RRAPDS

A Joint AMCOM-AMRDEC & TACOM-ARDEC
Science and Technology Objective (STO)

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Abstract

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Health Monitoring Issues

Army cannot remotely monitor condition of missiles/munitions. Lack of condition/health data has already proven to be very costly.

TOW

- **Over $40M of TOW 2A Bosnia returns being restricted to training use only.**
- **Over $21M expended to determine condition of 70,000 TOW Desert Storm returns.**

Conventional Ammo

Continuous field monitoring will provide accurate history of what conditions ammo has been subjected to. For example:

- **2.75" Rockets – Monitor Temperature and Shock**
- **Propellant – Temperature and Humidity**
- **Tank Ammo – Temperature and Humidity**
- **Mortars – Temperature, Humidity, and Shock**

PATRIOT

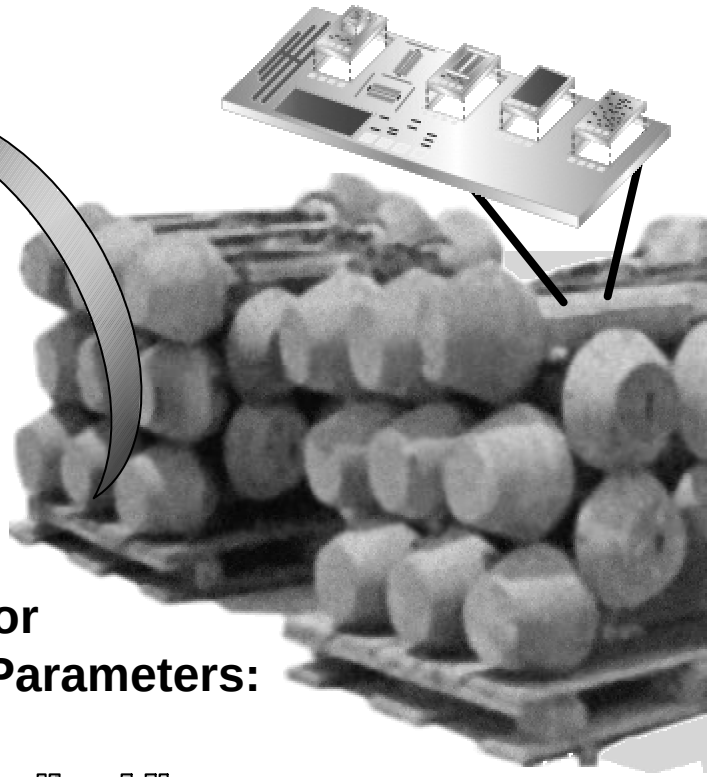
Moisture degradation in Patriot radome adhesives results in potential rework of 5000 Patriot Missiles ($25,000 per msl).

Current Missile and Ammo Surveillance is Reactive Instead of Proactive.

What *is* RRAPDS?

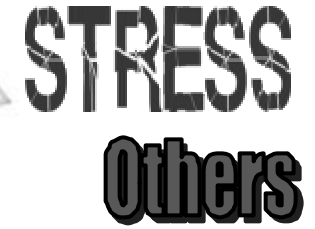
3-Year Army Science and Technology Objective

Focus On:
- **MEMS Sensors**
- **Prognostics (i.e., Predict Failures)**
- **Low Cost**
- **Miniaturization**
- **Extremely Low Power**



Wireless Interrogator

Monitor Environmental Parameters:

