Mid Range Munition
Science & Technology
Demonstration

23 April 2008

Rick Williams
(520) 545-9658
r-williams20@raytheon.com
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
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

After Analysis Prototypes are Gun Tested

155mm M483 Cargo Projectile (modified)

Rotating Band
Base
Obturator
Forward Scoop
Integrated Flight Simulation & Real Time Processor In Loop Capability

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

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 runs precision IR and SAL performance tests.
PIL Architecture

- 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

Simulation Computer

I/O Chassis

Power Control

Cooling

Signal Processor

- CPU
- I/O
- Tactical S/W

Launch

IMU

Sensor Data

GPS

Gimbal Cmds

Steering Cmds

- S/W Download
- TM

I/O Chassis

- +5
- -5
+12
- 12

Silicon Graphics

NYX2
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
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.
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

Power Control

Target Motion

Launcher

IMU \( \Delta V, \Delta \Theta, \text{ Accelerometers} \)

Steering Cmdds

Carco Table Control

Target LOS Rate

Target Position, Velocity, Accel, Time

Target Scene Data

Power

Cooling

Silicon Graphics

if\( (ACC != 0) \)

\( APP = APP + DAPP * DT \)

\( APP = APP + DAPP * DT \)

\( WPP = WPP + DWPP * DT \)

\( WXP = WXP + DWXP * DT \)

\( WX3 = WX3 + WX2 * DT \)

Cooperate

Carco Table

Target Simulator

S/W Download

Target Scene Data

Seeker

GPS Satellite Constellation Simulator

Target LOS Rate

Carco Table Control

Target Motion

Target Position, Velocity, Accel, Time

Facility Control

Data collection and I/O

Target Generation

Motion Platform

Simulation Computer

I/O Chassis

Power Supply

VOLTAGE CURRENT

Power

Cooling
Hardware In the Loop Testing

HIL verifies all guidance control loops operate correctly during a real time flight simulation
Data Acquisition and control computers used in the PIL and HIL are also used during Captive Flight Test (CFT)
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™ !!!
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 !!!