

# **Mid Range Muniton Science & Technology Demonstration**

**23 April 2008**



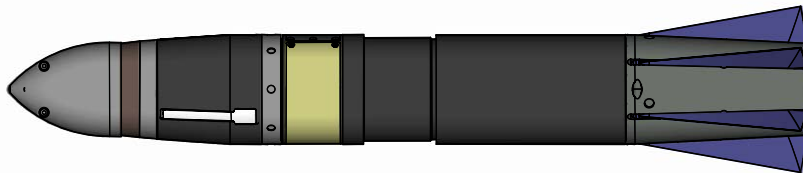
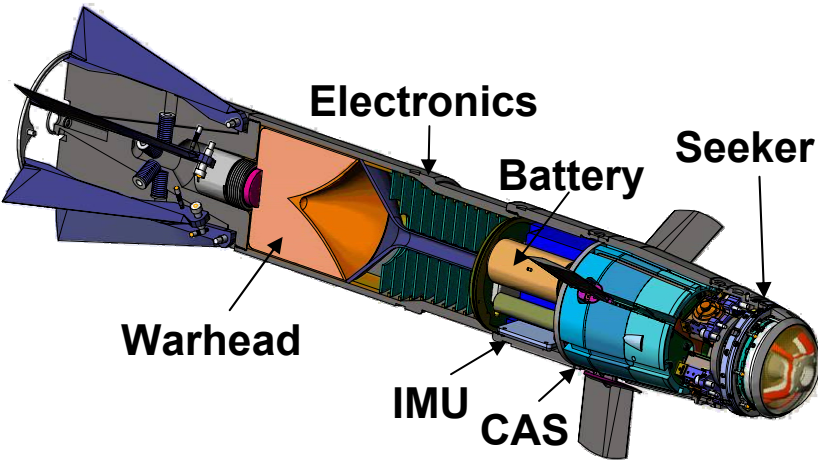
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# S&T Overview

## Gun Fired SAL & Dual Mode MRM against a Moving & Fixed T-72 Tank

- IR Autonomous / digital Semi Active Laser
- Adaptation of Proven Javelin Tracker/ Warhead
- Successful dSAL™ & Dual Mode Gun Firings





# MRM DMS Program Summary

- Projectile fully integrated into Production Capable Cartridge
- Dec 05, Successfully completed SAL Seeker Tower test at Picatinny
- 15 Aug 06, DSAL 202 Firing – **Direct Hit on Moving T-72 @ 8.7km!!!**
- 28/30 Nov 06, Fully Integrated Dual Mode Seeker CFT at Yuma
- 1 Mar 07, Dual Mode (DMS 301) Gun Firing – **Direct Hit T-72 @ 5.2 km!!!**



**MRM DMS Contract Requirements completed within Budget and Schedule**



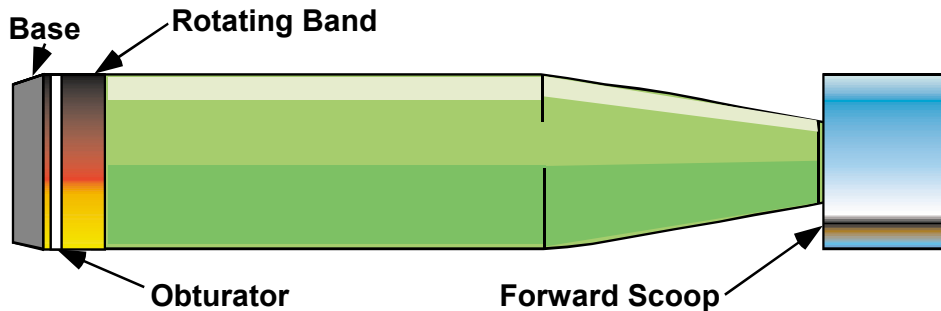
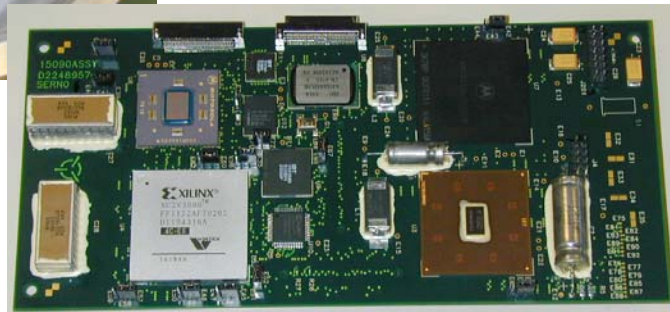
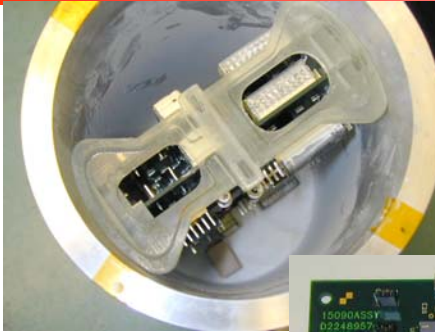
# Million Baby Steps – Design & Test

## System Engineering Approach

- Design Trades
- Requirements and their Flow Down to Sub-Systems/Assemblies
- Initial Design and Engineering Reviews
- Prototyping Sub-Assemblies
- Gun Hardening Testing
- Initial Integration and Interface Check-out
- Final Design
- Fabricate all Sub-Assemblies
- Testing of Sub-Assemblies (IFS,SWES,SKR,PIL,HIL,CFT,PM)
- Integration of Sub-Assemblies
  - Cartridge-Propulsion-Airframe-Tails-CAS-Electronics-Seeker Guidance
- Final Gun Test of complete cartridge



