ENHANCED EXPEDITIONARY

ENGAGEMENT CAPABILITY

Guided Projectiles for an Enhanced Expeditionary Engagement Capability

2017 NDIA Armament Systems Forum

1-4 May 2017

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Enhanced Expeditionary Engagement Capability (E3C)

- Sponsor:
  - ONR 30 Fires
- Objective:
  - Demonstrate the “Art of the Possible” in fire support technologies for USMC weapons, through an ongoing series of integrated system firing demonstrations
- Structure:
  - Demonstrate systems to TRL 5-6
  - Transition Systems and/or Technologies to Acquisition or FNC programs
  - One new caliber every 3-4 years
  - Flexible to meet future stakeholder needs

Today’s Briefing Covers Product Portfolio and Recent 81mm Guided Mortar Testing

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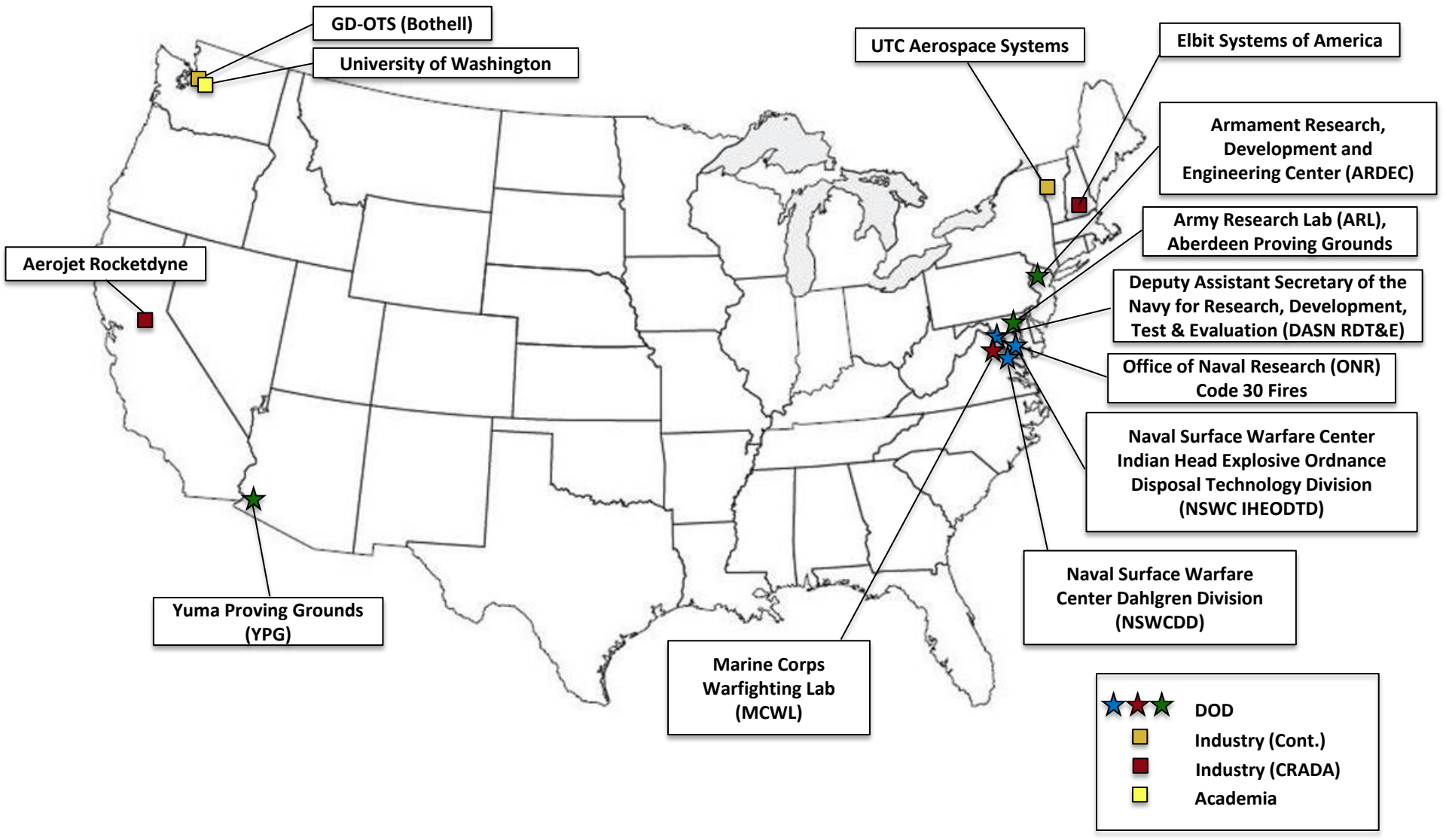
E3C Development Team (Current)



