ARMAMENT SYSTEMS & TECHNOLOGIES FOR THE FCS/OBJECTIVE FORCE

NDIA FIREPOWER CONFERENCE
20 JUNE 2001

Frank Hartline
Senior Business Development Manager
Raytheon Guided Projectiles

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OUTLINE

RMS Technologies for FCS Armaments **Rodger Elkins**

FCS Emerging Requirements
RMS Technical Programs & Technologies
Examples: MRAAS Ammo Suite & Netfires

Guided Projectiles for the FCS Objective Force **Frank Hartline**

Guided Projectiles in the US Army Transformation
Excalibur Program Overview
XM982: Technology carrier for FCS guided projectiles

Netfires **Paul Lehner**

Netfires Program Overview
Netfires in the FCS/Objective Force

NetFires

- XM982 Excalibur Precision-Guided Projectile
  - Modernizes **Legacy Force** platforms
  - Transforms **Interim Force** fire support
  - Enables **Objective Force** transformation
- Provides high lethality, long range dominance with low collateral damage/logistics burden
- Returns Field Artillery to the Close Fight
- Matures GP technologies for MRAAS/FCS
  - gun-hardened projectile guidance electronics
  - Leverages the digital battlefield for FCS
  - 3-6X light platform battlefield effectiveness

Excalibur Description

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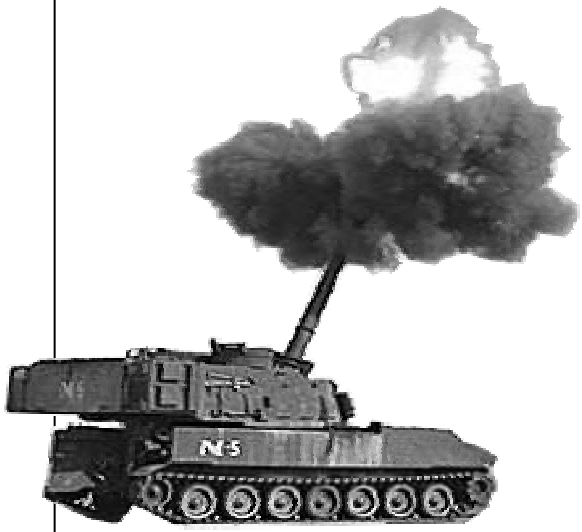
UNITARY

SFM

DPICM



Family of Fire & Forget GPS/IMU Guided Projectiles

Compatible with Digital 155mm Howitzers

Precision Accuracy (<10 m CEP w/ Unitary)
Independent of Range

- Paladin & JLW155: 6 to 37Km
- Crusader: 6 to 50Km

Single Projectile Design Accommodates Multiple Payloads

Supports Legacy, Interim, & Objective Force

Excalibur XM982
Operational Sequence

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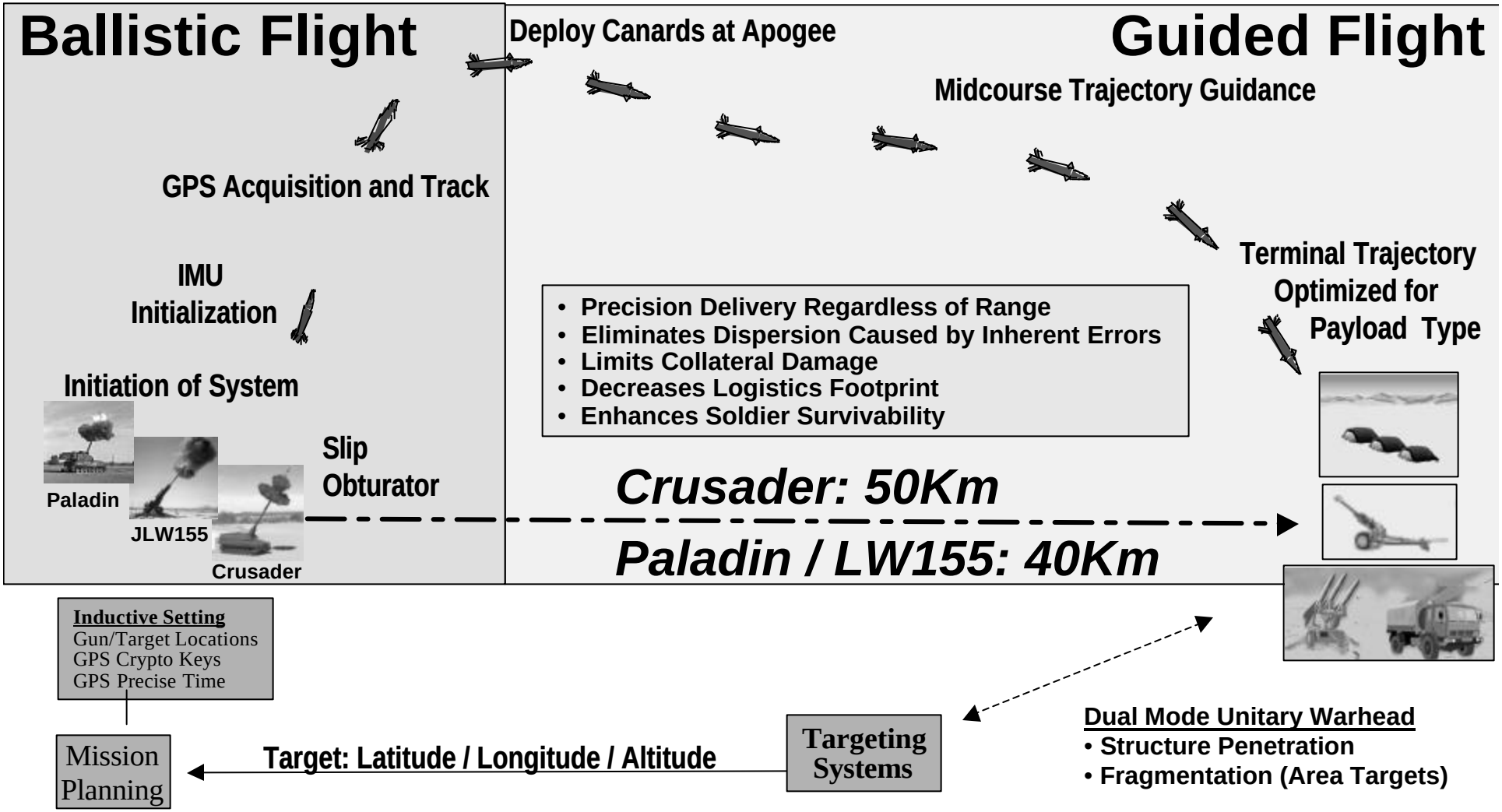

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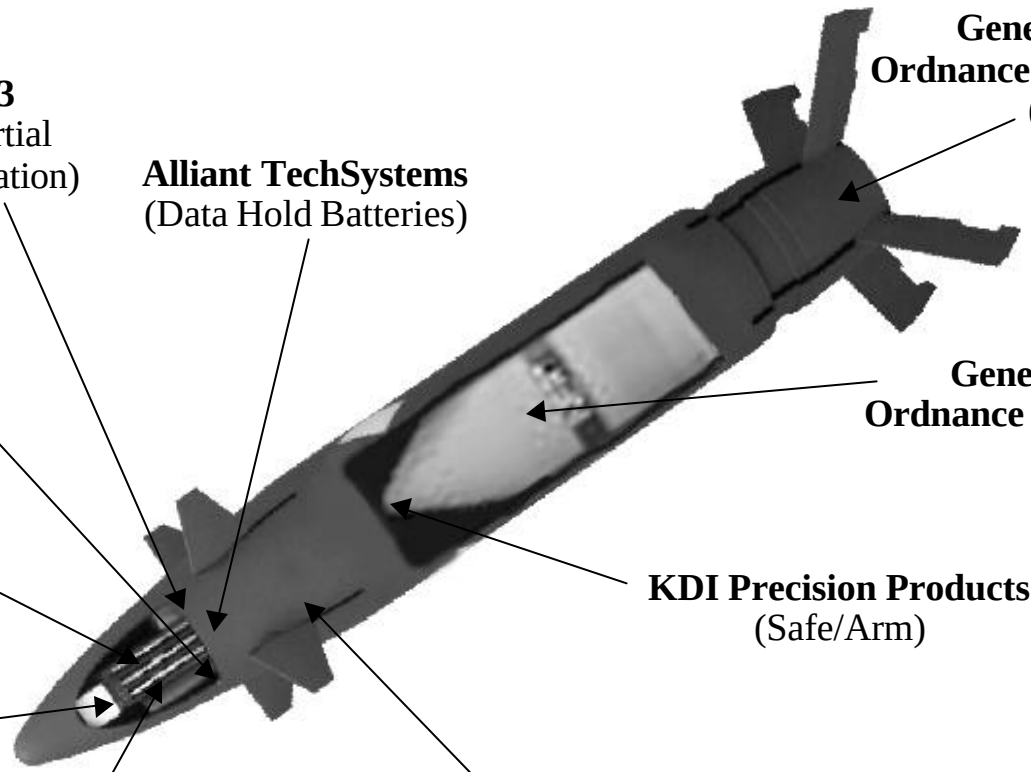
Industry Team