# Rail Gun Testing

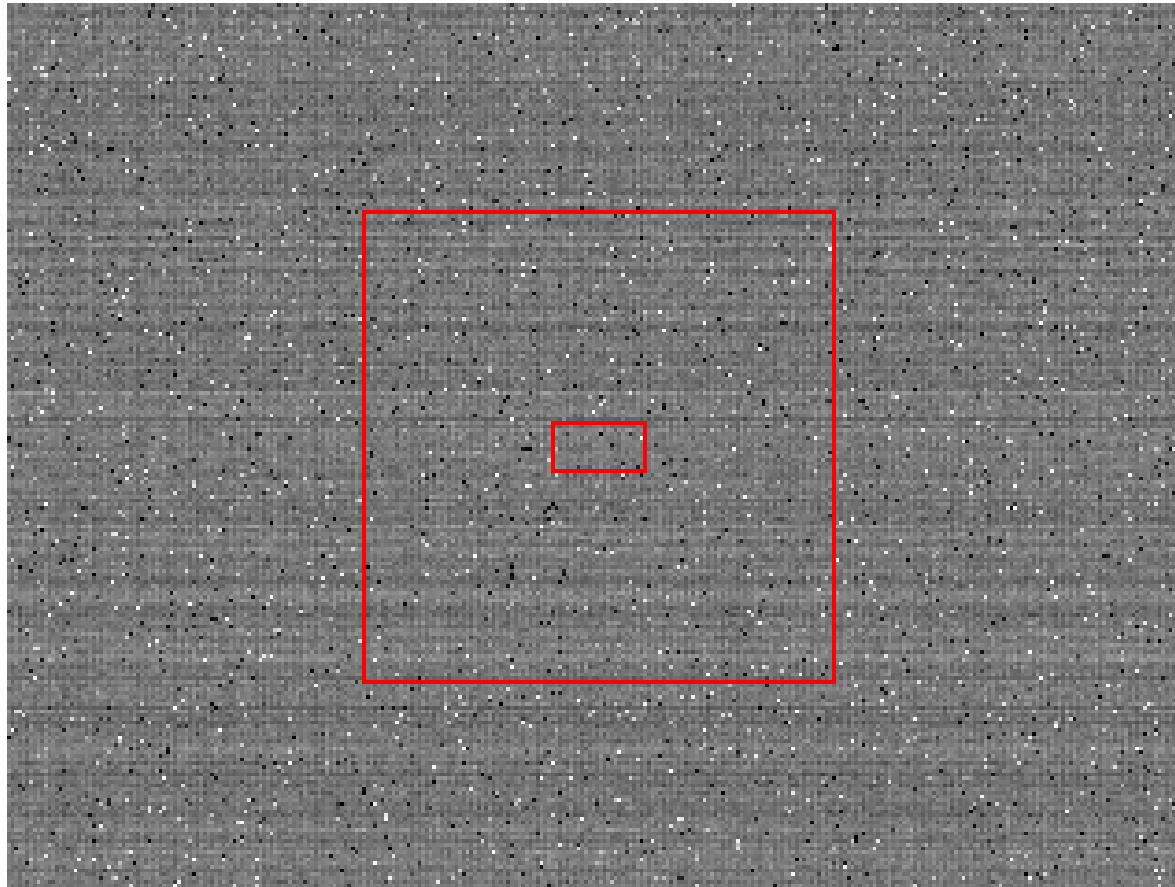


155mm M483 Cargo Projectile (modified)

