duration of vibration exposure and temperature
- Version 2: Recorded duration of vibration exposure on Kiowa and Apache (platform ID) plus temperature
- Version 3: Added:
  - Humidity sensing
  - Shock sensing
  - Vibration characterization
  - BIT and Verification Modes
  - RF Data Transfer (demo only)
  - Front panel connector

Health Monitor Data Acquisition

Data Storage

Storage Requirements

- Peak
- "Top Ten"
- Time in range
- Histogram
- Discrete Values
- Waveform

Data Capture

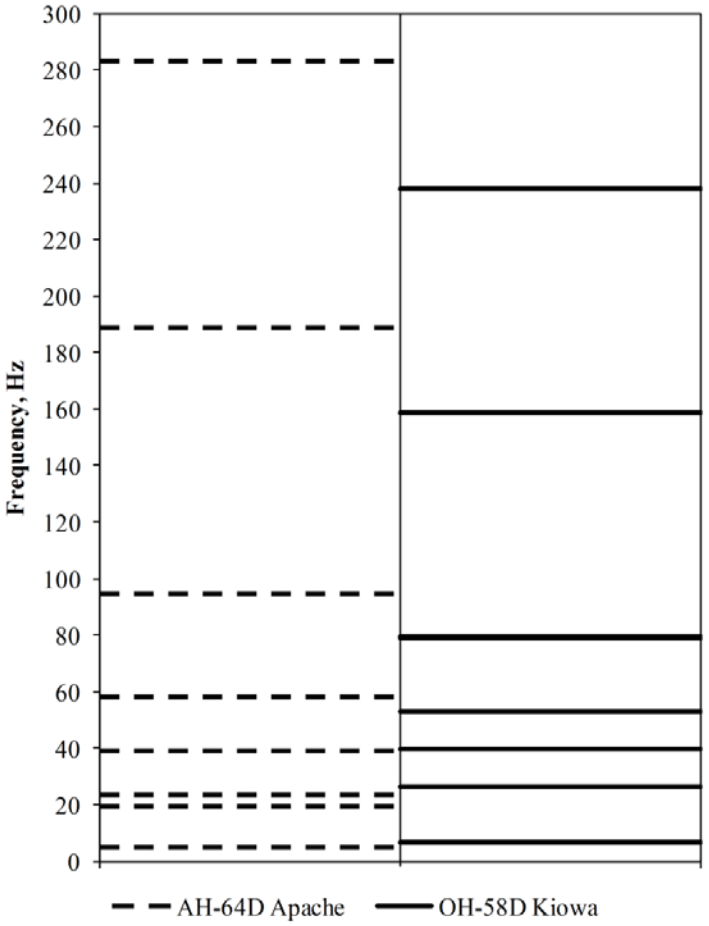
- Periodic
  - Temperature
  - Humidity
- Event Driven
  - Shock

- Hardware vulnerabilities drive selection of data storage method
- Measurement variability drives selection of data capture method

Helicopter Frequency Identification

- Missile vibration is a complex function of flight condition, airspeed, missile location, and missile payload
- PNNL has developed helicopter detection technology to classify vibration and identify transportation platform