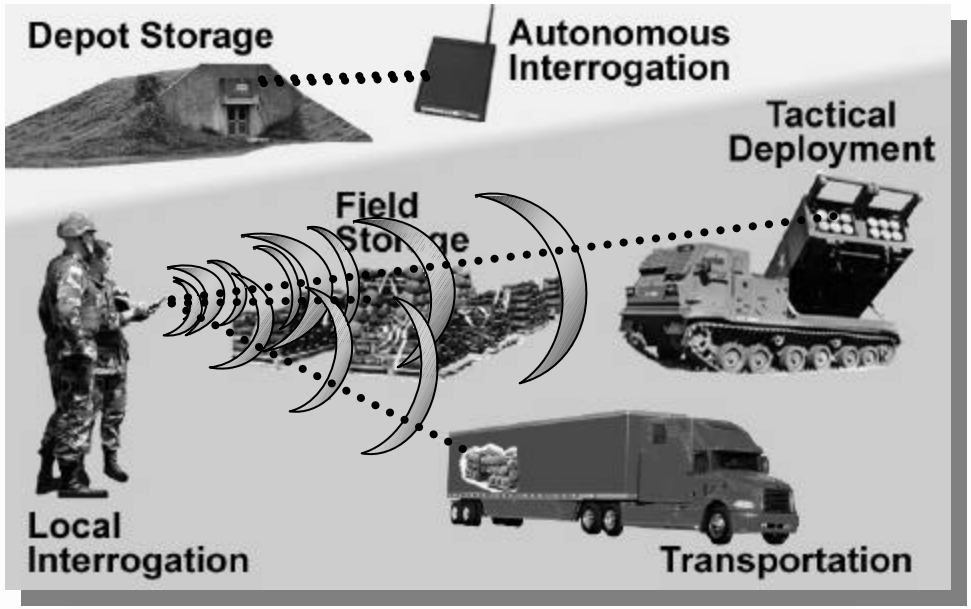


RRAPDS Overview

Solution: Autonomous, Low Cost Health Monitoring

WARFIGHTER Needs

- Integrated System to Monitor a Weapon's Health/Condition
- Advanced Prognostics/ Diagnostics
- Real-Time Situational Awareness to Anticipate and Accurately Plan Maintenance Requirements
- Low Cost
- Transparent to the Warfighter



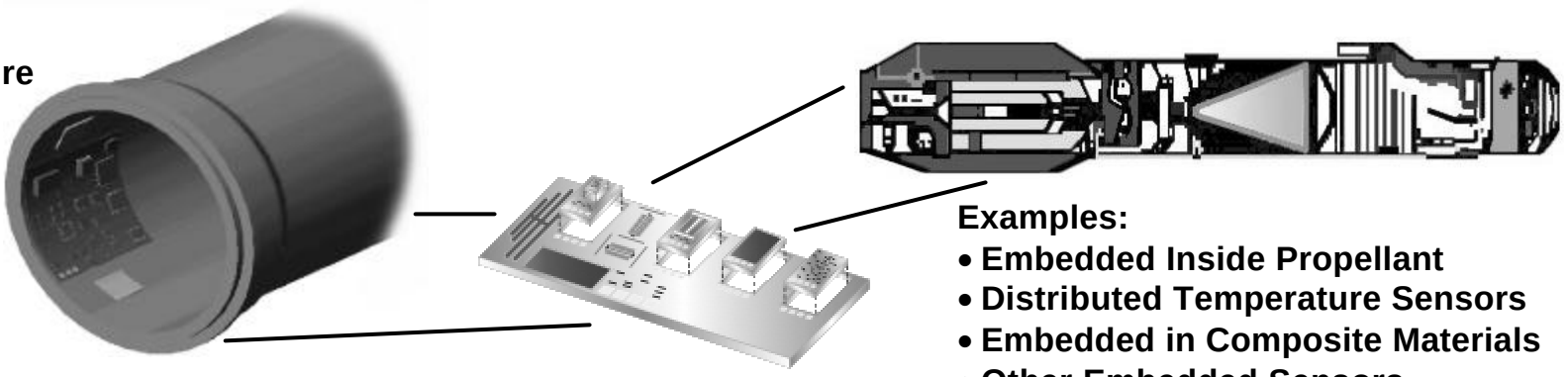
TECHNOLOGY Required

- MEMS-Based Sensors and Microchip Technology for Minimum Size and Power Consumption
- Intelligent Power Management for Long Periods of Maintenance-Free Operation
- Prognostics through Artificial Intelligence-Based Decision Tools and Failure Models

