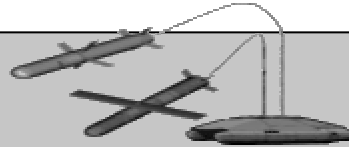


Raytheon



NetFires



ARMAMENT SYSTEMS & TECHNOLOGIES
FOR THE
FCS/OBJECTIVE FORCE

**NDIA FIREPOWER CONFERENCE
20 JUNE 2001**

Frank Hartline
Senior Business Development Manager
Raytheon Guided Projectiles

Report Documentation Page

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	Program Element Number	
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	Work Unit Number	
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Report Classification unclassified	Classification of this page unclassified	
Classification of Abstract unclassified	Limitation of Abstract UU	
Number of Pages 40		

OUTLINE

R

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 Hartline

Frank

Guided Projectiles in the US Army Transformation

Excalibur Program Overview

XM982: Technology carrier for FCS guided projectiles

Netfires Lehner

Paul

Netfires Program Overview

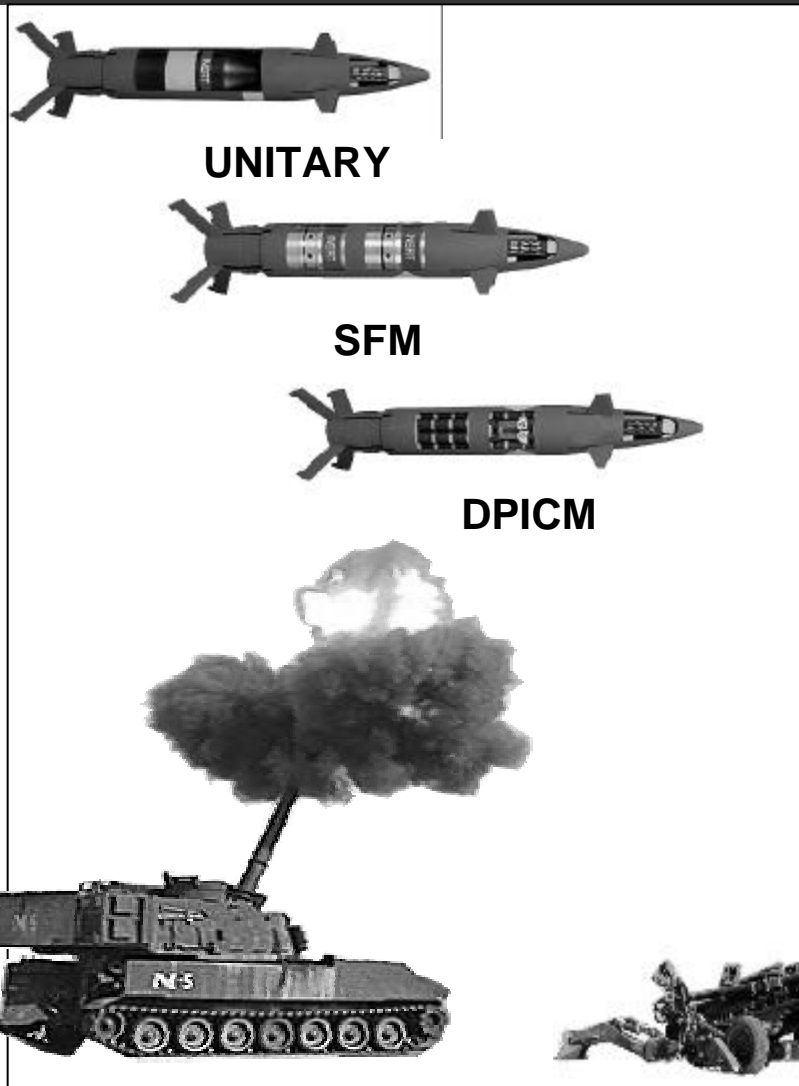
Netfires in the FCS/Objective Force



- 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

R