GOVERNMENT	LOCATION	ROLE
PEO-GCSS, OPM-ARMS	Picatinny Arsenal, NJ	Functional Management
Excalibur Product Office	Picatinny Arsenal, NJ	Program Management
ARDEC	Picatinny Arsenal, NJ	Technical Support
TSM-Cannon	Ft.Sill, OK	User Representative
DCMC-Raytheon	Tucson, AZ	Contractual Support

CONTRACTOR	LOCATION	ROLE
Raytheon Missile Systems	**Tucson, AZ**	**System Integrator**
General Dynamics - OTS	Redmond, WA	Payload Dispense
	St. Petersburg, FL	Structure and Payload
	Red Lion, PA	Airframe
L3 (Allied Signal)	Redmond, WA	Inertial Measuring Unit
Alliant Techsystems	Horsham, PA	Initialization/Fuze
Versatron (Primex)	Healdsburg, CA	Control Actuator Sys
L3 (Interstate Electronics)	Anaheim, CA	GPS Guidance
Ball Aerospace	Broomfield, CO	TM Antenna
Day & Zimmerman	Parsons, KS	Submunition
Eagle Picher	Joplin, MO	System Battery
KDI Precision Products	Cincinnati, OH	Safe and Arm Device
Micropulse	Camarillo, CA	GPS Antenna

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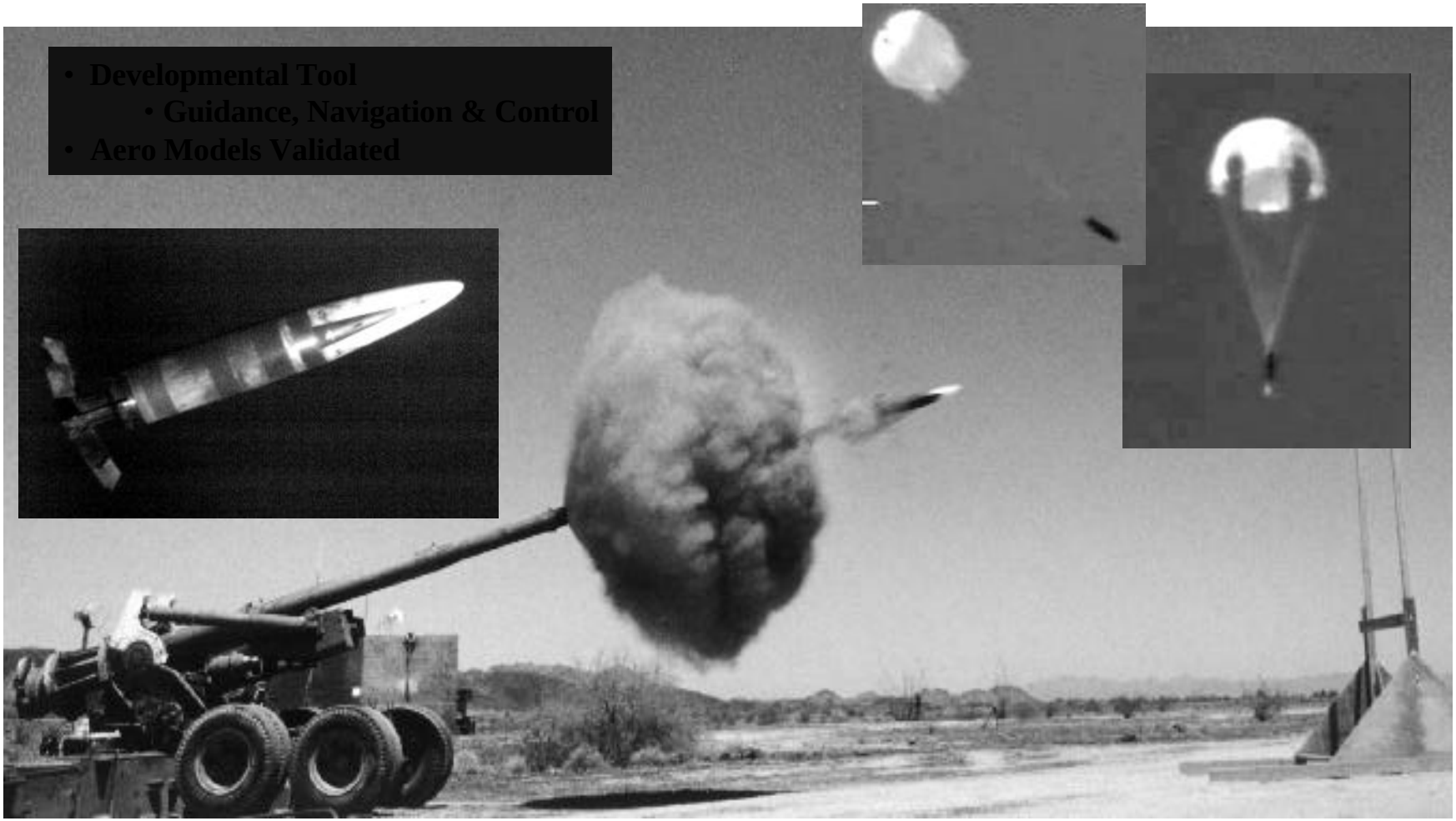
Soft Recovery Projectile Validated!



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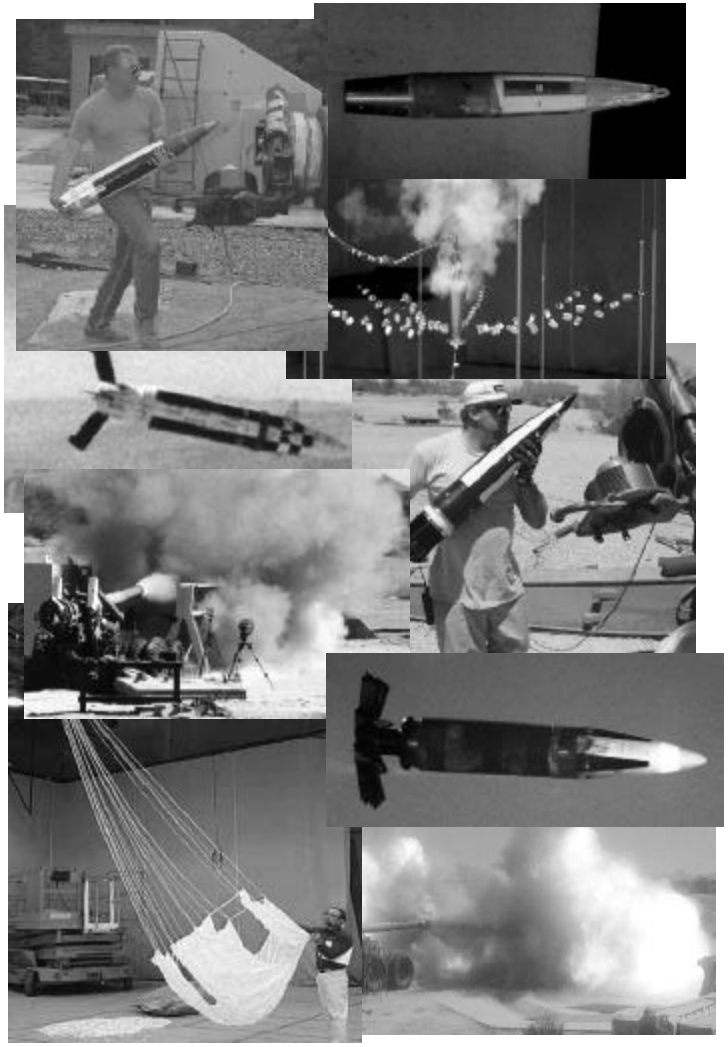
Test Results



