Fuzing at Dahlgren

Michael A. Till
NSWC Dahlgren Division
G34, Fuze Branch
### Report Documentation Page

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ERGM System Description

- Length: 61 Inches
- Weight: 110 Pounds
- Fuze: Integral, GPS Initiated
- Guidance: GPS/INS
- Accuracy: <20m CEP
- Payload: Submunitions
  - 72 EX-1s (Modified M80s)
  - Self Destruct Fuze (M234)
- Propulsion: Rocket Motor
- Range Objective: 63 nmi
- Prop Charge: 18 MJ
- Loading: Double Ram

- Roll-Attitude Controlled Airframe
- Vertical Endgame Trajectory
ERGM Mission Profile

- Altitude: 250-400 meters
- Submunition Dispense Target
- GPS Jammed
- Inertial Guidance
- Motor Burn
- Canards Deploy
- Battery On
- Fins Deploy
- DCI

GPS Acquisition Window

Altitude 250-400 meters
Target
Submunition Dispense
GPS Jammed
Inertial Guidance
EX-87 Mod 1 S&A:
- Completed Design Validation Tests (DVT)
- Successfully Fired 3 in Canister Projectiles
- Successful Fired in Dynamic Dispense Air Drop Test (DD-1)
  - Lessons Learned from DVT have been Incorporated

Near Term Testing:
- S&A Qualification (July 01)
- Piston Actuator Component Qualification (June 01)
  - Dynamic Dispense Gun Fire (May 01)

M234 E1 Self-Destruct Fuze:
M234 E1 Self-Destruct Fuze:

- DD-1 Test (YPG, 18 Aug 00)
  - Slight Over-Test Condition (Expel/Dispense Altitude Too Low)
  - 13 Primary Mode Failures (82% Successfully Armed)
  - 0 ERGM Shunt Removal Failures (100% Successfully Armed)
  - 14 Spiral Flag Failures (81% Successfully Armed)
- Additional Improvements Incorporated for Dynamic Dispense Gunfire Test (DD-2) Scheduled for early May ‘01
To package the electronics and mechanical components of the Proximity Fuze in the shape and size of the current M234 SD Slider for the M80 Submunition for ERGM

- One-for-One replacement of current Slider
MK 45 MOD 4

EX 3

ERGM

Proximity Fuze
Major Component Layout

Prox. Fuze Slider

Firing Cap
Nesting Switch
Battery Flex Print
Print Wiring Board
MMIC
Antenna
Battery
Signal Processor ASIC
Firing Cap
Navy 5” Cargo Projectile

- MK2 Submunition
- 49 Submunitions
- High-Frag Shaped Projectile Body (1 Caliper boattail)
- Expelling charge
- ET Fuze
- Discarding Rotating Band
- Base Plug

Navy 5” Cargo Projectile Diagram
Design challenge:

- Add a safety feature to the grenade for the 5” cargo round
- Minimal cost and ASAP - we’re already in production: 700,000 fuzes made
- Requirements driven from WSESRB letter (objective) & PEO “acceptance of risk” (threshold)
Resolution Efforts (Grenades already purchased)

Numerous add-on and redesign fixes were sketched and analyzed, then down selected a number of add-on fixes.

Program has invested over $1.5M to date to resolve issue.

- Shrink Tubing
- Dayron Setback Clip
- Slow Cook-off Simulated Magazine Set-up
- Thermocoupled Grenades
- Dayron Dual Mode Clip

Metal spin clip line of designs stopped by WESRSB letter.
1st tests show both significantly improve safety

Solutions will meet 95% of the WSES RB concerns. May still leave 1 armed grenade plus 2 w/o an extra lock post cook-off

Reliability testing and final downselect in May 01

Cargo Program review at end of month. May change design course & require a 100% solution
MK 432 ELECTRONIC TIME FUZE
A New Fuze for the US Navy
Team Approach

BULOVA TECHNOLOGIES LLC
Design, Testing, Production

Contract, Design Support, Testing

Requirements, Design Support, Testing
Navalization of the M762A1

- Inductive Set Compatibility
- Battery Activation
- Targets
- Remove PD back-up
- EEE improvements
- IM
Completed in 9 months:
  – 400 fuzes delivered
  – Successful gun firings

Qualification Completed Summer 2001

Production Scheduled to begin July 2001

14,600 Fuzes Delivered October 2001
Multi-function Fuze (MFF)
Replaces VT, CVT, MT & PD fuze on HE rounds.  
Simplifies logistics.  
Uses IM Explosives.  