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

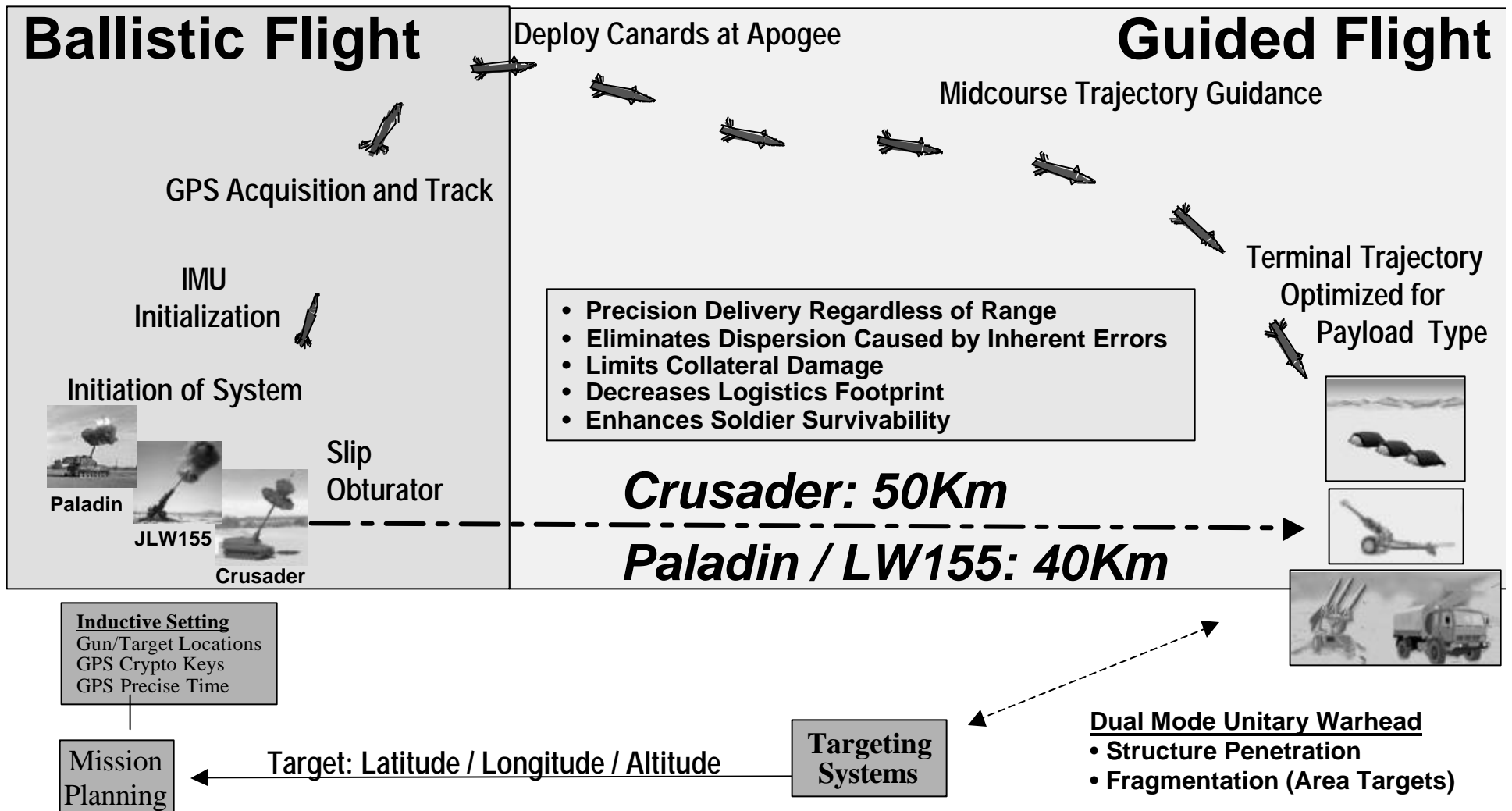
Crusader: 6 to 50Km

Single Projectile Design Accommodates Multiple Payloads

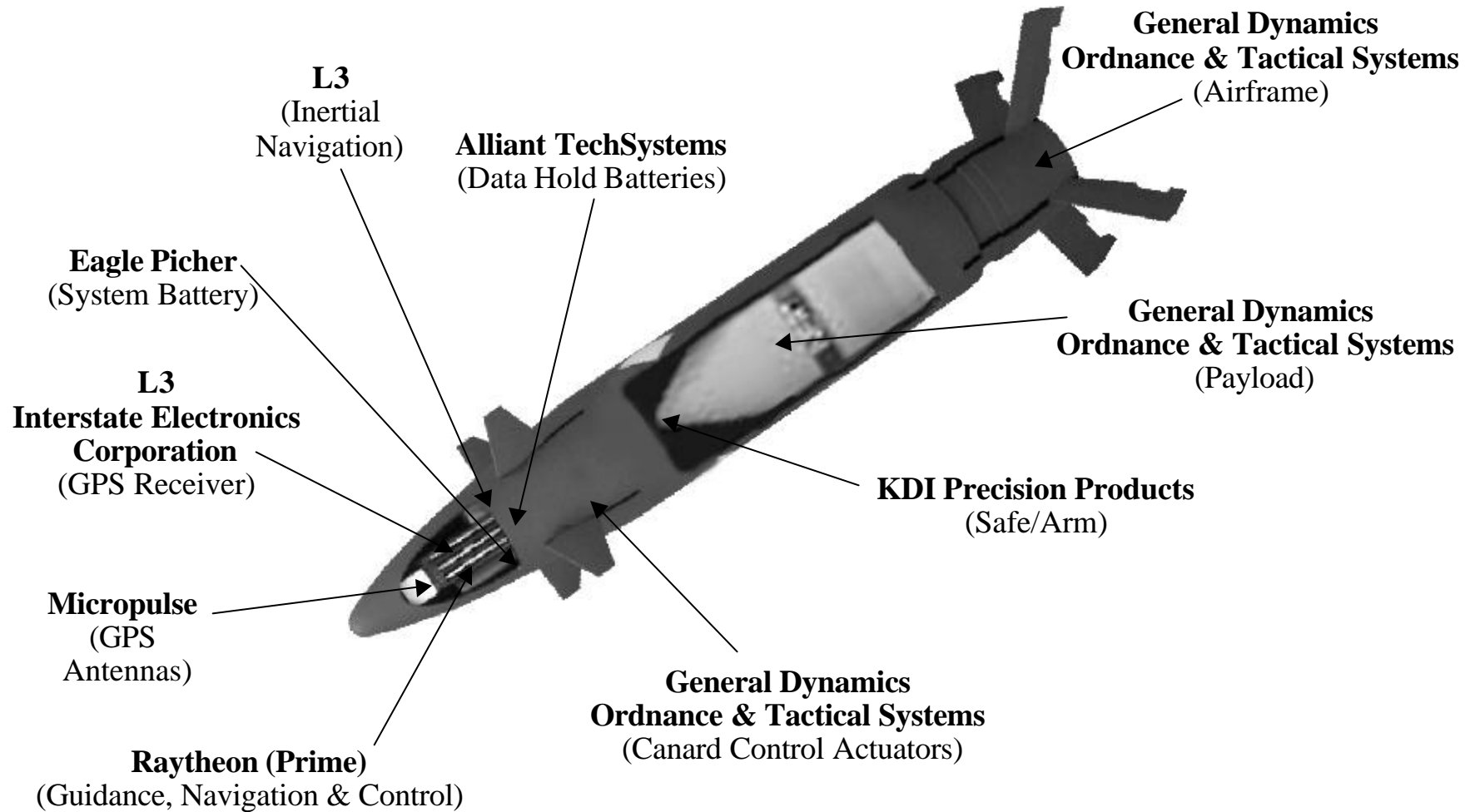
Supports Legacy, Interim, & Objective Force

Excalibur XM982 Operational Sequence

R



Industry Team





GOVERNMENT

PEO-GCSS, OPM-ARMS
Excalibur Product Office
ARDEC
TSM-Cannon
DCMC-Raytheon

LOCATION

Picatinny Arsenal, NJ
Picatinny Arsenal, NJ
Picatinny Arsenal, NJ
Ft.Sill, OK
Tucson, AZ

ROLE

Functional Management
Program Management
Technical Support
User Representative
Contractual Support

CONTRACTOR

Raytheon Missile Systems
General Dynamics - OTS

L3 (Allied Signal)
Alliant Techsystems
Versatron (Primex)
L3 (Interstate Electronics)
Ball Aerospace
Day & Zimmerman
Eagle Picher
KDI Precision Products
Micropulse

LOCATION

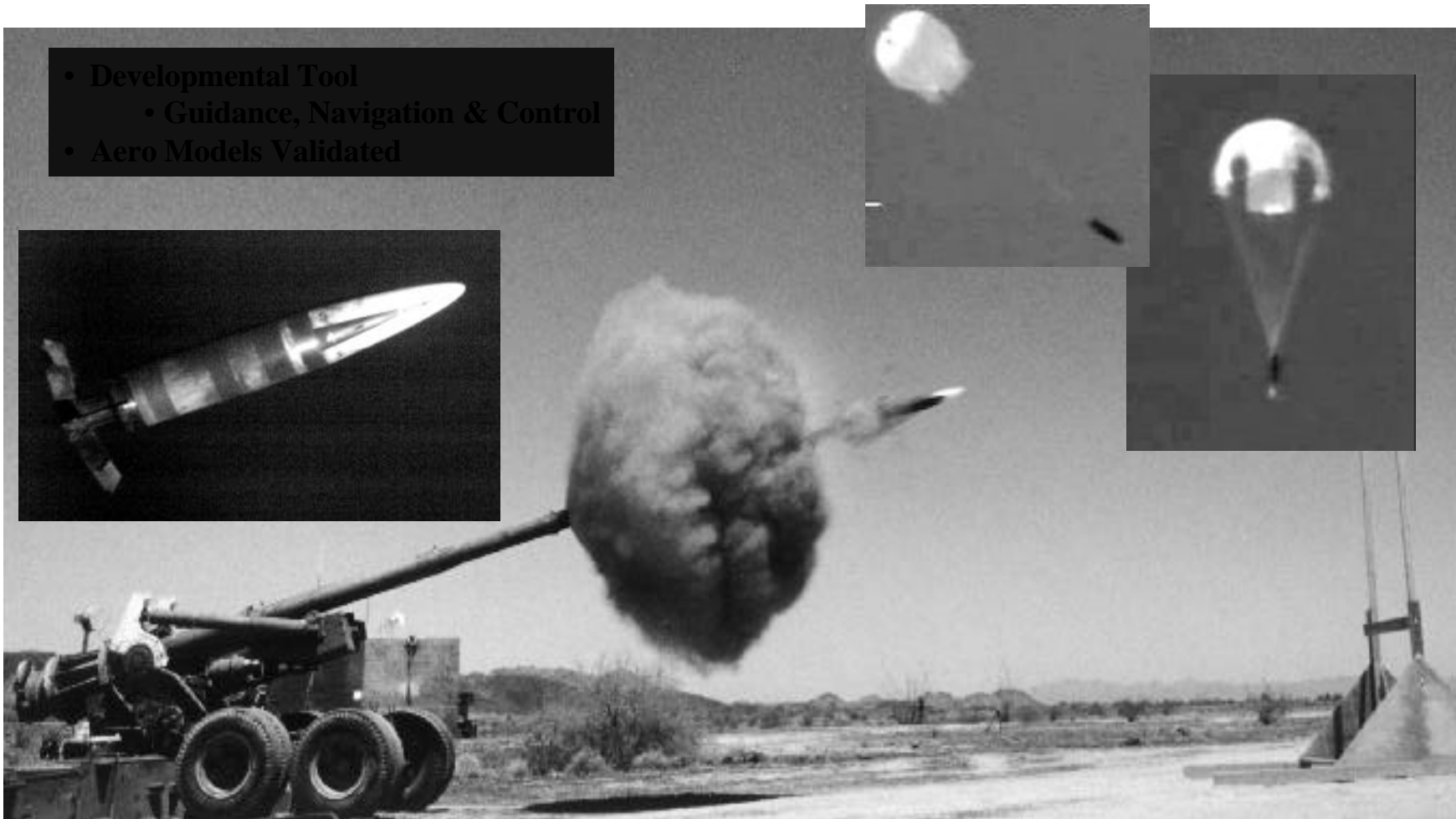
Tucson, AZ
Redmond, WA
St. Petersburg, FL
Red Lion, PA
Redmond, WA
Horsham, PA
Healdsburg, CA
Anaheim, CA
Broomfield, CO
Parsons, KS
Joplin, MO
Cincinnati, OH
Camarillo, CA