**After Analysis Prototypes are Gun Tested**



# Integrated Flight Simulation & Real Time Processor In Loop Capability



**Computer Generated Scene Integrated with Flight Software Pre-Shroud Deploy Through Impact**



# Software Evaluation Station

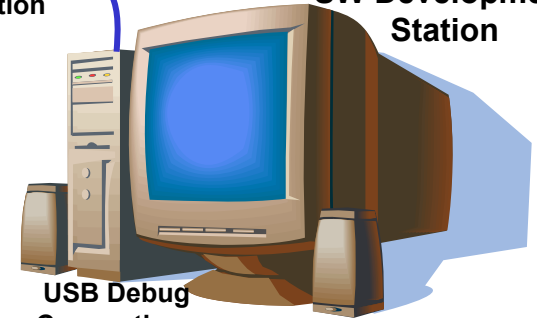


**CPU CCA**  
(MAPS Development board)



Ethernet Debug Connection

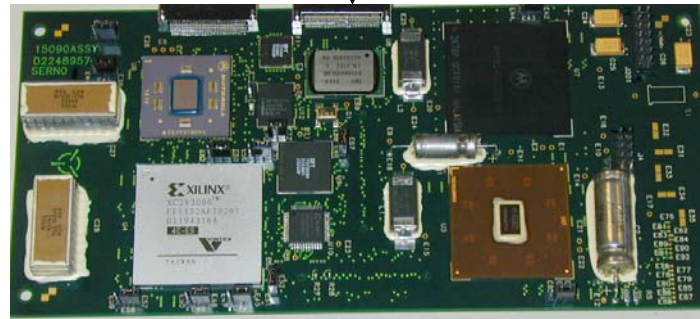
SW Development Station



USB Debug Connections

PCI Express Connection

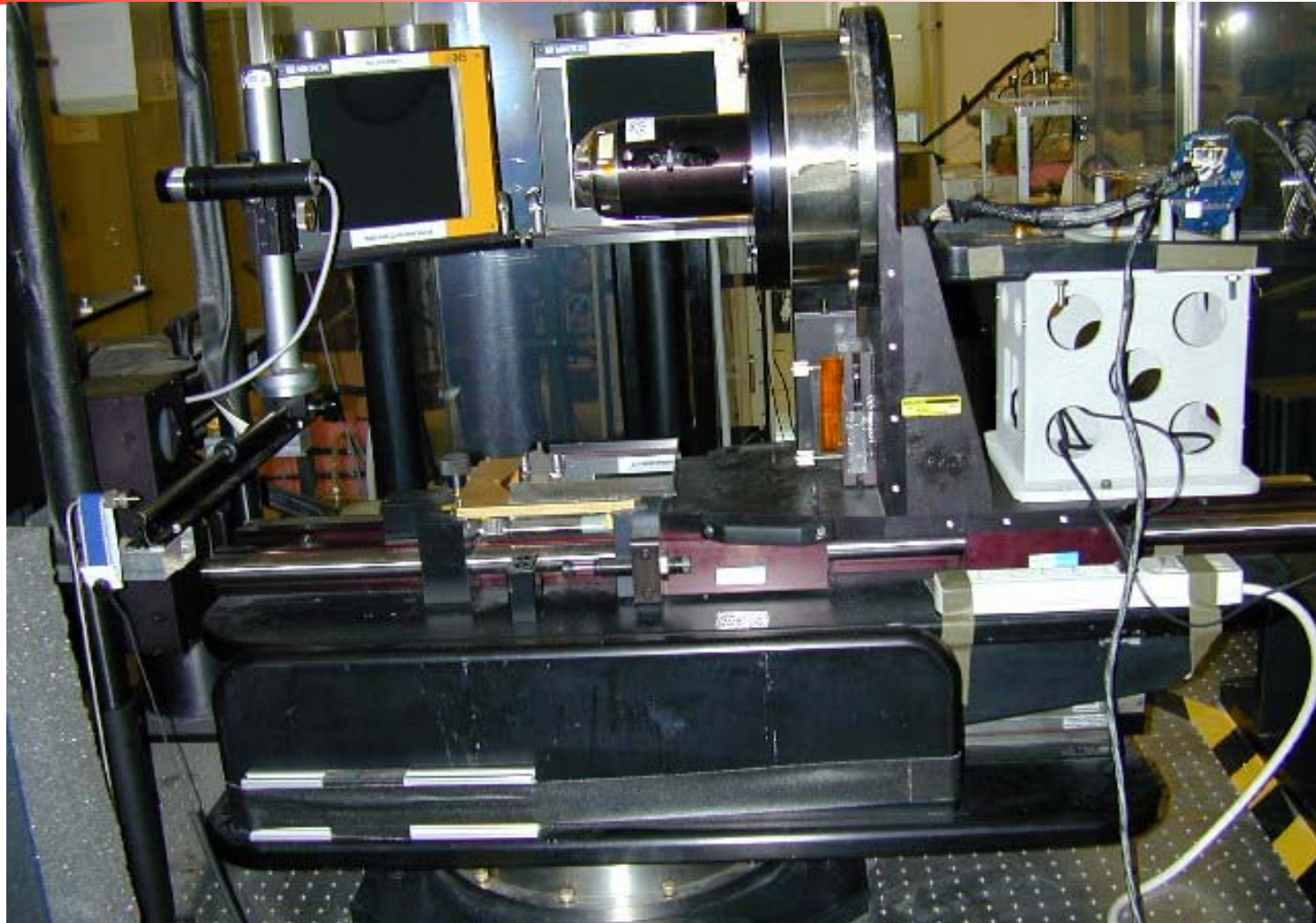
**Video/IO CCA**  
(MAPS FPGA Development board)



**Functioning check-out of the HW interfaces with real CAS, Seeker, IMU, Control and Data Collection test equipment. Check processor throughput and execution timing**



# Seeker Test Station



**Seeker Test Station runs precision IR and SAL performance tests.**

**GENERAL DYNAMICS**

Ordnance and Tactical Systems

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MRM S&T Demo Overview

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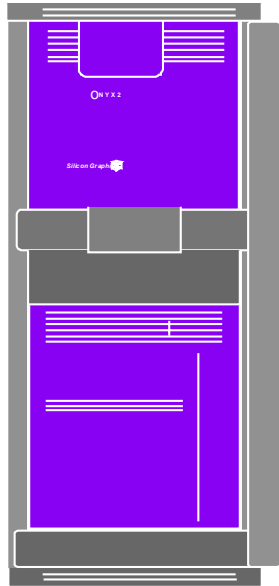