Despinning Obturator	✓
Payload Static Dispense	✓
GEU & CAS Structure	✓
Airframe Joints	✓
Base Structure Eval	✓
Soft Recovery System	✓
Tactical Base Structure	Sep 01
Electronics Gun Hardening	Dec 01

The Benefits of Accuracy

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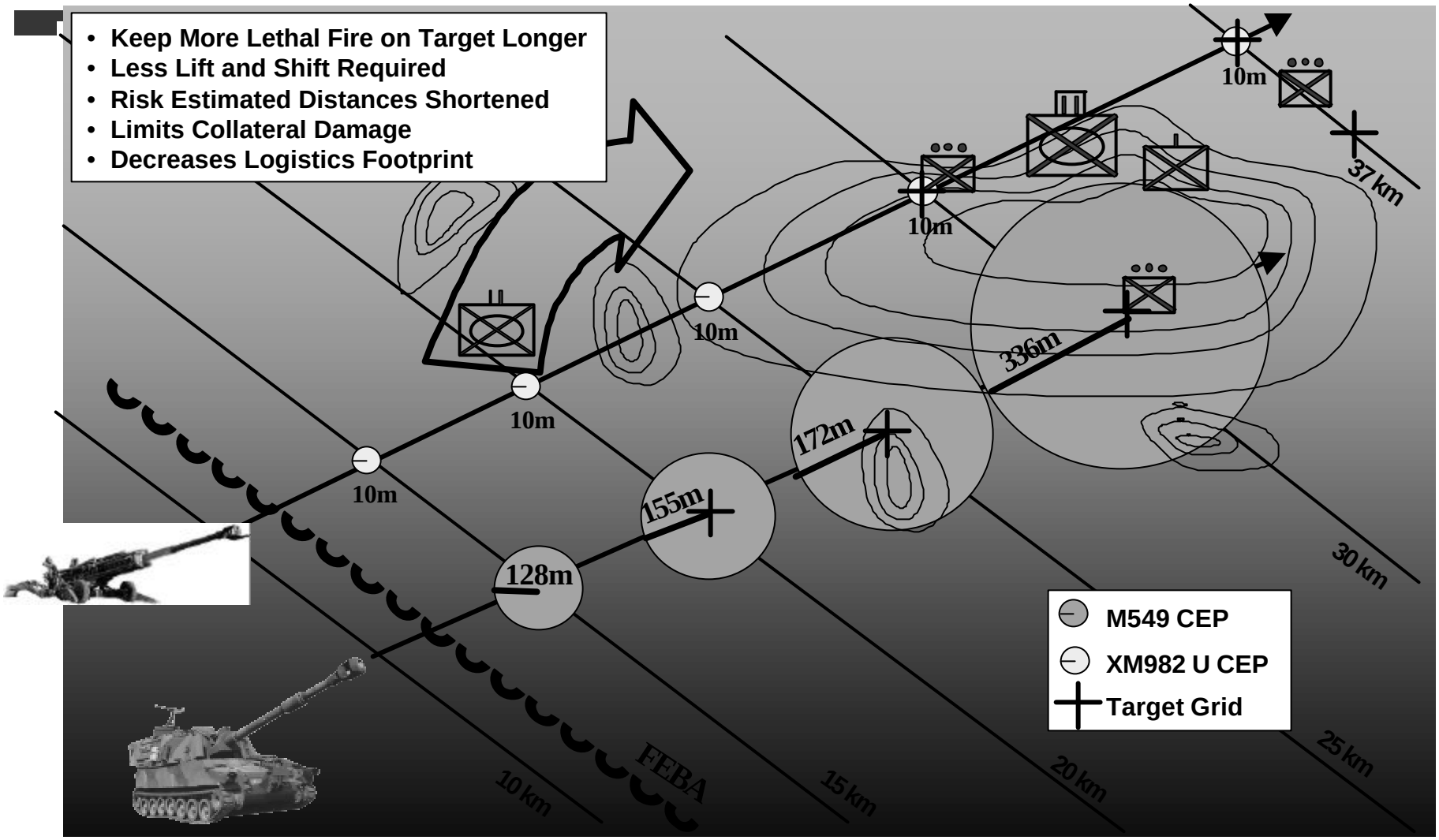

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ARTQUIK Results

Number of Volleys Required to Achieve
20% EFD Against the ORD Target

Excalibur-DPICM

1 - volley

M864

25 km - **6** - volleys
20 km - **3** - volleys
15 km - **2** - volleys

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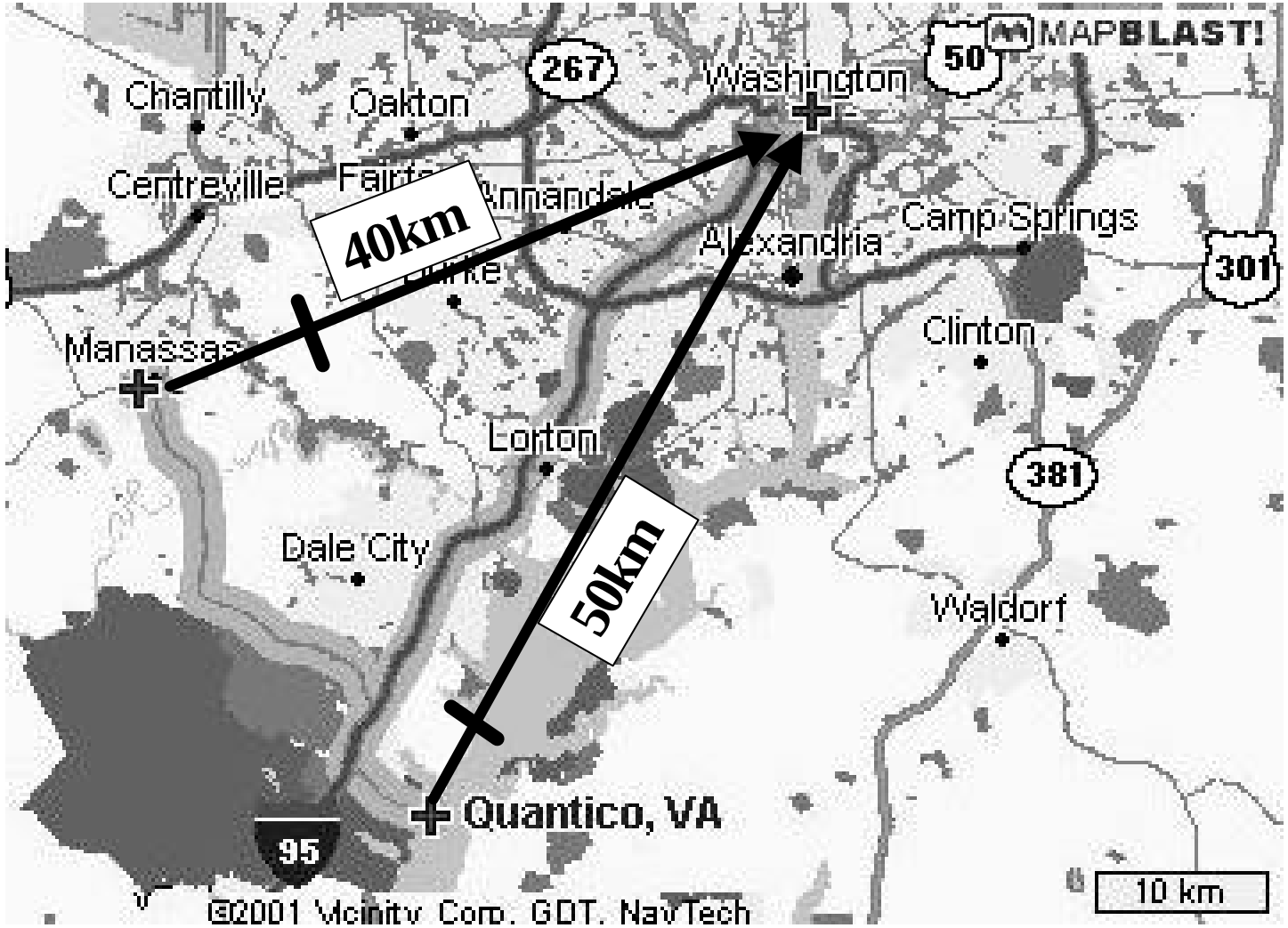
The Area of Operations