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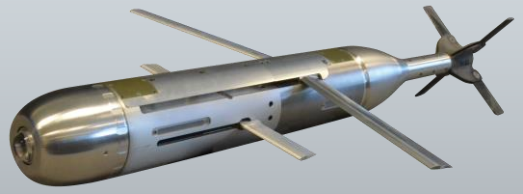
E3C Portfolio

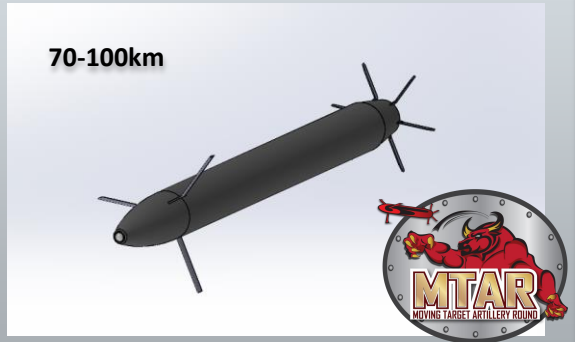
Current Guided Projectiles

81mm Advanced Capability Extended Range Mortar (ACERM)



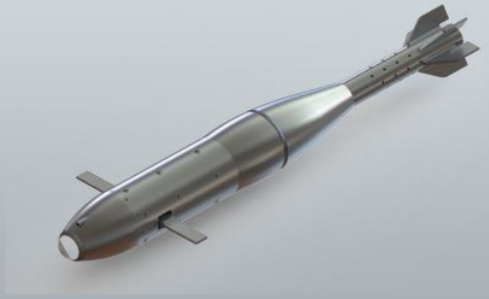
Demonstrated 22.6km World Record Maximum Range

155mm Moving Target Artillery Round (MTAR)



Future Naval Capability (FNC) Program

60mm Precision Mortar



FY18 New Start S&T Program

Future Guided Projectile

Supporting Technology Products

Miniature Mission Setter (MMS)

Low-Cost SAL Seeker (LCSS)

Leap Ahead Capabilities Across the Spectrum of Calibers

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Supporting Technology Products

Miniature Mission Setter (MMS)

- <4lb replacement EPIAFS capability
- Direct Connect programming interface
- Common computing system with Target Handoff System (THS)
- Hosts LHMBC/MBK software
- Two-Wire/Tac-Link Modem for Digital Communications
- Backwards compatible with M982, M1156 with future Inductive Setter Kit

First Fielding in FY20 with
M327 Expeditionary Fire Support System (EFSS)

Low-Cost Semi-Active Laser (SAL) Seeker (LCSS)

- STANAG 3733 SAL Targeting Sensor
- Compatible with low power laser markers (10mJ/pulse)
- NSWCDD Developed for ONR
- Small form factor – 6.3 in^3, 4.0 in^3
- Estimated $1k/unit in production (2k unit/yr)
- Precision HOB add-on (1-20m selectable, 3.5% error)
- Flight tested on 81mm, 120mm precision mortar cartridges
- Upgrading to 155mm capability → 20,000g survivability, 2x Acquisition Range, Embedded GEU functionality