ROLE

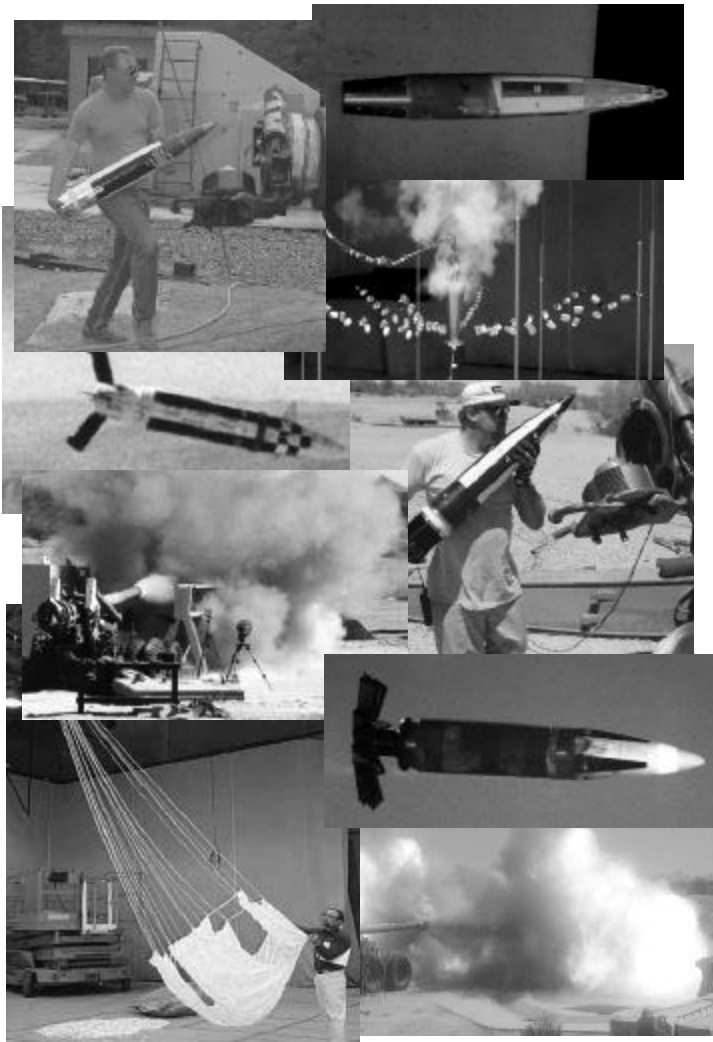
System Integrator
Payload Dispense
Structure and Payload
Airframe
Inertial Measuring Unit
Initialization/Fuze
Control Actuator Sys
GPS Guidance
TM Antenna
Submunition
System Battery
Safe and Arm Device
GPS Antenna

Soft Recovery Projectile Validated!

- Developmental Tool
 - Guidance, Navigation & Control
 - Aero Models Validated



Test Results



Despinning Obturator



Payload Static Dispense



GEU & CAS Structure



Airframe Joints



Base Structure Eval



Soft Recovery System



Tactical Base Structure

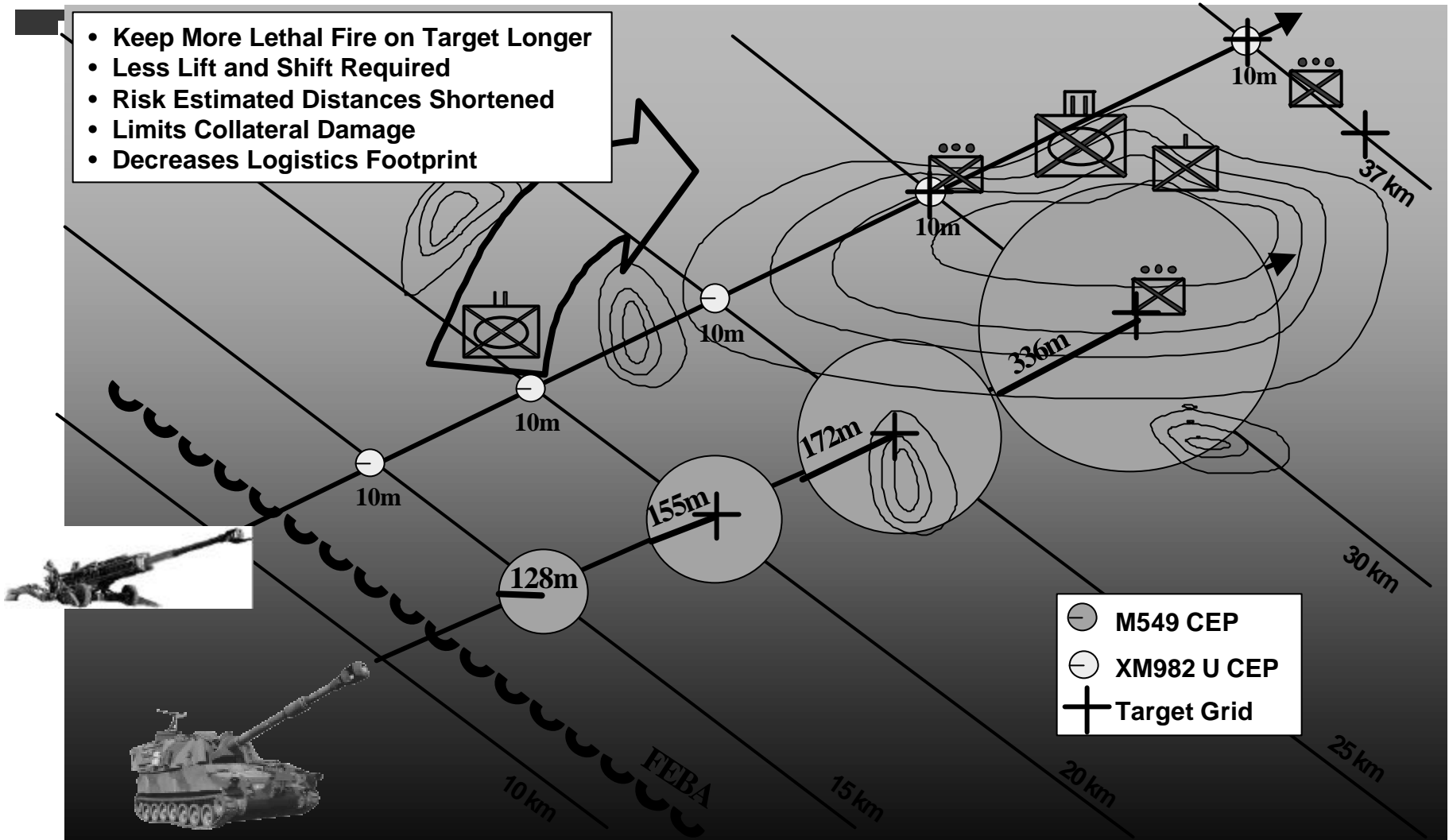
Sep 01

Electronics Gun Hardening

Dec 01

The Benefits of Accuracy

- Keep More Lethal Fire on Target Longer
- Less Lift and Shift Required
- Risk Estimated Distances Shortened
- Limits Collateral Damage
- Decreases Logistics Footprint