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The Target Area

20m X 20m
Bunker
8” Reinforced Concrete

50m X 50m
Towed 152mm Howitzer w/ Crew

Target Location Error
10m

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M549A1 - Conventional 155mm HE

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XM982-U

8 - 40 km

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M549A1 - Conventional 155mm HE

R

XM982-U

8 - 40 km

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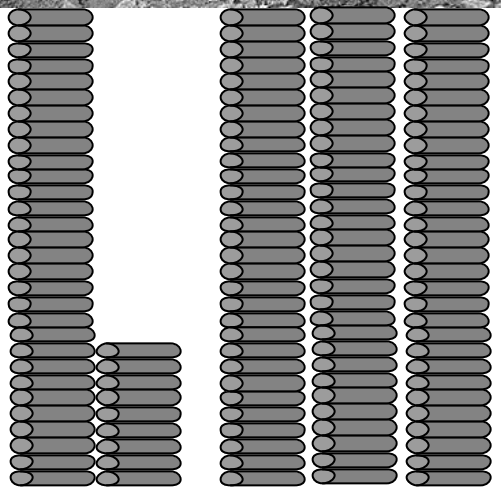
Logistical Implications



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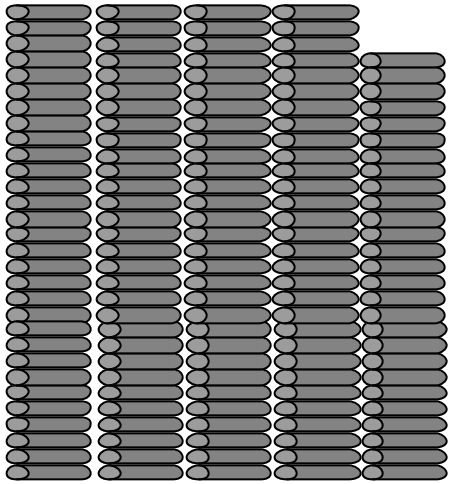
M549A1



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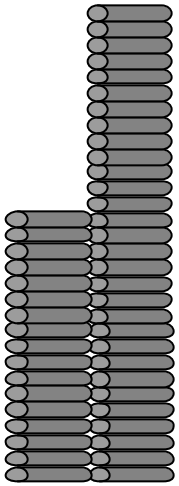
M549A1



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XM982

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XM982

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Guided Projectiles And The Close Fight

MG Carl Ernst, FA Journal, Sep-Oct 1999

NetFires

"…artillery and mortar fires must be able to support maneuver at much closer ranges than currently imagined."

"(because of minimum safe distances) the maneuver commander must stop the firing of indirect systems long before it would be tactically prudent on the battlefield."

"…the issue (is) logistics. It will come down to a matter of trucks and projectiles."

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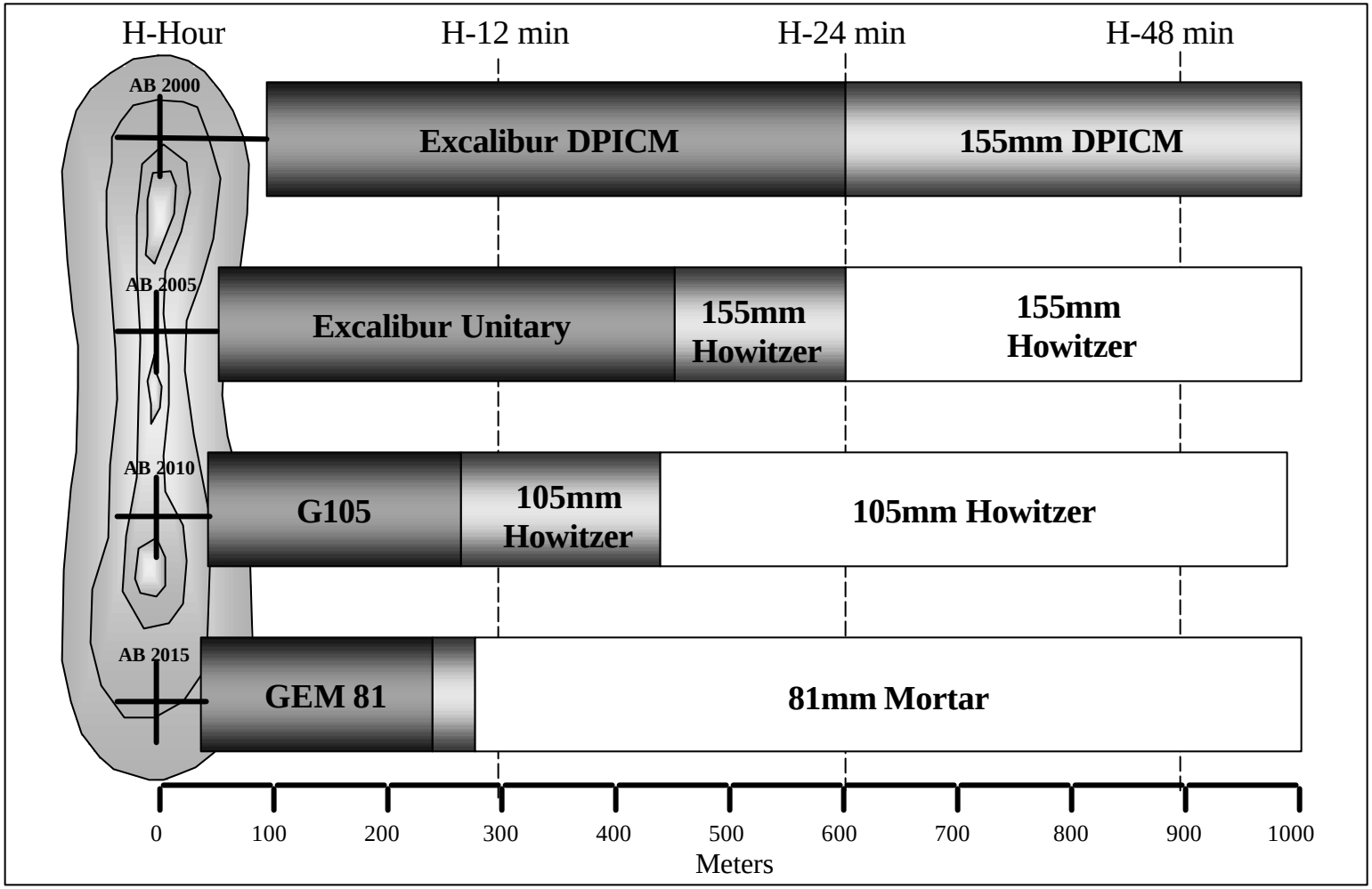
Guided Projectiles And The Close Fight