RRAPDS Target Capabilities

Internal Tube Mounted **OR** **Embedded**

Temperature
Humidity
Shock
Vibration
Chemical
Others

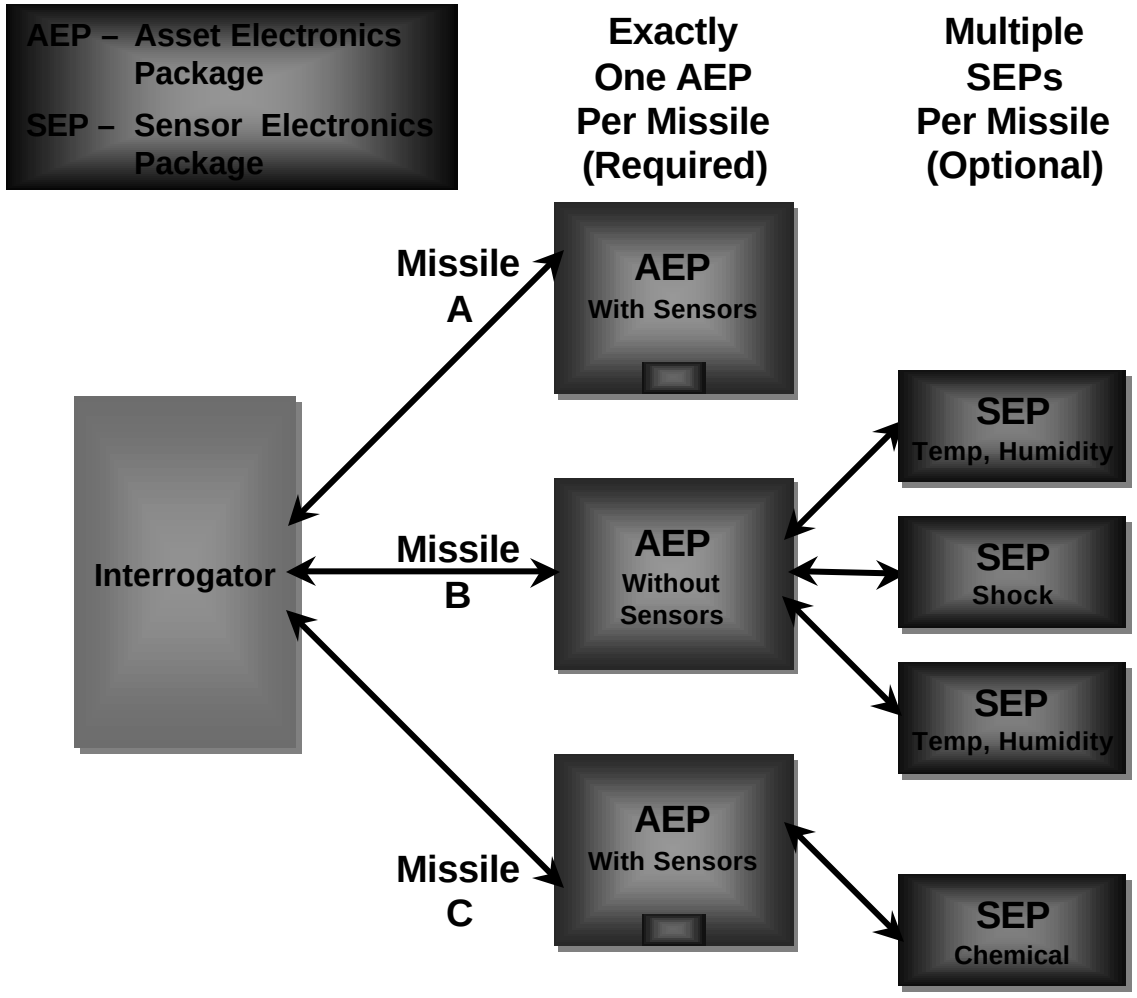


Examples:
- **Embedded Inside Propellant**
- **Distributed Temperature Sensors**
- **Embedded in Composite Materials**
- **Other Embedded Sensors**

RRAPDS Target Capabilities

- **Small Volume (<3 cu. in.)**
- **Fits Small, Tube-Launch Missiles (5.8 in. dia.)**
- **10-Year Operating Life w/no Battery Replacement**
- **Maintenance Free**
- **Fixed or Mobile Wireless Interrogation**
- **Autonomous Data Collection w/Intelligent Sampling Scheme**
- **Stores 2 Years of Data**
- **Multiple Sensors Capability**
- **Low Cost (Target $25/Unit)**
- **Ultra-Reliable**
- **Extreme Environments**
  - **-54 to +68 °C**
  - **0 to 100% RH**
  - **Up to 50g Shock**