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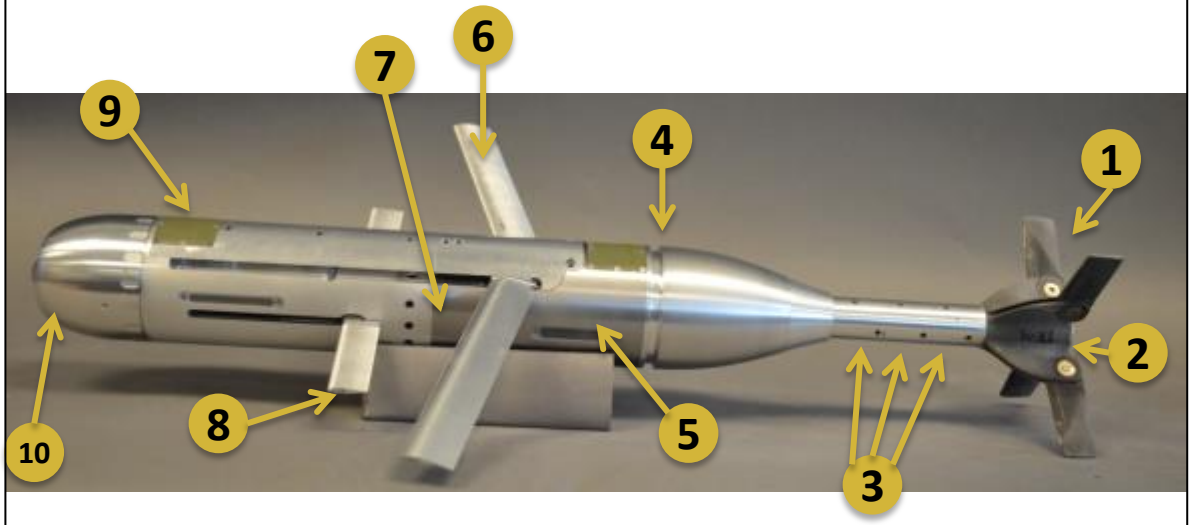
ACERM Cartridge

- 81mm Precision Cartridge
  - 3 Firing Tests to Date, 19 Cartridges
  - Currently TRL5/6
- >20km Maximum Range
  - ***Demonstrated 22.6km***
- GPS+SAL Precision
  - <10m CEP (GPS), 1m CEP (SAL)
  - ***Demonstrated <10m CEP w/ GPS @ 16.7km***
- Advanced Trajectory Shaping
  - Urban, Defilade, & Moving Targets
  - Counter Battery Radar Spoofing (novel trajectories)
  - ***Demonstrated Vertical at Impact***
- GPS Denied Precision to 10km
- Multi-Platform Capable (M252, LAV-M)
- Convertible for UAS Air Drop
  - Requires minimal upgrades
- Est. $15k AUPC @ 2k units/yr



1. Super Caliber Deployable Tail-Fins
2. M299 Ignition Cartridge
3. ERMA Propelling Charges (not shown)
4. Split Ring Obturator (not shown)
5. Enhanced Lethality Warhead
6. Lifting Wing
7. MEMS S&A Fuze (inside shell)
8. Dual Independent Steering Canards
9. Global Positioning System (GPS)
10. Low-Cost SAL Seeker (LCSS)

SAL Guidance vs. Static and Moving Targets Demonstration by End of FY17

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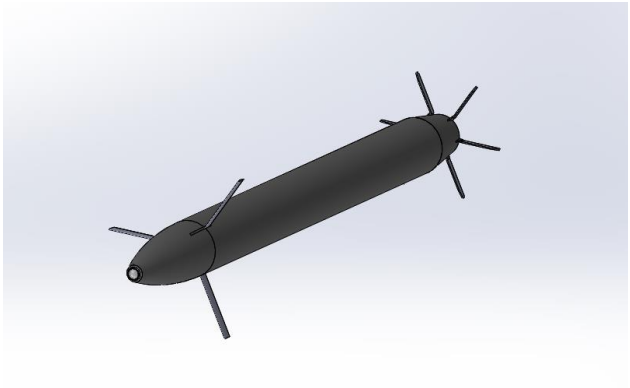
Moving Target Artillery Round (MTAR)

- New 155mm Guided Projectile for M777
  - Howitzer Artillery Fires to 70 – 100 km
  - Moving targets afloat/ashore
  - Operations in Satellite/Network Denied Environment
    - Fully mission capability w/o GPS
  - Modular Architecture



- Interest in 5-Inch Projectile Saboted to 155mm
  - Potential for Joint USMC, USN, US Army capability