Echelon Fires for the Light Infantry Attack/Defense*



* Close Fire Support (RED, 0.1% PI, Max Range

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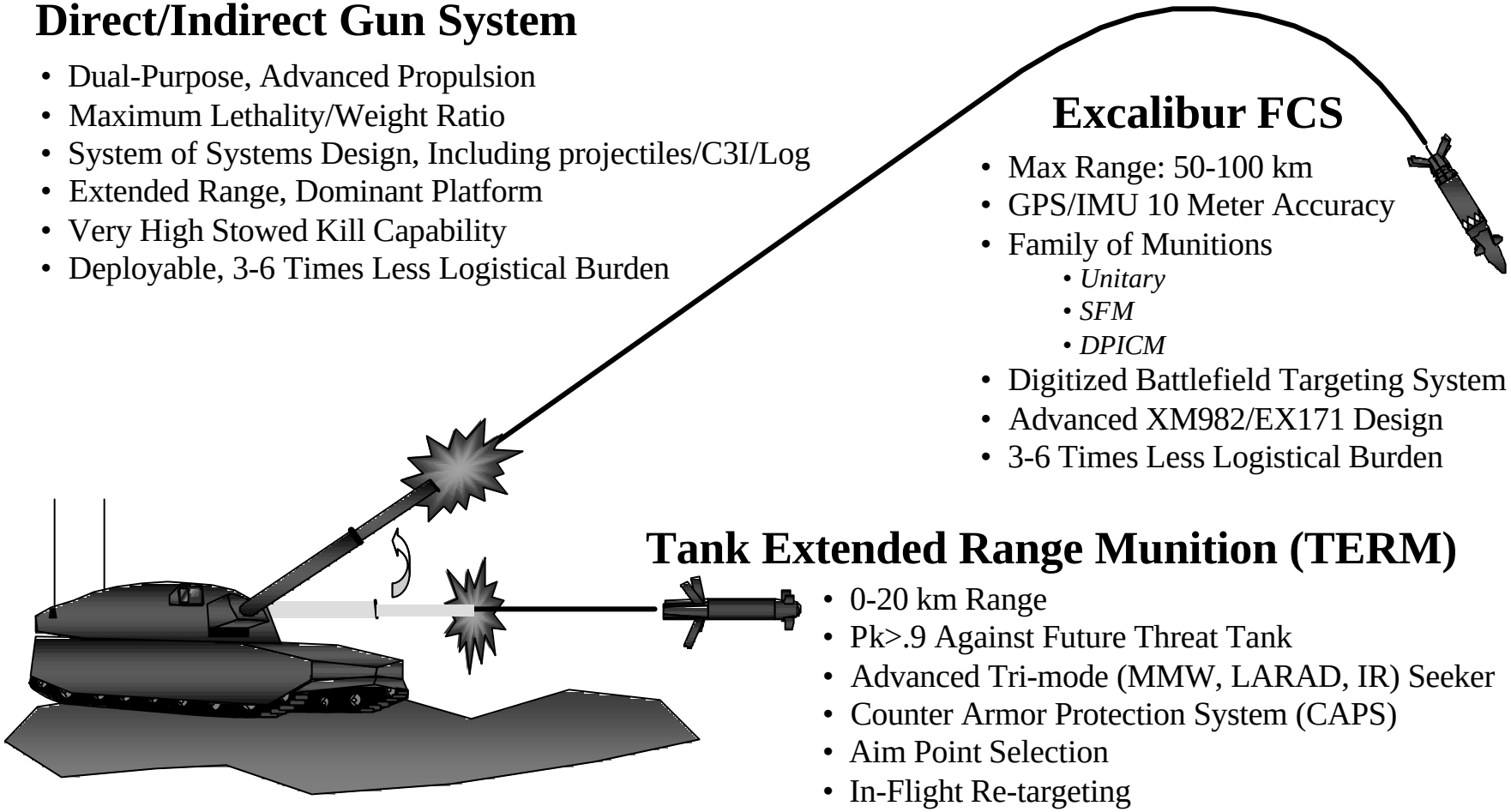
Future Combat System Guided Projectiles

Direct/Indirect Gun System

- Dual-Purpose, Advanced Propulsion
- Maximum Lethality/Weight Ratio
- System of Systems Design, Including projectiles/C3I/Log
- Extended Range, Dominant Platform
- Very High Stowed Kill Capability
- Deployable, 3-6 Times Less Logistical Burden

Excalibur FCS

- Max Range: 50-100 km
- GPS/IMU 10 Meter Accuracy
- Family of Munitions
  - *Unitary*
  - *SFM*
  - *DPICM*
- Digitized Battlefield Targeting System
- Advanced XM982/EX171 Design
- 3-6 Times Less Logistical Burden



Tank Extended Range Munition (TERM)

- 0-20 km Range
- Pk>.9 Against Future Threat Tank
- Advanced Tri-mode (MMW, LARAD, IR) Seeker
- Counter Armor Protection System (CAPS)
- Aim Point Selection
- In-Flight Re-targeting
- 3-6 Times Less Logistical Burden!

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Summary

XM982 Excalibur Precision-Guided Projectile

- **Modernizes** Legacy Force **platforms**
- **Transforms** Interim Force **fire support**
- **Enables** Objective Force **transformation**
- **Provides high lethality, long range dominance with low collateral damage/logistics burden**
- **Returns Field Artillery to the Close Fight**
- **Matures GP technologies for MRAAS/FCS**
  - **gun-hardened projectile guidance electronics**
  - **Leverages the digital battlefield for FCS**
  - **3-6X light platform battlefield effectiveness**

Weapons Guidance Technologies for the FCS/ Objective Force

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Agenda

- What Weapon Capabilities are Needed and Why
- Guidance Options for Precision Indirect Fire
- Missile Seeker - C4I Capabilities Trade Off
- Seeker Technology Options
- IIR
- LADAR
- Multi-Mode
- Plans for the Future

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What Weapon Capabilities are Needed and Why

- Precision Indirect Fire
- Low Cost
- Transportable
- Multi-Role Capable
- Avoidance of Collateral Damage
- Platform Survivability
- Affordability
- Minimize Time to In-Theatre Operational Capability
- Logistics Minimization and Increased Utility
- Limitation to Prosecution of Combatants / Political Considerations

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Guidance Options for Precision Indirect Fire

▪ GPS	▪ Ok for Fixed Targets, Relocatable Targets With Data Link, Susceptible to Jamming
▪ Inertial Only	▪ Expensive
▪ GPS/Inertial	▪ Increased Accuracy and Lowered Jamming Susceptibility vs GPS
▪ Seeker with ATR	▪ Necessary for Movers / Relocatables Assuming Slow/no Real Time Data Link

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Missile Seeker - C4I Capabilities Trade Of

- Seeker Capability, Functionality, Cost Can Be Offset by Capabilities Contained in the C4I Infrastructure
  - Minimization of Target Location Uncertainty Needs to Traded off With Seeker Performance Requirements in the Following Areas:
    - Probability of Correct ID vs Detection of Target Like Objects
    - Search Rate, Field of Regard
    - Sensitivity
  - Increased Sensor to Shooter Latencies and Increased Missile Flight Time Lead to Increased Location Uncertainty
  - In-Flight Targeting Updates Sent to Missile Will Reduce Required Seeker Capability

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Seeker Technology Options

- Imaging Infrared
  - Limited ATR Capability vs Mobile Targets Compatible With Minimal Target Location Uncertainty
  - Target Signature Limitations
- LADAR, SAR, Multi-Mode
  - Increased ATR Capability Compatible With Increased Targeting Uncertainty
  - Increased Cost
  - LADAR Offers a Robust ATR Solution - Lack of All-Weather Capability Is an Issue
  - Doppler Beam Sharpening or SAR Processing Is Required for MMW (Either Stand Alone or As a Part of a Multi-Mode System) to Be Effective - Processor Throughput Intensive, Requires Offset Trajectory During ATR