RRAPDS Modular Concept

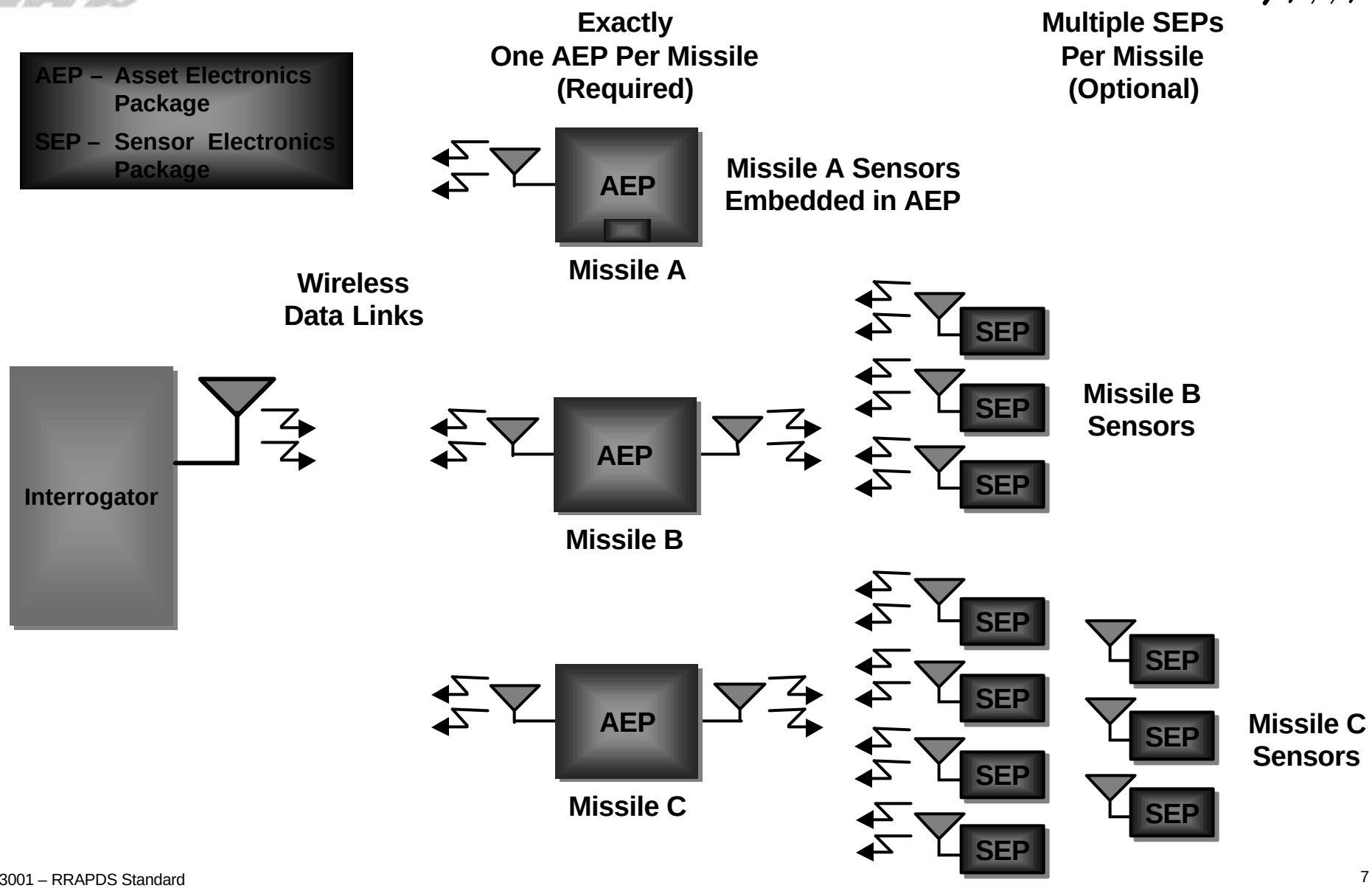


- Interrogator "Discovers" AEPs
- Does Not Need AEP ID in Advance
- AEPs May Include Sensors
- SEPs Are Transparent to Interrogator
- SEP Adds Additional Sensors
- SEP Variants Developed with Different Combinations of Sensors as Needed
- AEP Programmed with SEP IDs
- Interrogator Designed to Read Any Number and Type of Sensors