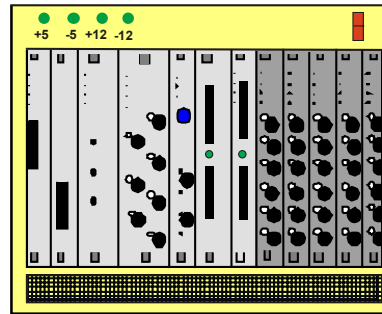
# PIL Architecture



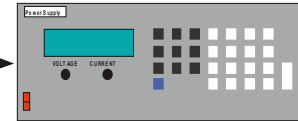
## Simulation Computer



## I/O Chassis



## Power



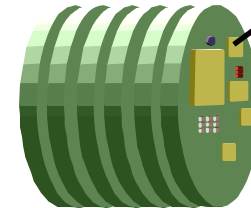
## Cooling



## CAS



## Signal Processor



- CPU
- I/O
- Tactical S/W

- Launcher →
- IMU →
- Sensor Data →
- GPS →
- Gimbal Cmds ←
- Steering Cmds ←

- Integrated Flight Simulation
  - Eqn of motion
  - Kinematics
  - Geometry
  - Aerodynamics
  - Simulated Subsystems
    - Propulsion    •Servo
    - Actuators    •IMU
    - Sensor       •GPS
- Facility Control
  - Data collection
  - Target generation
  - Processor I/O



## S/W Download



## TM



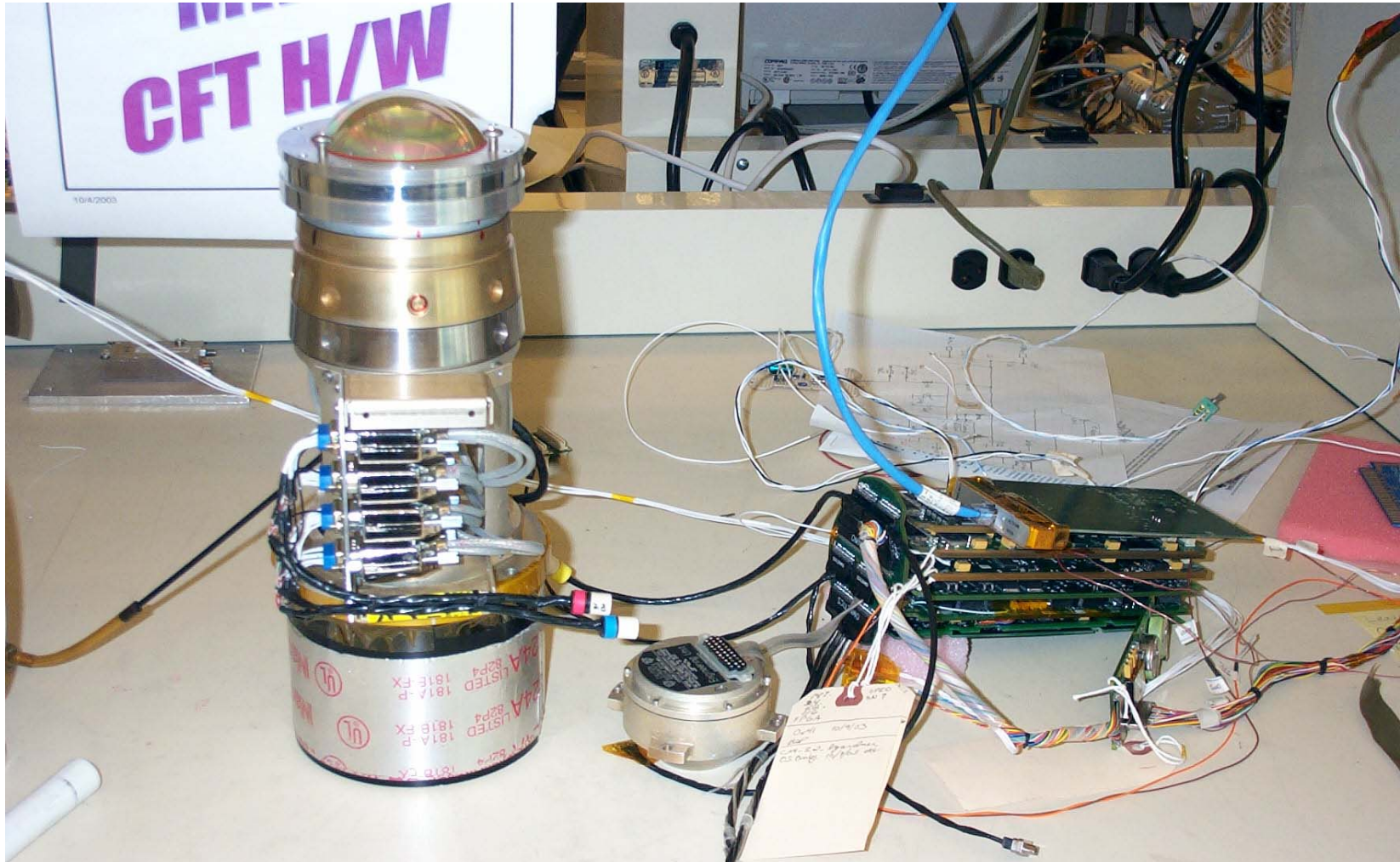
# Processor In the Loop Testing



**Common Computer Scene Generation, UUT Control and Data Acquisition Systems support multiple test efforts. Closes the Autopilot control loop around the IMU, CAS and Electronics**