Comparison Of Seeker Technologies

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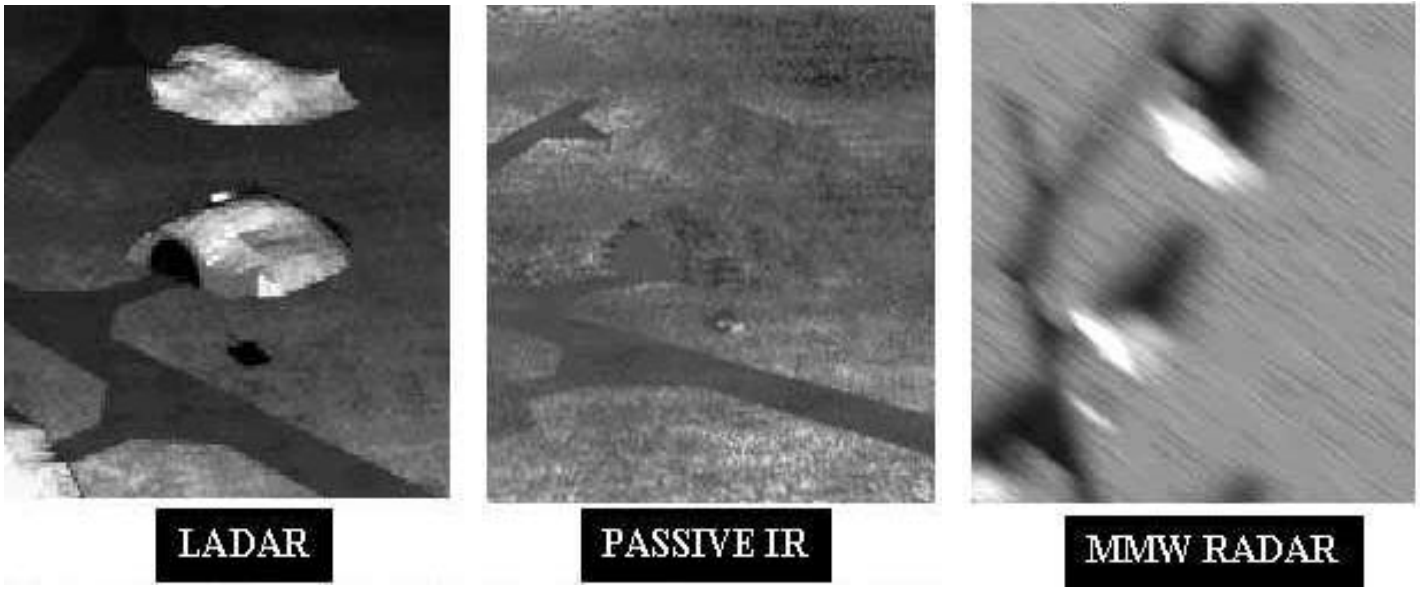
Irma - Multi-Sensor Signature Prediction Model



Above Are Synthetic Images Rendered From the Same Scene, a Bunker With the Door in Front and a Tank Parked Beside It. These Registered Scenes Were Generated From the Same Viewpoint, All Looking at Common Geometry Objects in the Field of View.
Source: Air Force Research Labs - Munitions Directorate
http://www.munitions.eglin.af.mil/public/mngg/irma/irma.html

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Imaging Infrared Seekers

- Diffraction Limits for Tactical Missiles Drive Achievable Resolution Making ATR Hard to Accomplish Much Beyond 1km Slant Range for Moving and Relocatable Targets (Assumes 6 Inch Diameter Seeker)
- Amount of Clutter and Target/Background Thermal Contrast Are Other Limiting Factors
- ATA With IIR for Moving and Relocatable Targets Has Only Been Shown to Work Where Target Location Is Sufficiently Small to Minimize False Alarms
  - Discrimination of the Target From Background Clutter Remains an Issue - White Sands Missile Range Is Especially Tough
- Recent Improvements in Uncooled FPA Sensitivity Have Made It Viable to Use These Arrays in Missile Seekers
  - Prime Advantage Is Low Cost
  - Limitations Include Reduced MTF, Longer Integration Times and Reduced Sensitivity As Compared to Cooled FPA's -

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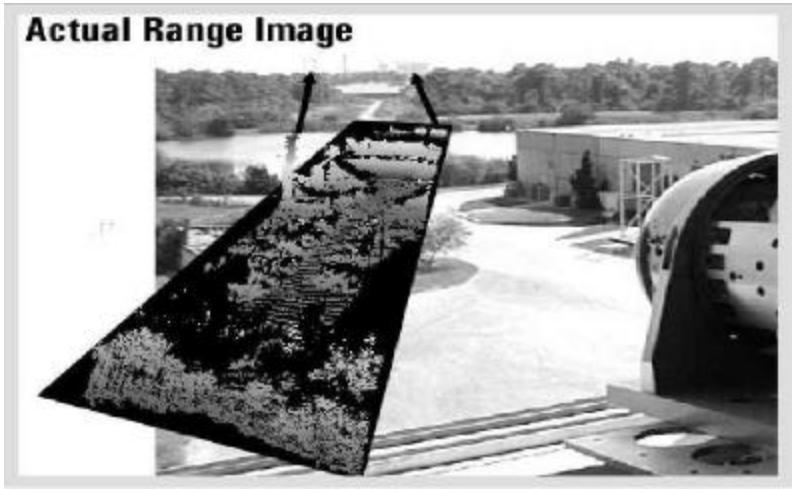
LADAR Seekers

- **Signature Stability**
  - Physical Dimensions of Target
  - Independent of Weather, Temperature
- **High Resolution and Data Rich**
  - 3-D Information (Angle-Angle-Range)
  - Reflectance As Discriminant
- **ATR Enabler - Robust Detection and Identification**
  - Size, Shape and Height Above Ground Eliminate Clutter
  - BDI Capable
  - Minimal Mission Planning
- **Enabling Technologies**
  - Solid State Lasers
  - Advanced Scanning Architectures
  - ATR Algorithms
- **Limitations**
  - Search Rate
  - Atmospherics: Fog & Clouds



- **Payoffs/Military Significance**
  - Precision Guidance W/ Aimpoint Selection
  - Limited Collateral Damage
  - Autonomous Operation
- **Being Pursued For**
  - NetFires LAM
  - Cruise Missiles
  - UAVs

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Multi-Mode Seekers

- Exploit Multi-Sensor Synergy

IIR
+ Finding Target Size Objects
- At Extended Ranges Non Target Objects Hard To Distinguish From True Targets

MMW
+ Discriminates Items with RCS Above Background (eg Metal Objects)
- False Targets Can Be Prevalent (Without Imagine SAR)

Combined Sensor
+ Finds Target Size Objects with RCS Consistent With Military Targets
+ Reduces False Alarms
+ Reduces Performance Required of Each Individual Mode

- Multi-Mode Candidates: IIR/MMW, LADAR/MMW, LADAR/IIR
- Enabling Technologies: Fusion Algorithms, High Throughput Processing, Low Cost Solid State RF Power, Uncooled IIR FPA's Flash LADAR, Electronically Scanned Arrays
- In Development for BAT P^3I and TERM

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Plans For The Future

Present	In -Work	Planned
Scanning LADAR	Flash LADAR	Dual Mode MMW / LADAR
Real Beam MMW	Low Cost MMW SAR	

Features:

- MMW Provides High Search Rate, Identifying Potential Targets For Interrogation By LADAR
- Flash LADAR Provides An Ability To Perform ATR On Selected Targets Of Interest At High Missile Velocities

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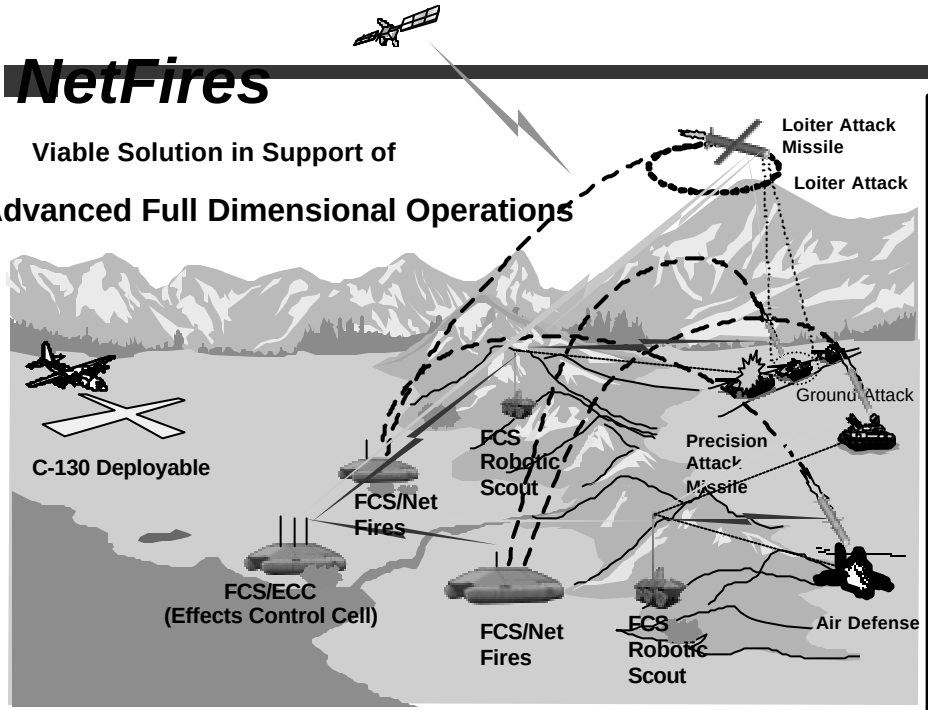
NetFires