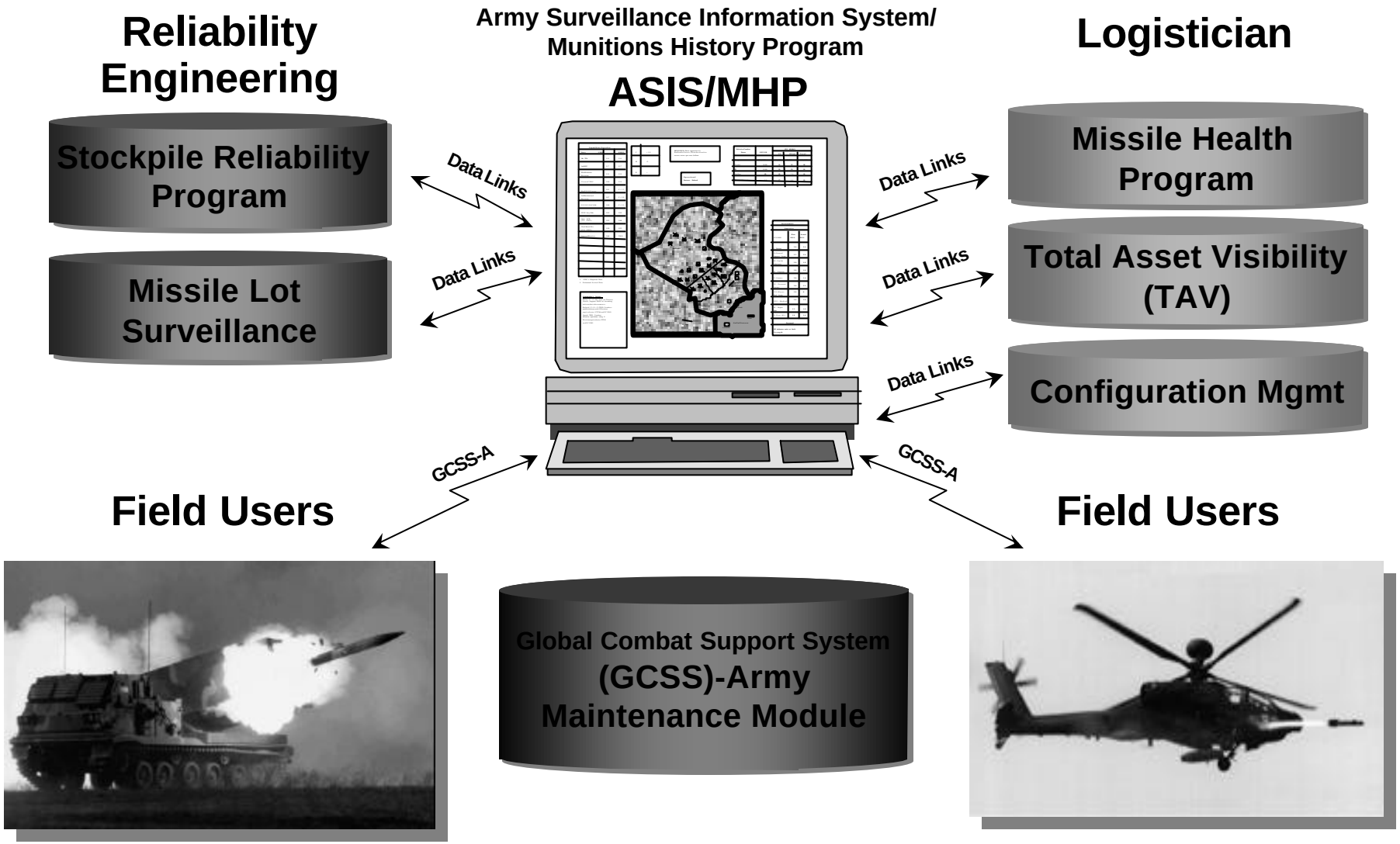
RRAPDS
Modular Communication Scheme

AEP – Asset Electronics Package

SEP – Sensor Electronics Package



RRAPDS User Applications



Ammunition Surveillance Information System Munitions History Program (ASIS MHP)

ASIS MHP Will Collect Munition Serviceability Data and Couple Advanced Query Capabilities with Worldwide Internet Data Access to Provide Inspectors, Engineers and Command Personnel Information Necessary to Facilitate Operational Efficiency, Tactical Readiness Decision Making and Engineering Assessment

ASIS MHP will:

- **Replace the Numerous Current Standalone Systems**
- **Provide Automation Capabilities that Eliminate Redundant Data Entry and Errors**
- **Standardize the Inspection Business Process**
- **Enhance Inspector Efficiency**

ASIS MHP is a Tool That Collects and Maintains the Ammunition Inspection, Test and Visual Observations which Determine the Ammunition Condition and Issue Status

There are 3 Primary Customers:

- **HQ/Engineering Center – Facilitates Enhanced Analysis Through Integration of Lot Inspection History Data and Ammo Stockpile Reliability Program Test Results**
- **Command Level – Enables Strategic Decision-Making Through True Asset Condition Visibility**
- **Operation Level - Improves Asset Condition Data Input Accuracy and Efficiency**

ASIS MHP is a DAC Surv Mod Team Effort Featuring the Collective Talents of Advanced Systems Concept Office (ASCO) Log R&D Activity, AMCOM, Automated Test Systems Team, Fire Support Armament Center at Picatinny, HQ, OSC and Defense Ammunition Center QASAS Surveillance Mod Team Members

RRAPDS Technology Emphases

- **Characterize Critical Materials**
  - **Model Failure in PEMs, Solder Joints, Propellants and Adhesives**
- **Prognostics Algorithms**
- **Advanced Manufacturing/Packaging Technologies**
- **MEMS Sensors**
- **Advanced Communication Hardware/Protocols**
- **Advanced Dynamic Power Management Scheme**
- **Apply Technology**
  - **Near-Term Technology Transfer and Application to PATRIOT (GEM and PAC-3)**

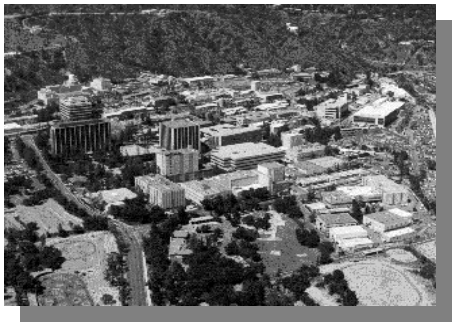
RRAPDS Technology Partners

DOE Sandia National Labs

- MEMS Sensors
- MEMS Reliability
- Failure Modeling (PEMS, Solder Joint, Propellants)
- TCG XIV

Pacific Northwest National Lab

- Sensor Integration
- Prototype Development
- Communication Protocols



NASA Jet Propulsion Lab

- Technology Assessment
- RRAPDS System Integration
- Demo Planning

NASA Marshall Space Flight Center

- Adv System Design
- Sensor Development
- Leverage Shuttle and X-33 Health Mgmt Initiatives
- AMCOM-MSFC MOU

- AMRDEC - Electronics, Software, Sensors and Communications
- DARPA Phase II SBIR (Canopus) - MEMS Sensors on a Multi-Chip Module
- TACOM-ARDEC/USADALA – Two Phase I SBIRs Low Cost Means to Wirelessly Determine Temperature Inside an Object (e.g. propellant)
- MEMs IPT
- MANTECH/PMTEC Project
- RTTC (Redstone Arsenal) – PATRIOT Environmental Testbed
- Pursuing Technical Collaboration MOU with the Navy ATOS

RRAPDS Critical Materials Characterization

DOD/DOE MOU - TCG for Predictive Materials Aging and Reliability

Objective

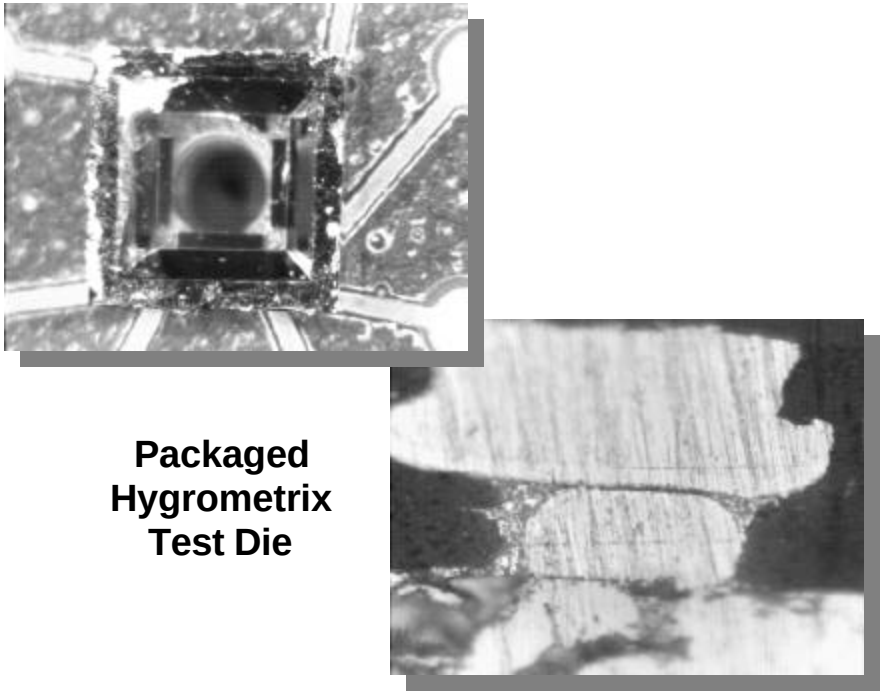
Address Common Concerns Between the DoD and DOE Driven by Aging Stockpiles