# Bench Testing



**Simple Prototype Integration required Limited Test equipment & Software**

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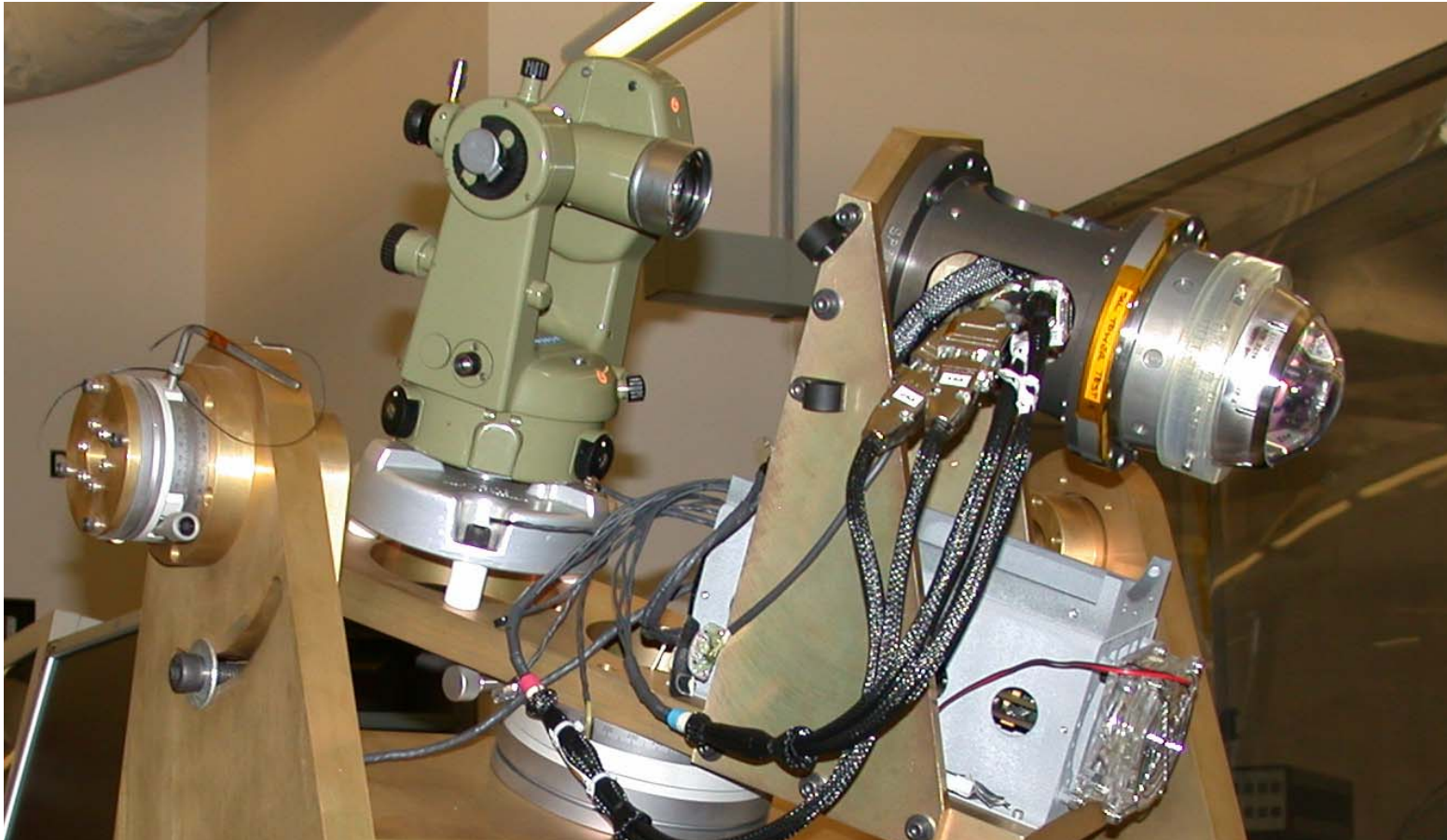
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# DSAL Tower Test System

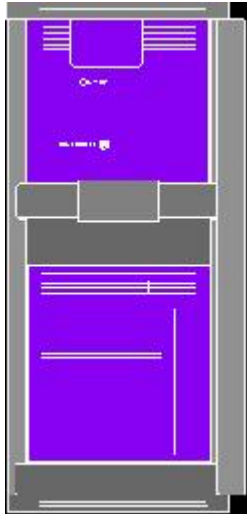


**07 December 2005 – Successfully completed SAL tower testing at the Picatinny Tower during winter conditions. The dSAL™ seeker correctly acquired and tracked the laser source at min/max ranges.**