- New Start FNC Program in FY19
  - Request for Information (RFI) → May ’17 via FedBizOpps
  - Request for Proposal (RFP) → Mar ’18 via DOTC
  - Seeking Full System Solutions
    - May use Gov’t solution for GPS Denied Navigation

Transitions to MARCORSYSCOM for Acquisition in FY22

MTAR
MOVING TARGET ARTILLERY ROUND

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Conceptual MTAR System vs. Land Target

1. Target ID, Track, Classification	7. Inertial Midcourse Guidance
2. Digital Call for Fire	8. Laser Target Designation
3. Call For Fire Processing & Assignment	9. Laser Terminal Guidance
4. Weapon Programming	10. Fuzing & Detonation
5. Ram & Fire	11. Battle Damage Assessment
6. Radar Track & Navigational Data Uplink	

NO USE OF GPS
FOR MTAR GUIDANCE

AFATDS

M777A1

MMS

Tracking Radar

Many Target Designator/FO Combinations Possible

> 70,000m

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Future 60mm Precision Mortar

- Investigating enabling technologies for smaller form factor (60mm & below) caliber precision ordnance
  - Architecture Compaction Research
    - Topological Data Visualization Tools
    - Hybrid GN&C/Terminal Seeker Electronics Systems
    - Piezo-Electric based Control Actuation Systems
  - Guided Projectile Development Timeline Reduction
    - CFD Alternatives for Exterior Flow Analysis
    - Artificial Intelligence GN&C Software
    - Additive Manufacturing

Technology Leap Aheads Will Need to Be Cost Effective to Maintain Caliber Affordability

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81mm ACERM Development Timeline

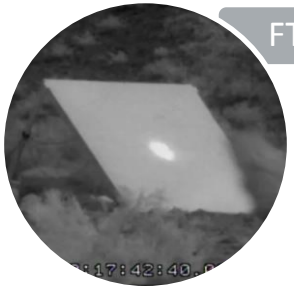
FY14 | FY15 | FY16 | FY17

Wind Tunnel Testing
(May 2014, Sep 2014)

FT1 (May 2015)

FT3 (Nov 2015)

FT3.5 (Sep 2016)



FT4 (July 2017)

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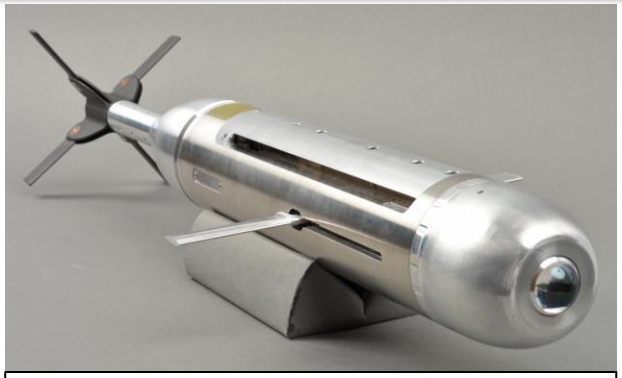
Flight Test #1 (FT1)

- ACERM Survivability & Roll Control (6 Rounds)
  - Survivability of Key Sub-Systems
  - Validation of Wind Tunnel Aerodynamic Data
  - Active Roll Control Demonstrated
  - Validated IMU Capabilities
  - LCSS Track on Designated Target (Ride-Along)
    - Using GLTD II
  - Precision Delivery – 3,200m Target
    - 10-20m Miss Distances using C/A GPS



ACERM FT1 Test Projectile
- No Wing
- Diagnostic Telemetry Module (DTM) Warhead Surrogate
- No Tactical GPS, C/A Code GPS in DTM
- M38 Propellant (Zone 3)

- ERMA Propellant (10 Rounds)
  - ACERM Ballistic Slugs
  - Charge weight assessment & validation
  - Achieved 292.5m/s on 13.5lbm fly away mass