Viable Solution in Support of

Advanced Full Dimensional Operations

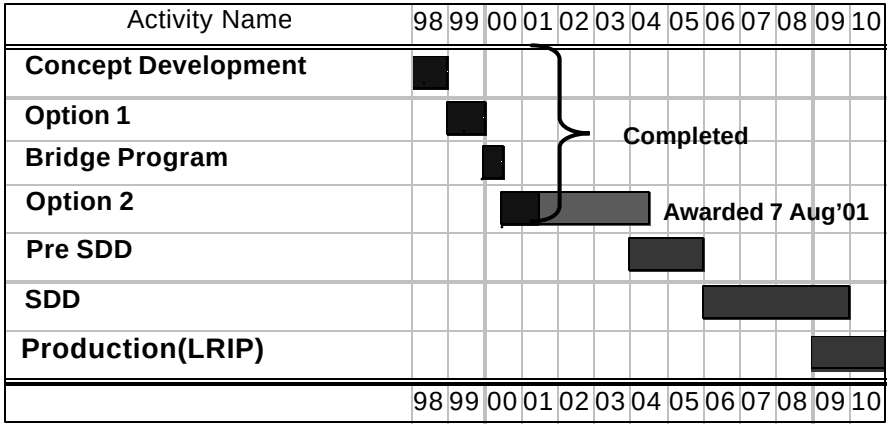


Objective: Design, development, and demonstration of affordable, containerized, platform independent indirect-fire weapon systems capable of performing a variety of missions such as ground attack, air defense, and surveillance, and which can be remotely fired and robotically deployed in a variety of military scenarios

Enabling Technologies:

- **Dual-mode SAL/Uncooled IIR Seeker**
- **LADAR Seeker**
- **Automatic Target Acquisition & Recognition**
- **Counter Active Protection System**
- **MEMS Inertial Measuring Unit**
- **GRAM/SAASM GPS**
- **Low-Cost Data Link**
- **Variable Thrust, Solid Propulsion (Pintle)**
- **Low Cost Turbojet Propulsion**

Schedule/Customer - DARPA/TTO



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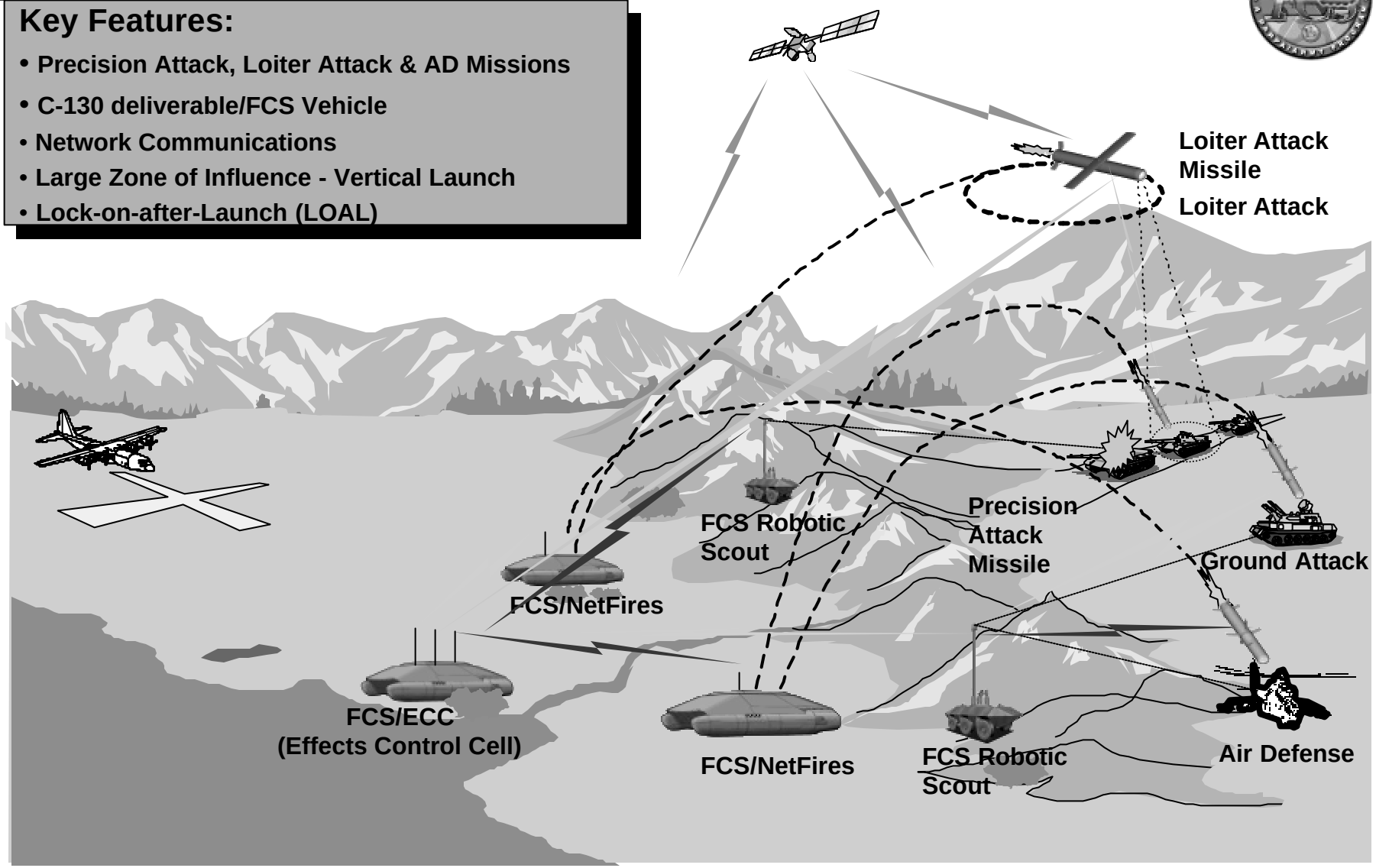
Key Features:

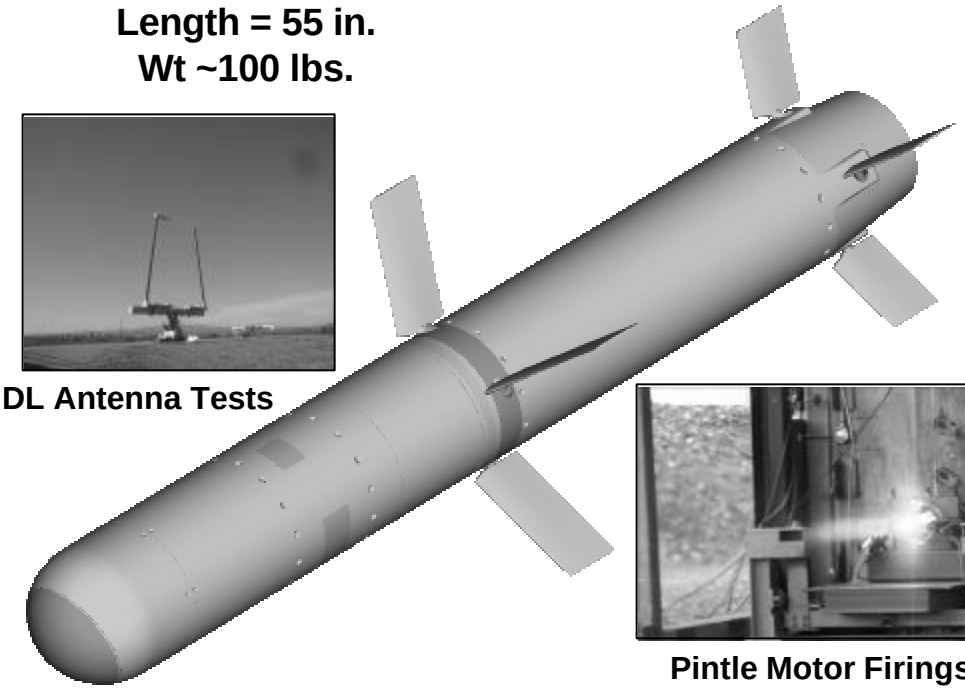
- Precision Attack, Loiter Attack & AD Missions
- C-130 deliverable/FCS Vehicle
- Network Communications
- Large Zone of Influence - Vertical Launch
- Lock-on-after-Launch (LOAL)



Precision Attack Missile (PAM)

Diam. = 7 in.
Length = 55 in.
Wt ~100 lbs.