ARTQUIK Results

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

Excalibur-DPICM

1 - volley

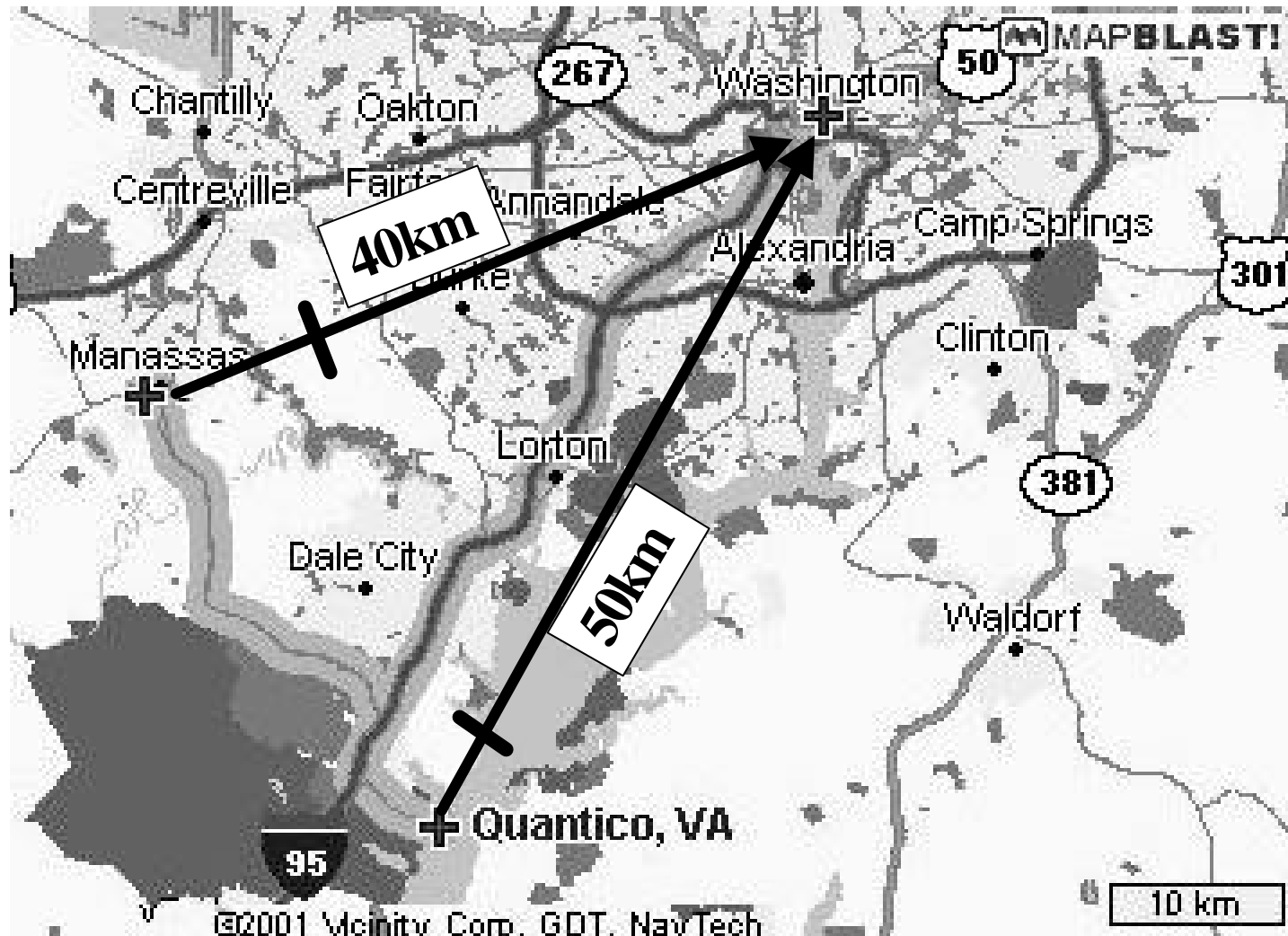
M864

25 km - **6** - volleys

20 km - **3** - volleys

15 km - **2** - volleys

The Area of Operations



The Target Area



20m X 20m

Bunker

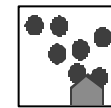
8" Reinforced Concrete



50m X 50m

Towed 152mm

Howitzer w/ Crew

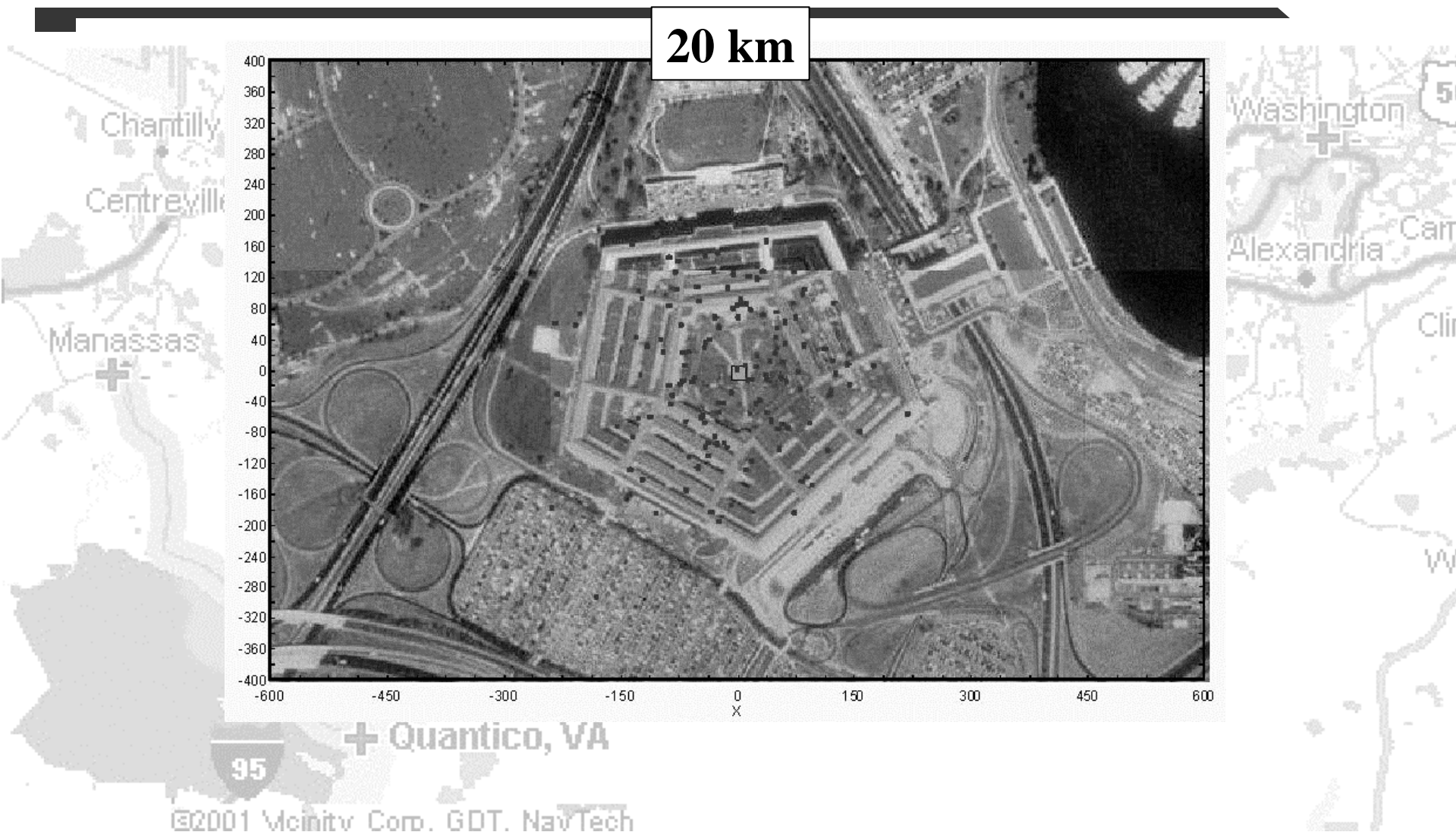


Target Location

Error

10m

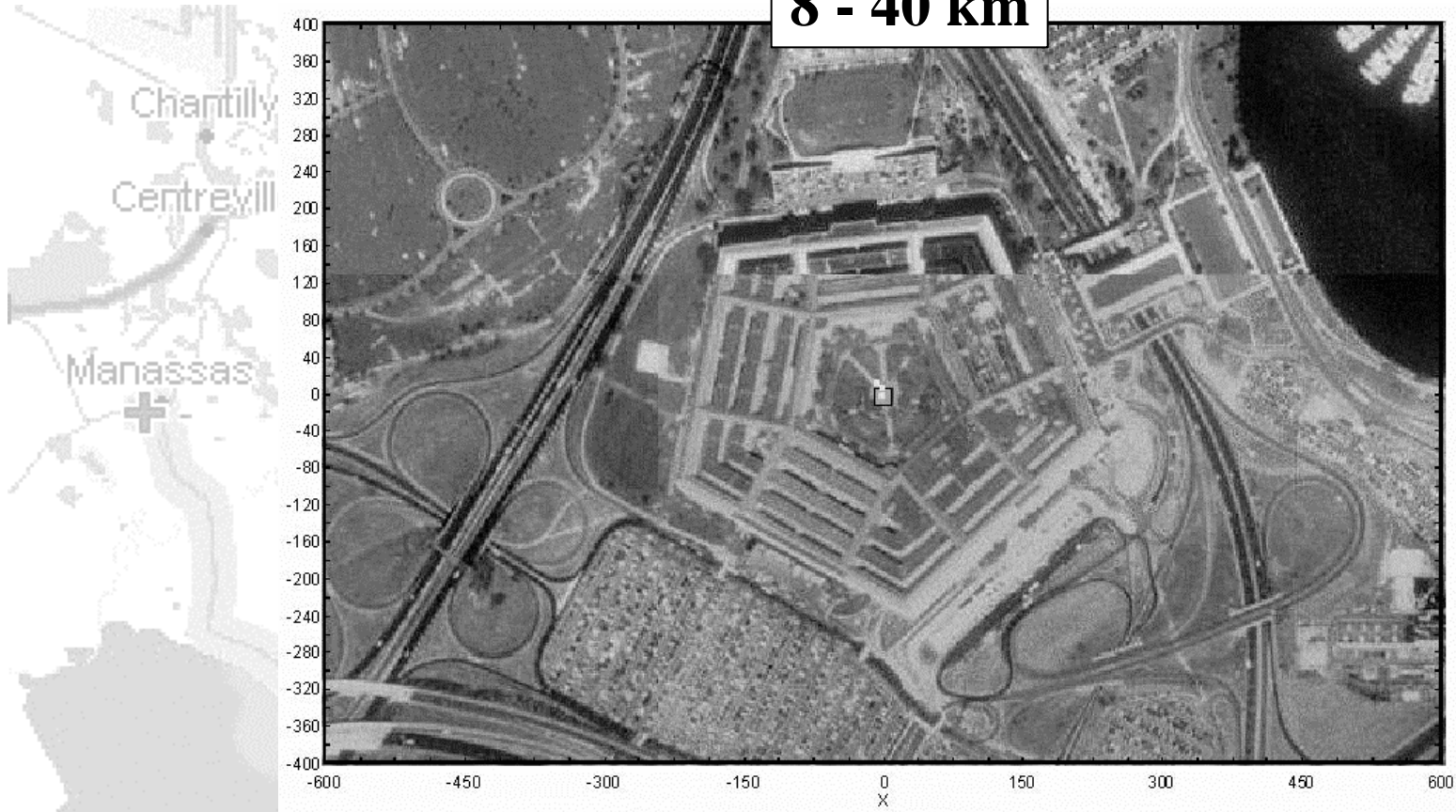
M549A1 - Conventional 155mm HE



XM982-U

R

8 - 40 km

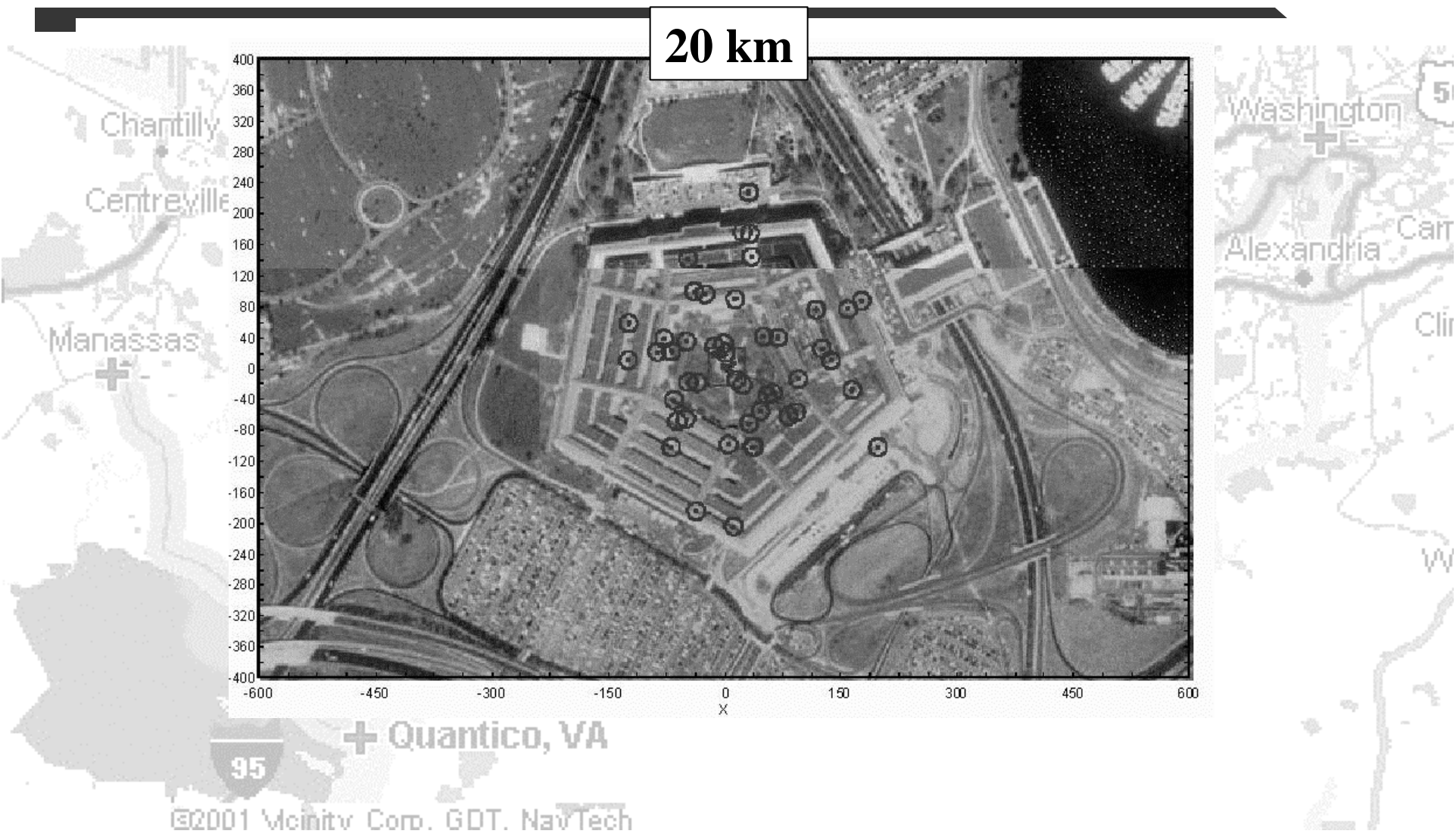