Groundwork Laid for Extended Range 81mm Flight Testing

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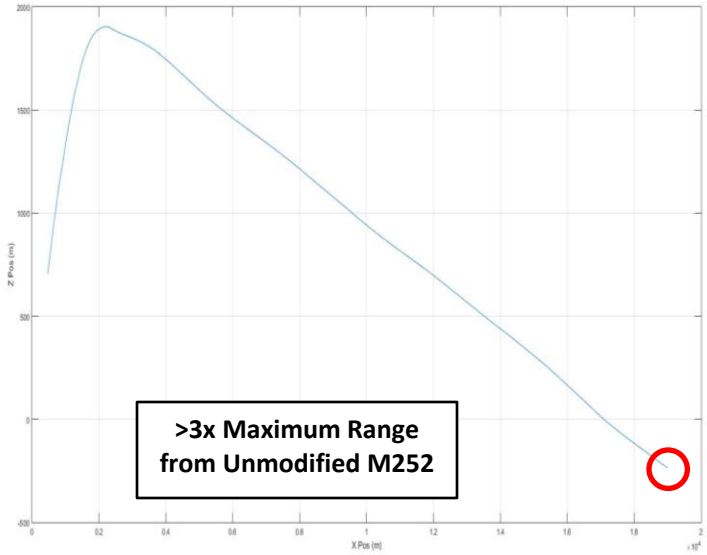
Flight Test #3 (FT3)

- ACERM Extended Range and Closed Loop Precision Guidance (8 Rounds)
  - Full ACERM Configuration
    - Diagnostic Telemetry Module (DTM) Warhead Surrogate
    - C/A GPS in DTM, C/A GPS (L3) in GNC
  - Validation of Full Airframe Design
    - Survivability, Closed Loop Guidance
  - Combined Test Objectives with unfunded FT2
    - Open Loop Guided Flight

- Results
  - 19.1km Maximum Range Glide
    - GPS Navigation to Hold Line-of-Fire, ERMA Propellant (290m/s)
    - ***Record for 81mm Maximum Range***
  - GPS Guide-to-Hit at 13.7km
    - 1.7m and 5.3m miss distances
    - ERMA Propellant – Reduced Charge (243 m/s)
    - ***Record for 81mm Precision Delivery***
  - LCSS track on Designated Target (Ride-Along)
    - Using AN/PEQ15 JTAC-LTD



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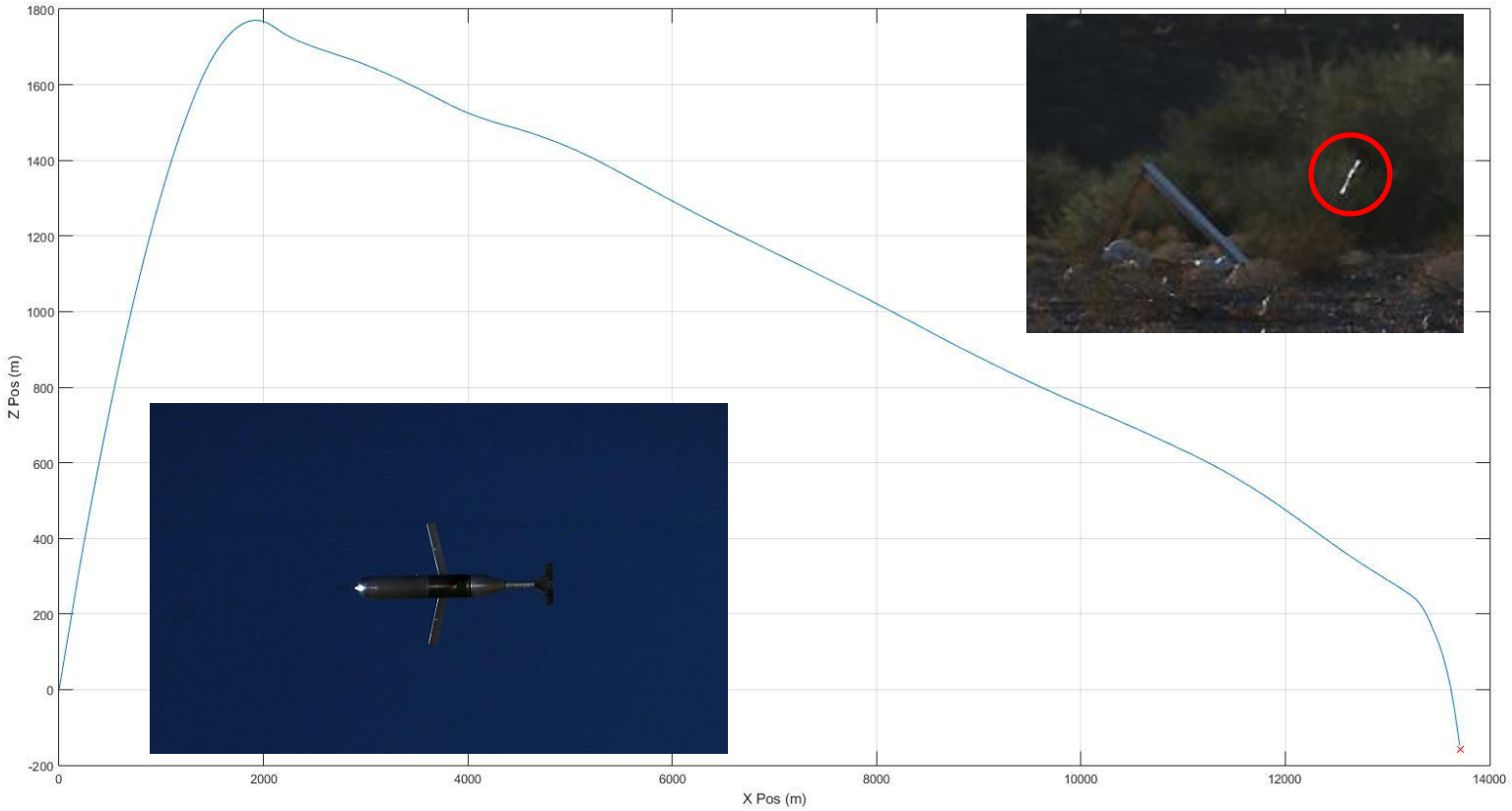
ACERM FT3 – GPS Guide-to-Hit