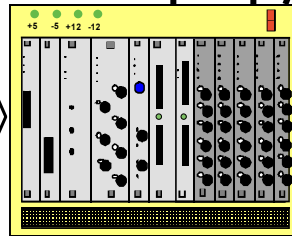


# HWIL Architecture

## Simulation Computer

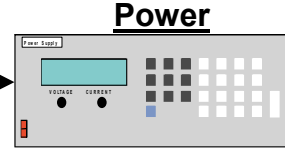


## I/O Chassis



Target Scene data

Power Control



Cooling



Target Motion

Launcher

IMU  $\Delta V$ ,  $\Delta \theta$ , Accelerometers

Steering Cmds

Carco Table Control

Target LOS Rate

Target Position, Velocity, Accel, Time



Target Simulator

Seeker

Carco Table

```
IF(ACC != 0)
APP=APP+DAPP*DT
AYP=AYP+DAYP*DT
WPP=WPP+DWPP*DT
WXP=WXP+DWXP*DT
WX3=WX3+WX2*DT
```

S/W Download

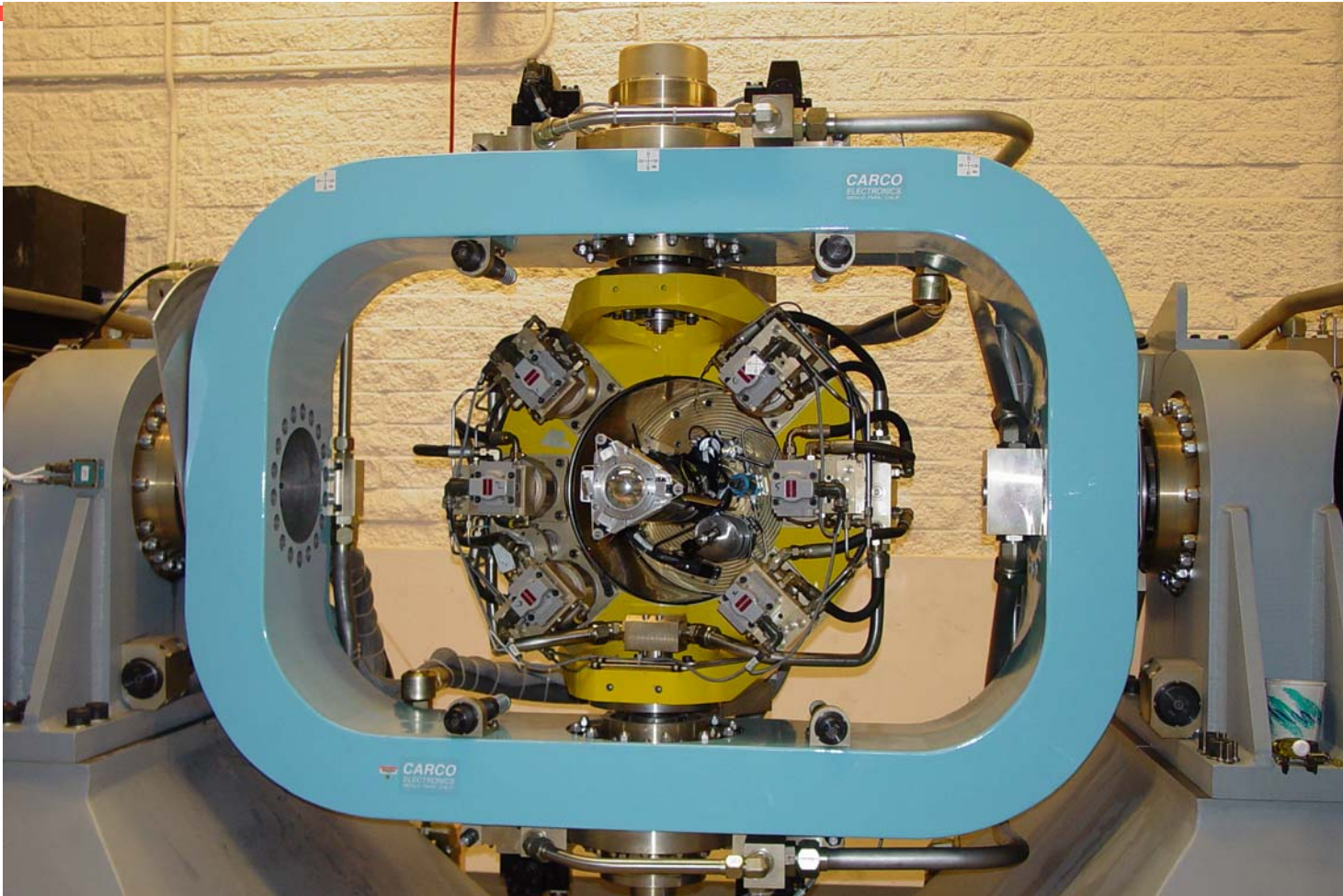


- Integrated Flight Simulation
  - Eqn of motion
  - Kinematics
  - Geometry
  - Aerodynamics
  - Simulated Subsystems
    - Actuators
    - Sensor
    - IMU
- Facility Control
  - Data collection and I/O
  - Target Generation
  - Motion Platform