+ Quantico, VA

95

©2001 Mcinty Corp. GDT. NavTech

M549A1 - Conventional 155mm HE

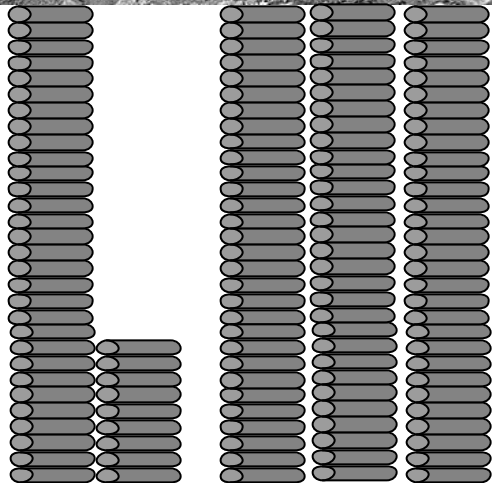


XM982-U

8 - 40 km



Logistical Implications

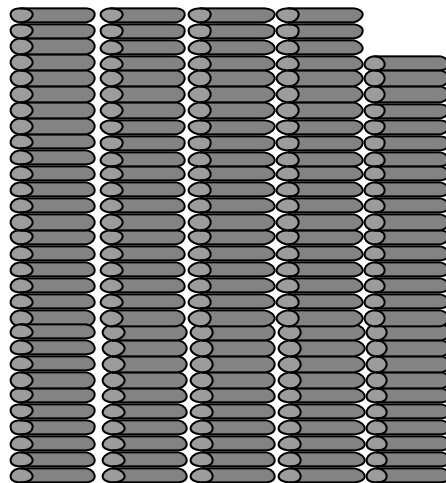


39

90



M549A1

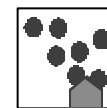


147

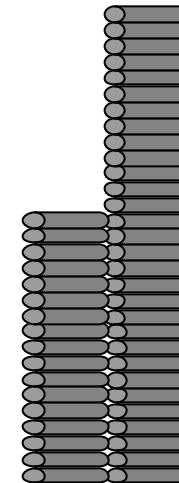
XM982



3



M549A1

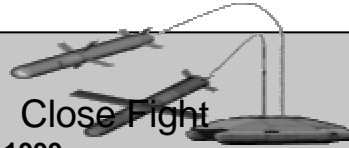


47

XM982



4



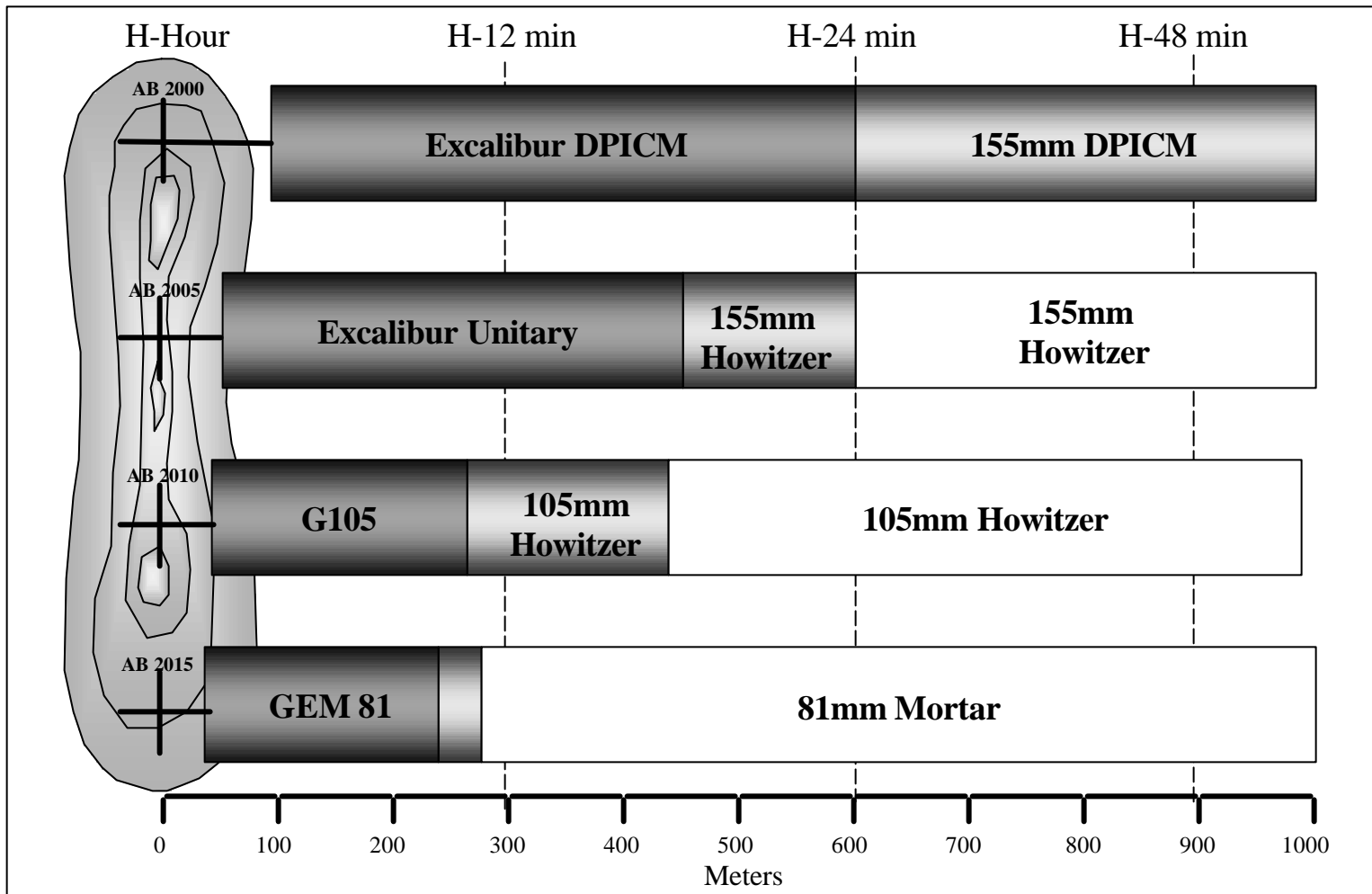
“...artillery and mortar fires must be able to support maneuver at much closer ranges than currently imagined.”