Range vs. Altitude



1.7m Miss @ 13.7km target – Reduced Launching Charge (243m/s)

(Target altitude below gun position)

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Flight Test #3.5 (FT3.5)

- ACERM Reliability Upgrade Engineering Test (5 Rounds)
  - Same Configuration at FT3 with Reliability Enhancements
- Results
  - 22.6km Maximum Range Glide
    - GPS Navigation to Hold Line-of-Fire, ERMA Propellant (290m/s)
    - ***NEW Record for 81mm Maximum Range***
  - GPS Guide-to-Hit at 16.7km with Trajectory Shaping
    - 6.7m miss distance, 87.5 deg AOF
    - ***NEW Record for 81mm Precision Delivery***

FT4 Test Scheduled for Jun/Jul ’17
SAL Guidance Against Static & Moving Targets

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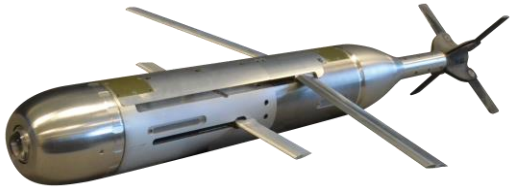
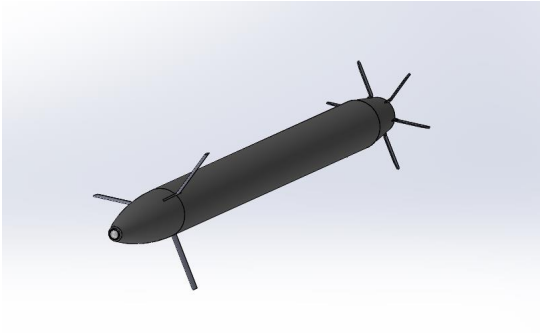
Conclusions

- E3C Program Researching Next Generation of Expeditionary Guided Projectiles
  - 81mm ACERM
  - 155mm MTAR
  - Future 60mm Precision Mortar



- Supporting Technologies Key to Enabling Future Capabilities
  - Miniature Mission Setter (MMS)
  - Low-Cost SAL Seeker (LCSS)



- Flight Test Program Proves Revolutionary Capabilities of Next Generation Guided Projectile Concepts

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- Questions?

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