# Hardware In the Loop Testing



**HIL verifies all guidance control loops operate correctly during a real time flight simulation**



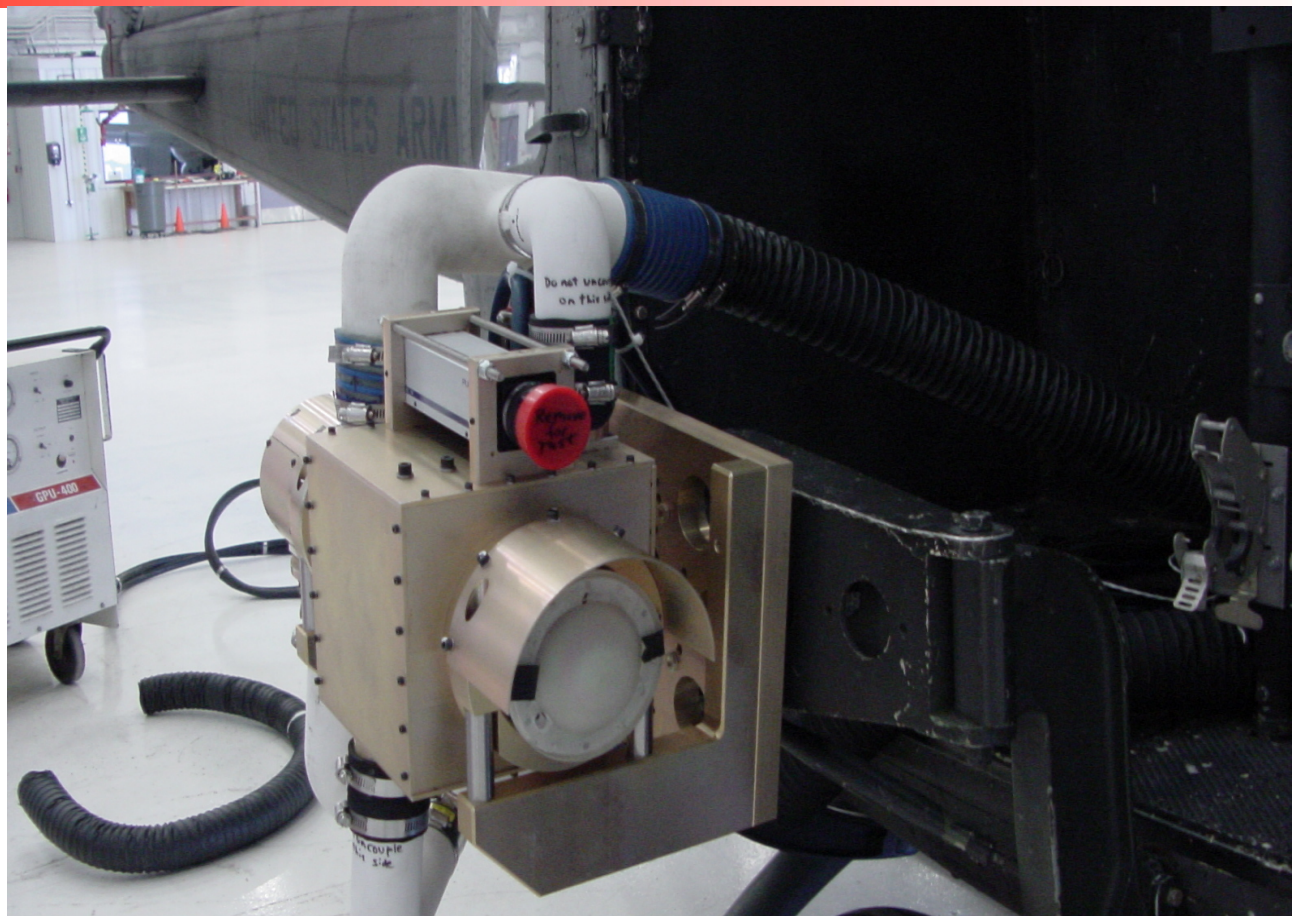
# Captive Flight Test



**Data Acquisition and control computers used in the PIL and HIL are also used during Captive Flight Test (CFT)**



# MRM CFT Assembly Mounted on Helicopter Front View

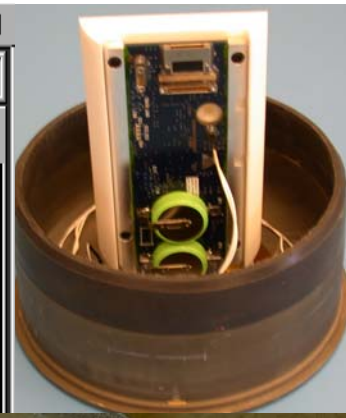
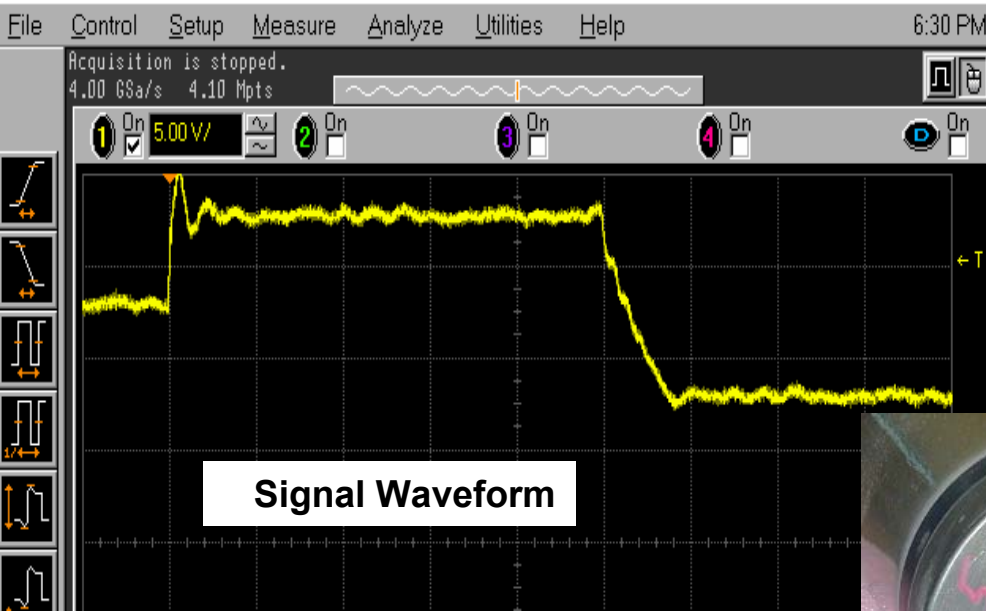