“(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.”

Guided Projectiles And The Close Fight

Echelon Fires for the Light Infantry Attack/Defense*



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

Future Combat System Guided Projectiles

Direct/Indirect Gun System

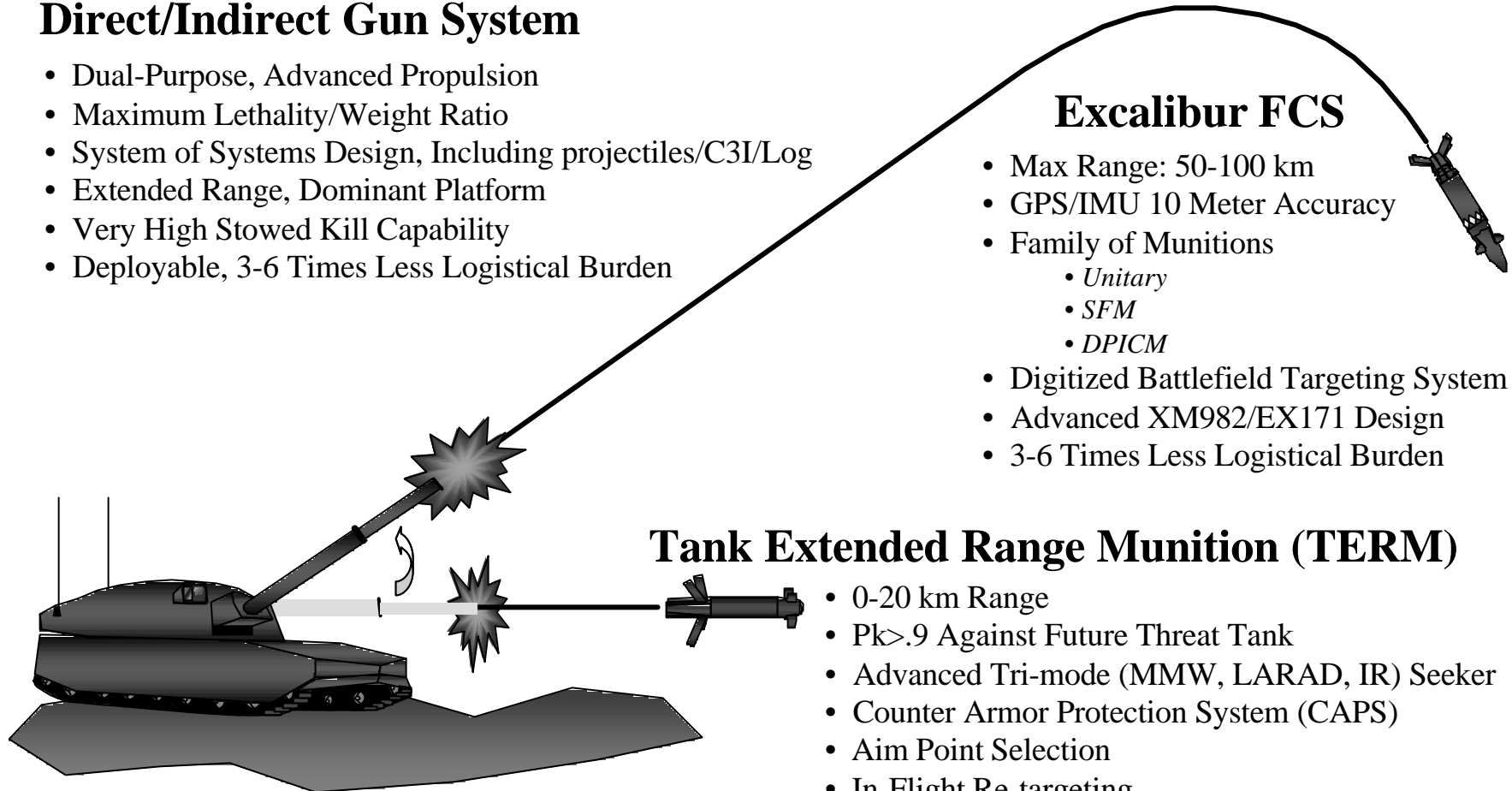
- Dual-Purpose, Advanced Propulsion
- Maximum Lethality/Weight Ratio
- System of Systems Design, Including projectiles/C3I/Log
- Extended Range, Dominant Platform
- Very High Stowed Kill Capability
- Deployable, 3-6 Times Less Logistical Burden

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!