DL Antenna Tests



Pintle Motor Firings

Seeker Tower Tests

Wind Tunnel Tests

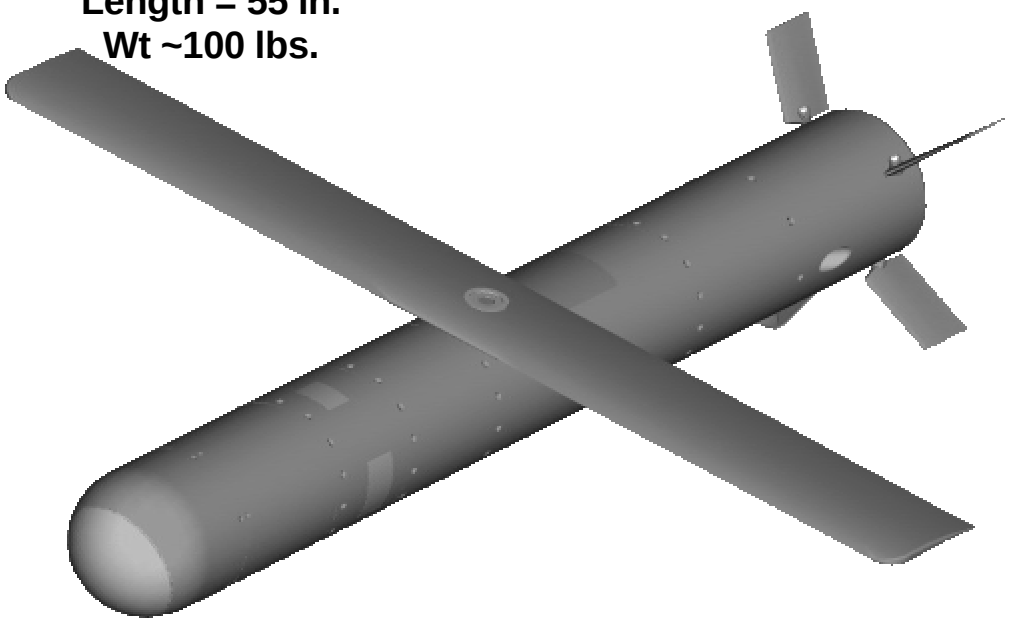
Status: **Preliminary design completed. Detailed design, fabrication/integration and demo in progress under Option 2**

Features:

- **Multi-mode SAL/UCIIR seeker with SAL, SAL cued IIR and IIR terminal guidance modes employing IIR ATA/ATR for search, target detection/acquisition and terminal guidance, high A/J GPS/INS navigation and CAPS ECM**
- **Network data link for in-flight targeting & BDI**
- **Indirect-Fire -- LOS and BLOS capable**
- **Hellfire equivalent warhead - multi-mode warhead - i.e. Heavy armor - personnel in field**
- **Solid Pintle rocket propulsion(variable) for vertical/controlled launch and fly out**
- **Modular design incorporating seeker/ processing, GNC, WH, propulsion, CAS and common folding wings & control fins**
- **Addition of RF Proximity Fuse for SAM application**

Loiter Attack Missile (LAM)

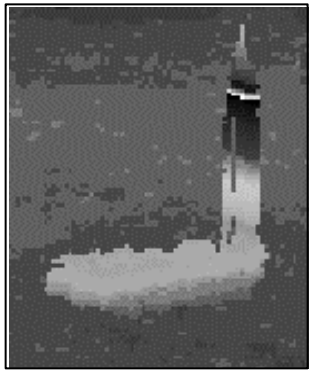
Diam. = 7 in.
Length = 55 in.
Wt ~100 lbs.



Status: **Preliminary design completed. Detailed design, fabrication/integration and demo in progress under Option 2**

Features:

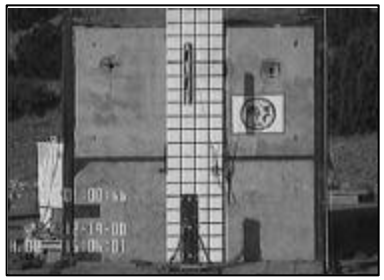
- **LADAR seeker with ATA/ATR for search, target detection and recognition and terminal guidance, High A/J GPS/INS navigation and CAPS ECM**
- **Network data link for Reconn, BDA and in-flight targeting/re-targeting**
- **Warhead for designated target destruction**
- **Low cost, swing wing offers simplicity and reliability**
- **Solid booster for launch for vertical launch and TJ-30 turbojet for high speed dash and fuel efficient loiter**
- **Modular design incorporating seeker/processing, GNC, WH, propulsion CAS and folding wing & control fins**



Captive Flight Tests

Wind Tunnel Tests

Container/Launcher Unit(C/LU) & Fire Control System(FCS)

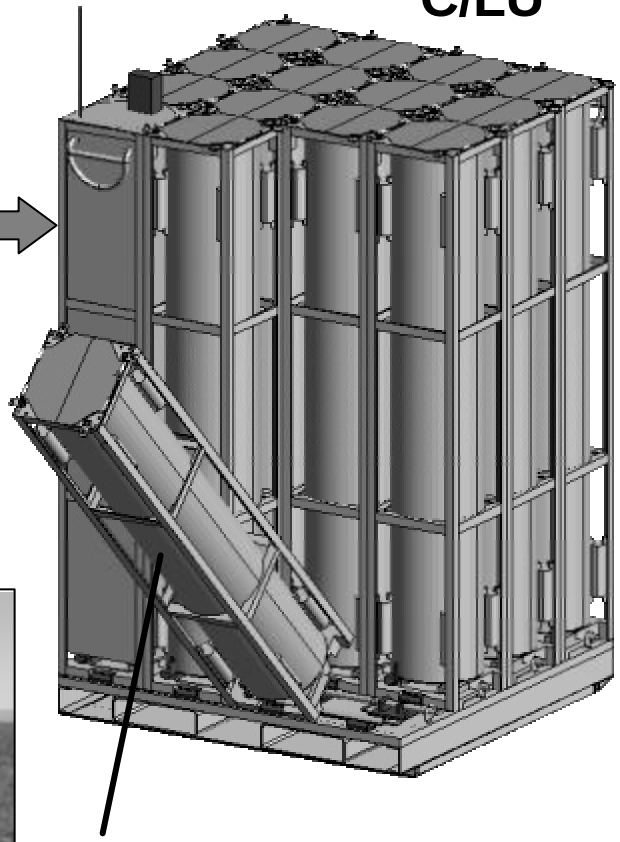


FCU

Launcher Compatibility Tests

HMMWV Compatibility

C/LU



Shipping/Storage/Launch Canister(SSLC)

Status: Preliminary design completed. Detailed design, fabrication/integration and demo in progress under Option 2

Features: Vertical launch/large of influence & non-platform specific:

- C-130 RO-RO aboard HMMWV
- Break-apart elements are two man lift compliant - Modular assembly
- Total assembled weight:: 2500 lbs - FCU + 15 SSLCs...PAM/LAMs
- Fire Control Unit (FCU) is self locating and launch compatible with PAM, LAM & ECC - Network data link
- 30 day unmanned/autonomous operation
- Transportation/Deployment :
  - 20’ Standard ISO Container -Reduced LCC
  - Fixed wing
  - Rotary wing
  - Parachute Drop

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Summary

- Raytheon's NetFires Program is on schedule..Completion May'04
- Both Precision Attack and Loiter Attack Missiles will be demonstrated via a platform independent/vertical launcher
- Stay tuned for progress reports