**Captive Flight Testing provides end to end testing of target acquisition, tracking and guidance commands as the helicopter closes with the tank target. CFT was critical to the flight software development and debugging efforts.**





# Cartridge Ammo Data Link Demo



**Ammo Data Link has been developed, integrated and tested**  
**Successfully tested in M1A2 SEP using a emulator**



# Battery Init / Shroud Video



## Initial Shroud Deployment





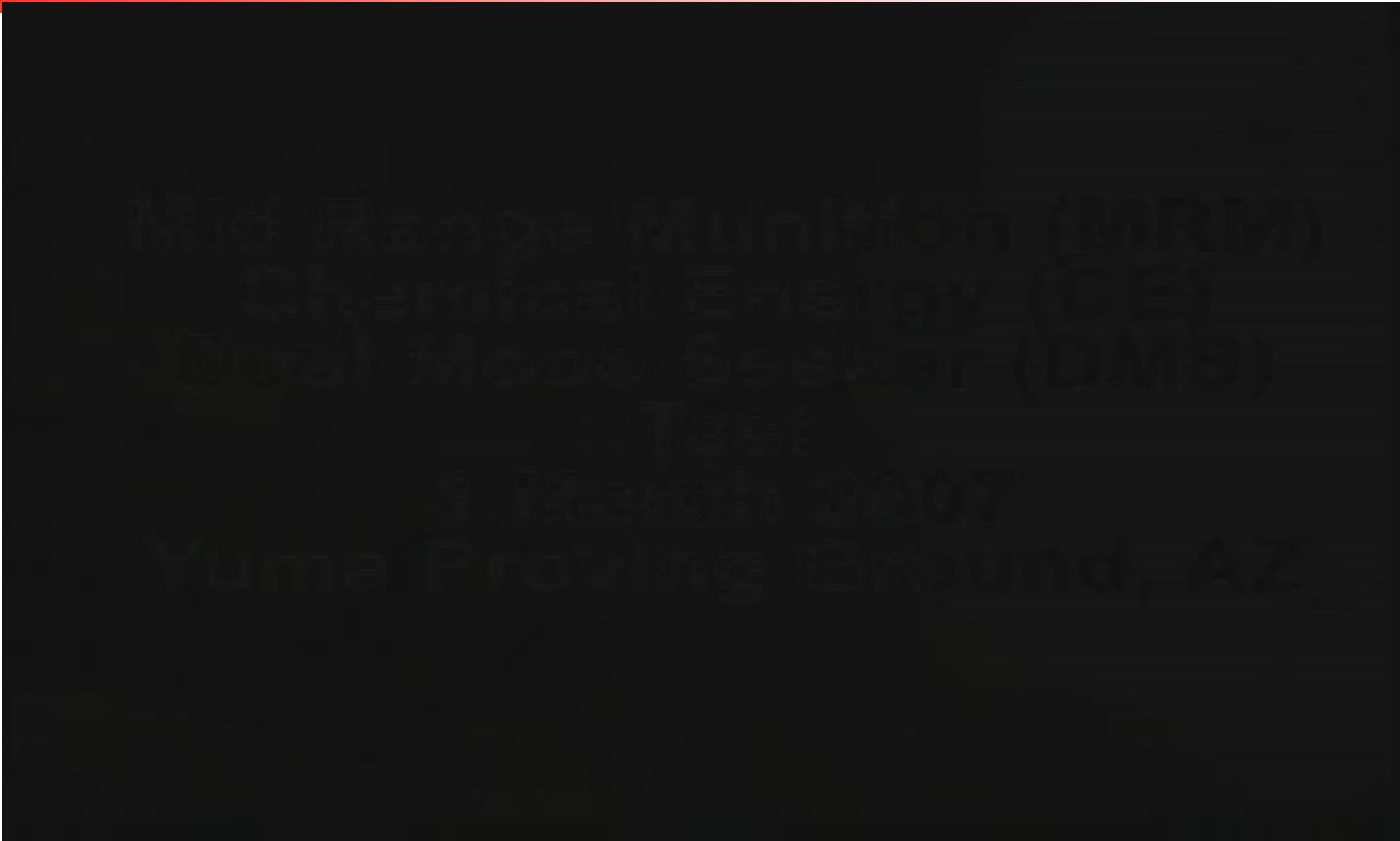
# Battery Init / Shroud Video



**Shroud Deploy – Both Halves**



# Final Gun Tests



**Direct Hits with Both dSAL™ and Dual Mode I2R/dSAL™ !!!**

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# Summary

- **System Engineering approach allowed Fast Pace**
- **Aggressively Pushed Detailed Testing**
- **Combined Test Objectives For Highest Efficiency**
- **Rapidly review Failure Analysis**
- **We always learn more after a failure than success**
- **Lessons Learned**
  - ✓ **Run Detailed Post Analysis After All Tests – Even Successes !!!**
  - ✓ **Do Not Ship Test Articles Until You Have Tested Outside Of The Expected Test Conditions. Test It until It Fails – Then Fix It. Always Understand The Failure Even If It Can Not Be Fixed !!!**