Multiplies effectiveness of ship’s magazine.  
Improves fuze performance, accuracy, reliability & versatility.
IPT: NSWC Dahlgren, NSWC Crane & ATK
   – Performance Specification
Production at Alliant Precision Fuze Company, L.L.C in Janesville, WI
LRIP ~9500 fuzes in 3 lots
Options for another 6000 to 12000
Pre-First Article performance
   – Twice as sensitive as MK 418 VT-RF fuze against the same air target
   – E&MD performance & production issues resolved
MFF Schedule

- New Program Schedule Approved
- Updating the ORD and TEMP
- TECHEVAL 3rd Qtr FY01
- OPEVAL 4th Qtr FY01
- Milestone III Decision 1st Qtr FY02
- LRIP 1st Lot delivered 2nd Qtr FY02
- IOC 1st HE-MF rounds delivered 2nd Qtr FY02
- FOT&E for 5in/62 Gun Qualification in FY02
MK 419 TECHEVAL

- San Clemente Island, SHOBA, 3rd Qtr FY01
- USS Bunker Hill (CG 52)
- 57 MK 419 Test rounds, 90 rounds total
- Part of First Article
- Test HOB, PD, ET, AUTO(HOB) performance over land and water
MK 419 OPEVAL

- San Clemente Island, SHOBA, 4th Qtr FY01
- USS Bunker Hill (CG 52)
- 170 MK 419 Test rounds, 200+ rounds total
- Test AIR, HOB, PD, ET, AUTO(HOB), AUTO(AIR) performance over land and water
- Towed RF air target
MFF Cost Reduction
RF System

- MMIC Receiver
  - Plastic encapsulation vs. ceramic pkg
  - Adjust frequency to reduce tuning effort
  - Align with optimum antenna and transmitter frequencies

- MMIC Transmitter
  - Plastic encapsulation
  - Frequency tweak if required

- Antenna
  - Improve dielectric material properties to enhance producibility
  - Decrease raw material cost
MFF Cost Reduction

Battery

- Use MOFA battery with minimal modification
  - Failed to meet performance requirements
- European battery conference held to identify potential battery sources
Technical Objectives

- Develop an alternative Low Cost Guidance Electronics Unit (LCGEU) for the EX171 Extended Range Guided Munition (ERGM)
  - design as a form, fit, & function replacement for existing ERGM GEU
  - identify & select performance trades versus affordability
  - demonstrate performance via a series of guided flight tests

Low Cost GEU

Form, Fit, Function GEU replacement for EX-171
Technical Objectives (Contd)

- Prepare for transition to future EMD phase
  - Work closely with Rockwell / Collins (EMD prime) to develop cost as independent variable in LCGEU design
  - Deliver complete HW/ SW documentation package
  - Identify future production cost reduction opportunities

Low Cost GEU

Form, Fit, Function GEU replacement for EX-171
Baseline Mechanical Design
Integrated Product Team (IPT) Assembled to Select a Height of Burst (HOB) Sensor and Incorporate as Primary Fuze for LASM

- Raytheon
  - HOB IPT LEAD
  - MISSILE DESIGNER

- TDA, REQUIREMENTS DEFINITION
  - MODELING, TESTING

- NAVSEA
  - GOVERNMENT FUZE EXPERT
  - BAA
Mission Overview

**Boost Phase**
- Pitch over Guidance (VLS only)
- Missile Achieves Supersonic Speed

**Targeting Data**
- Forward Observer
- UAV
- Satellite

**VLS Initialization**
- Initialization & Target Data Supplied
- GPS Initialization

**Midcourse Phase**
- Missile Flies to Vicinity of Command Point
- Guidance Commands Generated Within Missile
- Inertial Instrument Errors Reduced by In-Flight GPS Updating

**Warhead Initiation Phase**
- Flight Path Angle Control
- Ground Height of Burst Calculated
- Inertial Guidance During GPS Jamming
Identify Candidate Sensors
- Broad Agency Announcement (BAA)
- Previous Trade Studies
- Recommendations from Team Members
- 18 Sensors from 12 Vendors Identified

Sensors Fell into 3 Classes: Radio Frequency, Electro-Optical, Mechanical

Down-select to Set of Sensors Meeting Minimum Requirements

Used Quality Functional Deployment Matrix for Comprehensive Comparison of Down-selected Sensors
- Evaluation Criteria Split Between Cost and Performance
- Relative Weights of Evaluation Criteria Determined by Team Consensus
- Scores Awarded Each Sensor Determined by Team Consensus
- Gen III - LASM Configuration
  - Near IR Pulsed Diode Laser
  - Low Cost, Rugged, Low Power, Array Logic, Microprocessor w/ EEPROM flash Memory, Serial Communication, Continuous Altitude readout, Obscurant Algorithms