Tasks

- **Determine the Reliability of Solder Joints as a Function of Environment, Joint Geometry and Alloy Composition**
- **Develop a Fundamental Understanding of Chemistry Driving Materials Degradation in Plastic Encapsulated Microcircuits (PEMs)**
- **Develop Methodologies for Understanding Aging Processes in Energetic Materials**
- **Develop Fracture Mechanics-Based Models Describing Failure in Adhesives**

- **DOE/DOD MOU Project with Sandia National Laboratory Initiated in 1996 under TCG XIV**
- **Long-Term Objective is to Develop Computational Models That Will Predict Critical Component Failures**

RRAPDS
Advanced Manufacturing Techniques



Packaged Hygrometrix Test Die

Working with the Printed Wiring Board Manufacturing Center (PMTEC) to Develop Manufacturing Processes for Low-Power and Low-Cost RRAPDS Microsensor Suites

Objectives

- Develop a Low-Cost Microsensor Packaging Using Commercial Off The Shelf (COTS) Devices
- Develop Standardizable Processes for Integrating Packaged and Unpackaged MEMS
- Investigate Robustness and Survivability

Accomplishments

- Developed Environmental Monitoring System Using COTS Devices from Analog Devices and Hygrometrix
- Designed Chip Carrier Packages for Hygrometrix Die. These Will be Integrated with Standard Surface Mount Packages and Electronics on FR4 PWBs
- Developed Chip Carrier Process and Packages for Hygrometrix Die

RRAPDS Applications

PAC-2 GEM+

- Upgrade PAC-2 Missiles with Guidance Enhancements
  - Initial Production Quantities Beginning in FY01
  - Production through FY09 for a Total of 1437 Missiles
  - Modifying SBIR Design to Qualify and Install in FY01

PAC-3

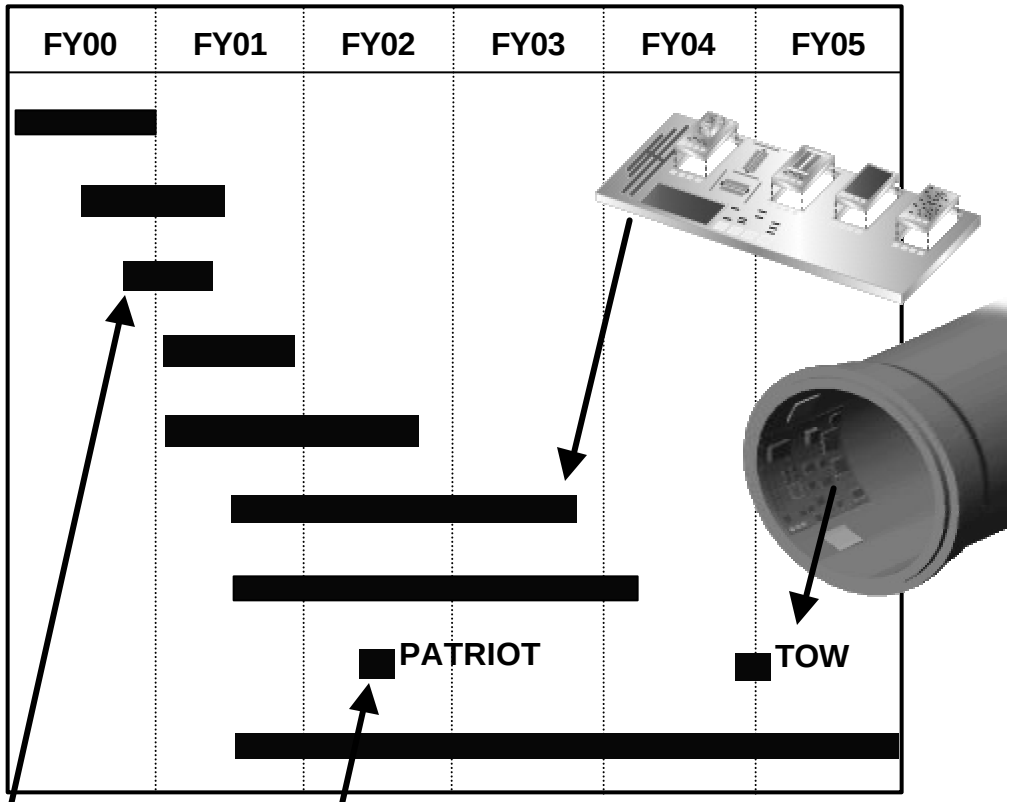
- New Air Defense Missile Technology
  - Initial Production Quantities Beginning in FY01
  - Production through FY11 for a Total of 1052 Missiles
  - SBIR and DARPA Prototypes Potential Candidates for Application