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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Rodger Elkins

520.794.3596

rhelkins@west.raytheon.com

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

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

Guidance Options for Precision Indirect Fire

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

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

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

R

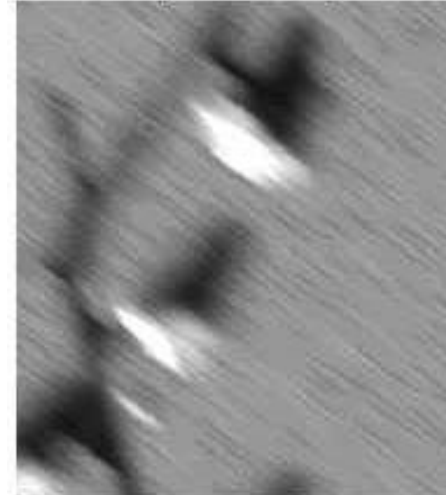
Irma - Multi-Sensor Signature Prediction Model



LADAR



PASSIVE IR



MMW RADAR

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

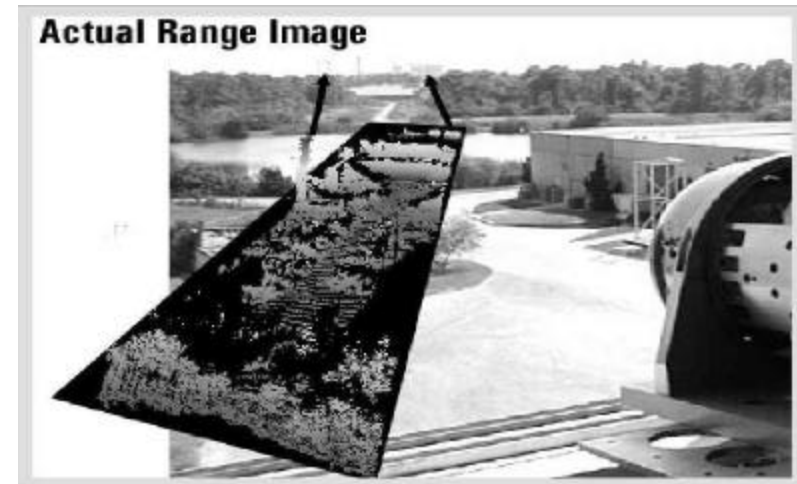
<http://www.munitions.eglin.af.mil/public/mngg/irma/irma.html>

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 -

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

Multi-Mode Seekers

- Exploit Multi-Sensor Synergy

- | | | |
|---|---|---|
| <p>IIR</p> <ul style="list-style-type: none"> + Finding Target Size Objects - At Extended Ranges Non Target Objects Hard To Distinguish From True Targets <p>MMW</p> <ul style="list-style-type: none"> + Discriminates Items with RCS Above Background (eg Metal Objects) - False Targets Can Be Prevalent (Without Imagine SAR) | } | <p>Combined Sensor</p> <ul style="list-style-type: none"> + 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 P³I and TERM

Plans For The Future

Present

Scanning LADAR



In -Work

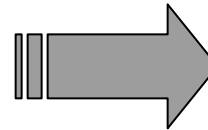
Flash LADAR

Real Beam MMW



Low Cost

MMW SAR



Planned

Dual Mode

MMW / LADAR

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

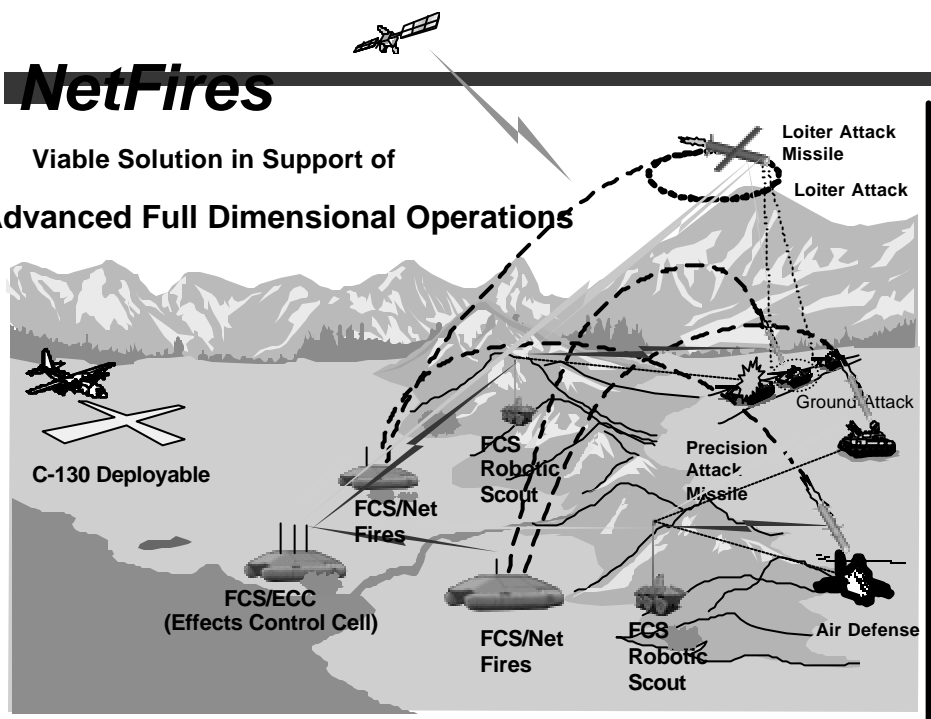


POC: LTC Brad Tousley, DARPA/TTO
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E-M: btousley@darpa.mil
Tel: 703-696-2355

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Bld 842M1,T3
Tucson, AZ 83734
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Tel: 520-794-2452