- Gen III - Performance
  - Cost Effective
  - Will Meet Missile Environments
  - Meets Clear Air Requirements
  - Will Not Pre-trigger on Obscurant
  - Will Distinguish Hard Targets from Obscurants
    - Degradation of Performance in Obscurants - TBD
  - Mechanically and Electrically Interface with GS
  - Adaptive Configuration for Future Growth
GUIDANCE SECTION ASSEMBLY

- Titanium Tip / Fuze Contact Device
- HOB Assembly
- GPS Antenna
- EMI Shield
- Nosecone
- Preamp-Limiter Filter
- AJ Unit
- Regulator Assembly
- Avionics Assembly
- Test Round Package
- Guidance Shroud
- Coupling Nut
- End ring
Summary

- Requirements Defined
- EO Sensor Characterized and Risks Identified With Mitigation Plans
- Preliminary Mechanical Design for HOB Main Assembly Complete
- Analysis and Test Performed
Future Efforts – Course Corrected Fuzes

- Trajectory error management
  - 1-D Corrections: drag chutes, drag fins, etc. to reduce range dispersion
  - 2-D Corrections: canards, pulse dots, etc. to reduce range dispersion and cross-track deflection
- Must not violate NATO standard fuze envelope during pre-flight
  - Ensures minimal impact on round handling equipment and procedures
  - MIL-STD-333B envelope selected
- Range increase not required
- Fielding by FY10
Future Efforts – Low Cost Projectile Fuze Alternatives

- Reduce Fuze Re-procurement Costs
  - Buy Fuzes with Army
    - Navalized MOFA
  - Buy Components with Army
    - Common S&A, battery, detonators
  - New Fuze
    - Low Cost Air Warfare Fuze
  - New Requirements
Issue #1: Batteries

- In the last few years, DOD has lost significant manufacturing and design ability to make batteries for gun fired munitions
  - Reduction in the last 10-15 years
    - Govt battery R&D personnel: approx 90% loss
    - Contractor companies: from 15 to 3
- The government has not maintained the expertise
- The contractors can not maintain the expertise
- No fundamental R&D conducted in the last 10 years in liquid reserve technology
- Applied chemical engineering has been conducted in a limited way on select programs with very limited success
  - Based on 15-20 year old technology
Impact to Navy Programs

- **JMPSIB-IPT**
  - Dahlgren is the Navy’s lead on the Joint Service IPT

- **MK 419 MFF Battery**
  - MK 44 Lead-chemistry battery unproducible within USA
  - No direct replacement
    - Lithium replacement program did not meet requirements
    - Investigating two European batteries
      - Lithium Chemistry
      - Lead Chemistry
EP, ATK, KDI have no success or limited experience in the cutting edge of power sources technology

Major concern to ERGM program for both submunition programs
- M234 SDF
- EX 433 Prox Fuze
Objectives

- Current Navy Projectile Battery Requirements
  - ERGM
    - 2 System batteries (1 thermal reserve, 1 liquid reserve)
    - 72 Submunition batteries
  - MK 419 - MFF
  - MK 418/MK 417 - VT-RF
  - MK 404 - VT-IR
  - EX 432 - ET

- Future Naval Gun launched projectiles requiring a power source
  - GPS Rounds
  - Best Buy - GPS, 100nmi
  - Badger - GPS, Hypersonic projectile
  - MRO Mission Responsive Ordnance
  - AGS munitions
"On April 24, five children playing with colorful unexploded submunitions were reported killed, and two injured, near Doganovic in southern Kosovo."
-Steve Goose, program director of Human Rights Watch's arms division as reported in the Washington Post, Saturday, June 19, 1999; Page A19

"PRISTINA, Kosovo, May 22 -- One boy was killed and two other children were seriously wounded by a cluster bomb on Sunday..."
-Carlotta Gall; published on Tuesday, May 23, 2000 in the New York Times

“Submunition weapons employment in Southwest Asia and Kosovo, and major theater war modeling, have revealed a significant unexploded ordnance (UXO) concern."
“It is the policy of the DoD to reduce overall UXO…
“…the desire is to field future submunitions with a 99% or higher functioning rate.”
“Submunition functioning rates may be lower under operational conditions…”
“Services may retain ‘legacy’ submunitions…”
“Waivers to this policy…shall require approval by the JROC.”
Navy Programs Affected

- ERGM
- Cargo
- MRO
- MLRS (Marine Corps)
What’s Next?

- Community Consensus on meaning of memorandum
  - “function”
  - “rates may be lower under operational conditions”
  - “waivers”
  - Safe UXO vs. “function”

- Evaluate Alternatives
  - Technology Investments – redundancy, miniaturization, reduced safety
  - Unitary Warheads – need valid lethality models to make comparisons