Helicopter Harmonics



Health Monitor Vibration Characterization

Existing Capabilities

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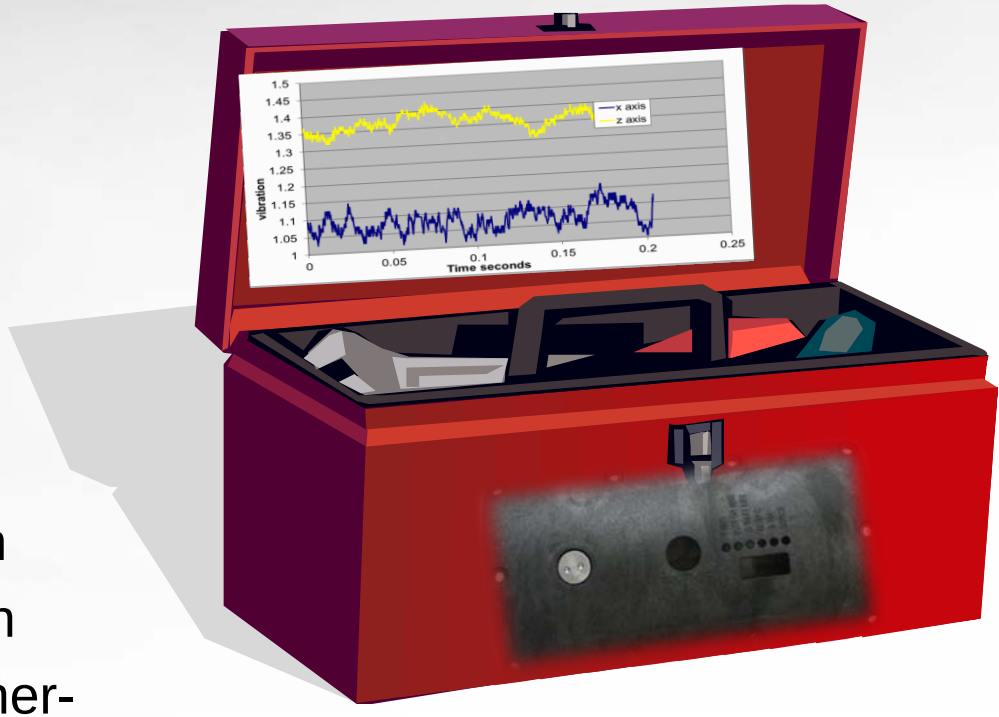
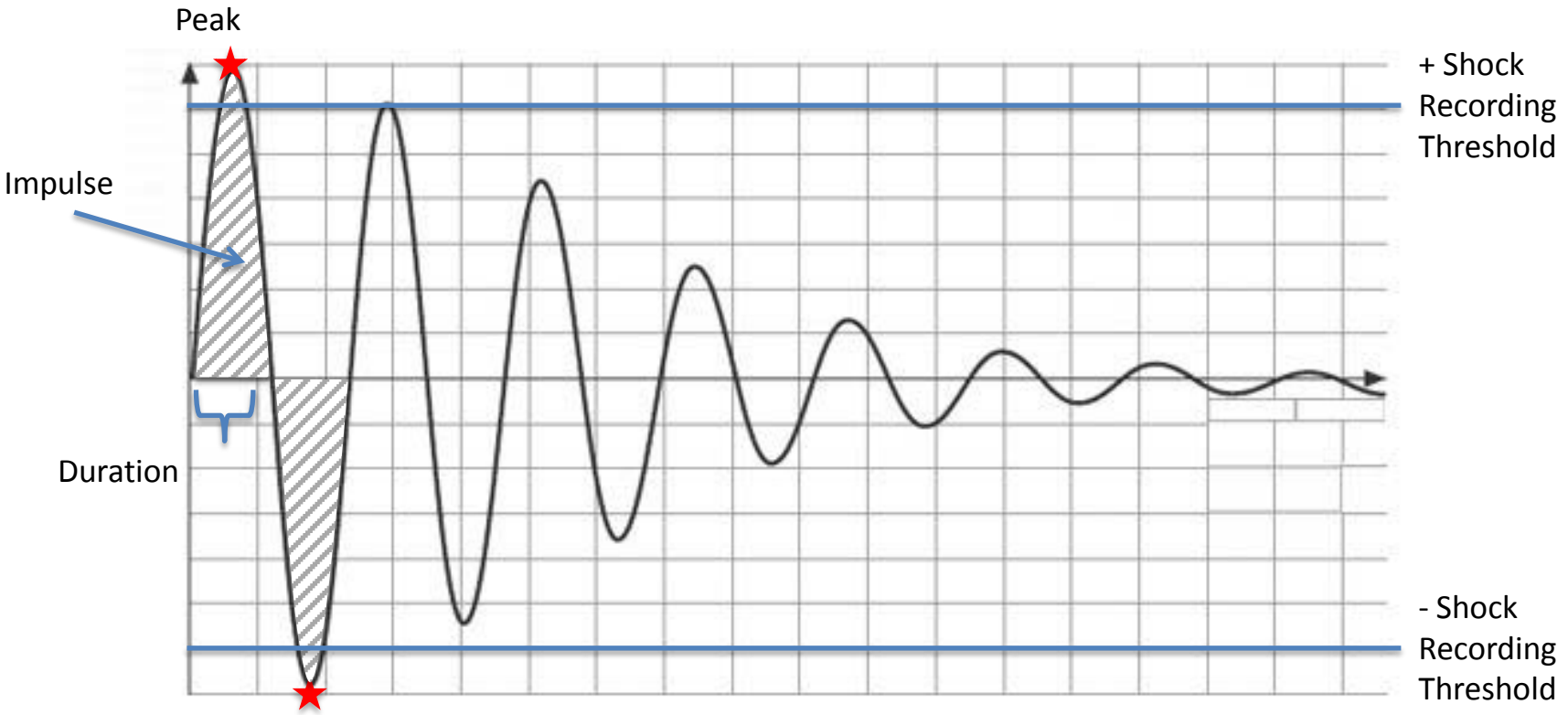
COMPLEXITY

- Peak
- RMS
- CREST Factor
- Low Pass Filtering
- RMS in frequency range
- Single frequency detection
- 3D vibration characterization
- Transport mode identification
- Reliability analysis using Miner-Palmgren Rule



On board analysis greatly reduces storage requirements

Shock Recording Capability



Conclusions

- Version 3 system development complete, qualification testing is underway, and production is planned for 2012
- The technology is autonomous, lightweight, cost-effective, and easily incorporated into existing systems
- ConOps defined the need for a system with
  - a simple human interface to enable decision making
  - a storage capability so that lifetime exposure to environmental stresses could be collected
- We are leveraging this technology on other programs
  - Excalibur
  - Patriot Missile
- I would welcome inquiries into integrating this technology into your system
  - Brian Hatchell, (509)375-2762, brian.hatchell@pnnl.gov