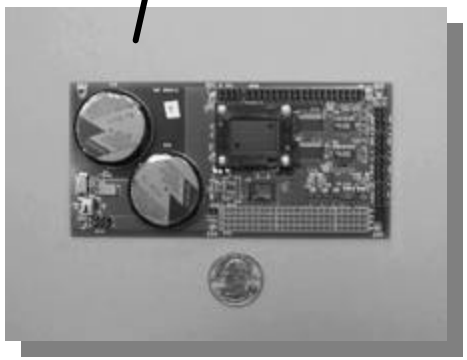
Other Potential Applications:

- TOW Fire and Forget
- Conventional Munitions – e.g. Tank Ammo, Mortars, 2.75" Rockets, Propellant
- THAAD
- GBI

RRAPDS Schedule

- Sensor/Component Selection
- Sensor Integration
- Initial Prototype Fabrication
- Initial Prototype Test & Evaluation
- Database Interfacing
- Advanced System Development
- Field Testing
- Tech Transfer to PMs
- Model Development & Incorporation





RRAPDS Benefits

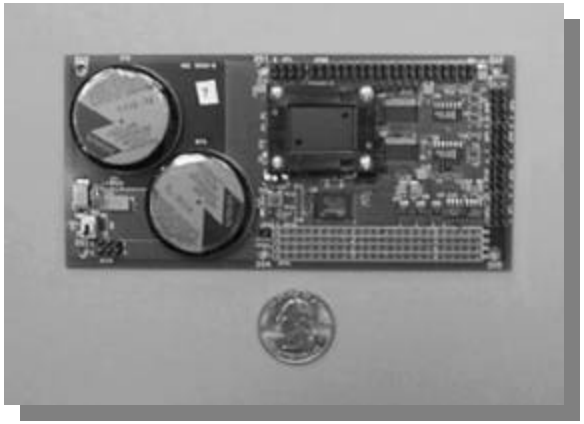
- **Identify Individual Missile/Munition Condition**
- **Sustainment of Legacy Systems for the Objective Force**
  - **Reduced Logistics Tail**
  - **Increased Confidence in Basic Load – Enhanced Readiness**
  - **Reduced Transportation Cost of "Poor Health" Assets**
- **Enhance Approved Systems for the Objective Force**
  - **Mission Ultra-Reliability c Improve Readiness**
  - **Lighter, More Lethal Load**
  - **O&S Cost Savings by Eliminating Recertification Requirements**
- **Support Stockpile Reliability Programs**

I Know That My Missiles/Munitions Will Work When Needed!

RRAPDS Status

- **Prototype Devices Fabricated and Tested**
- **Handheld Interrogator Prototype Complete**
- **Integration with ASIS/MHP Established**
- **Initial Communication Protocol/Command Set Defined**
- **Manufacturing/Packaging Effort in Progress**
- **Integrated MEMS Sensors Being Developed**
- **Prognostics Models in Early Development**

Prototype Devices



RRAPDS Summary

- **Advanced Health Monitoring Needed for Missiles and Munitions**
- **Low-Cost, Autonomous Health Monitoring System Solution**
- **RRAPDS Initial Prototypes Developed**
- **PM Applications in Progress; More on the Horizon**
- **Supports Missile Stockpile Reliability Program**
- **Reduced O&S Costs and Reduced Logistics Tail**
- **Lighter, More Lethal Load for FCS**

RRAPDS Assures the Warfighter High Reliability Missiles and Munitions When Needed