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

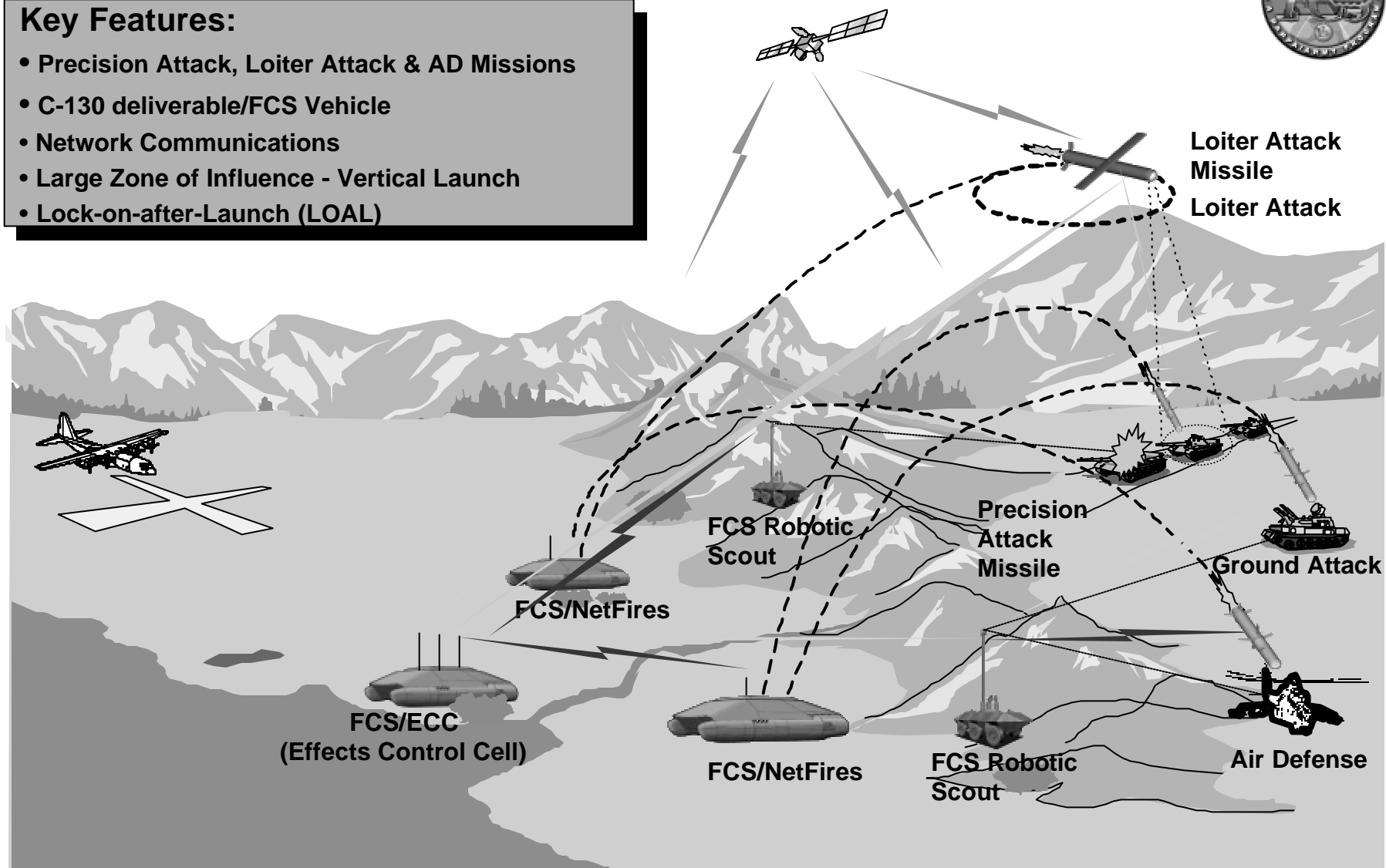
Schedule/Customer - DARPA/TTO

Activity Name	98	99	00	01	02	03	04	05	06	07	08	09	10
Concept Development	█	█	█	█									
Option 1			█	█	█								
Bridge Program			█										
Option 2				█	█	█	█	█	█	█	█	█	█
Pre SDD							█	█	█	█	█	█	█
SDD										█	█	█	█
Production(LRIP)												█	█
	98	99	00	01	02	03	04	05	06	07	08	09	10



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)

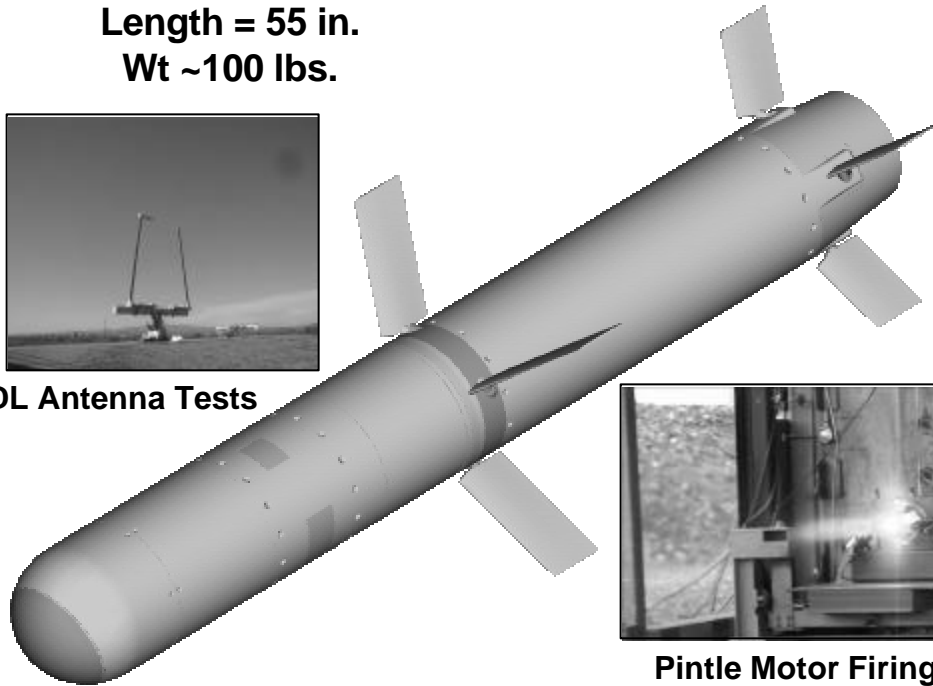


Precision Attack Missile (PAM)

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



DL Antenna Tests



Pintle Motor Firings



Seeker Tower Tests



Wind Tunnel Tests

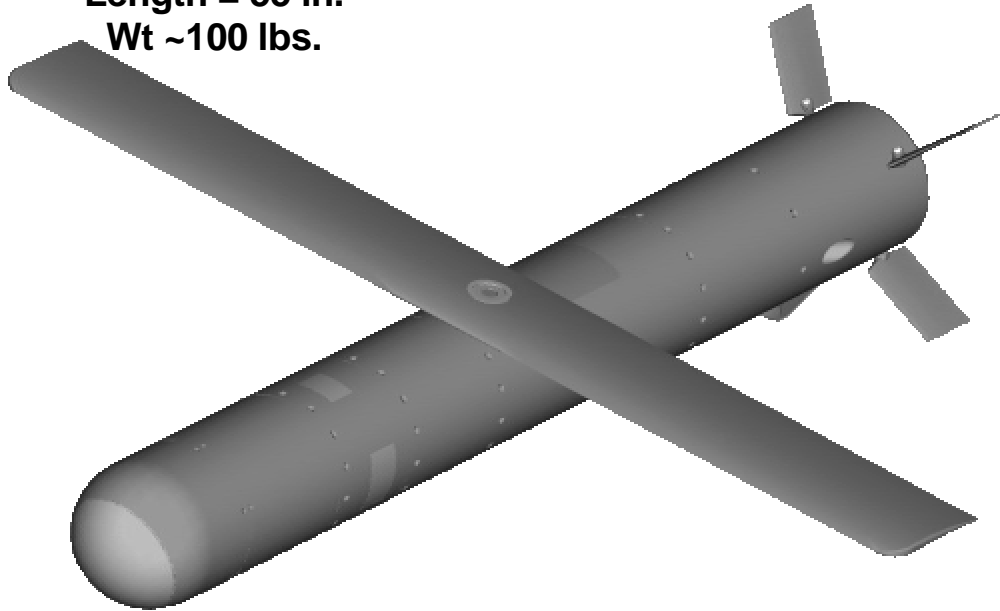
Status: Preliminary design completed.
Detailed design, fabrication/integration and demo in progress under Option 2

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)

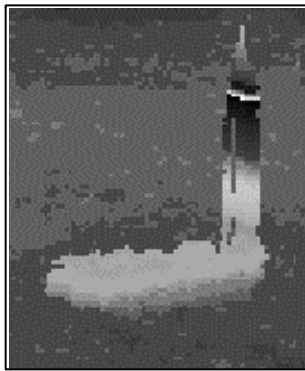
Diam. = 7 in.
Length = 55 in.
Wt ~100 lbs.



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 Recon, 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

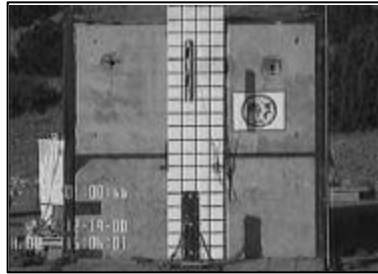


Captive Flight Tests



Wind Tunnel Tests

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



FCU

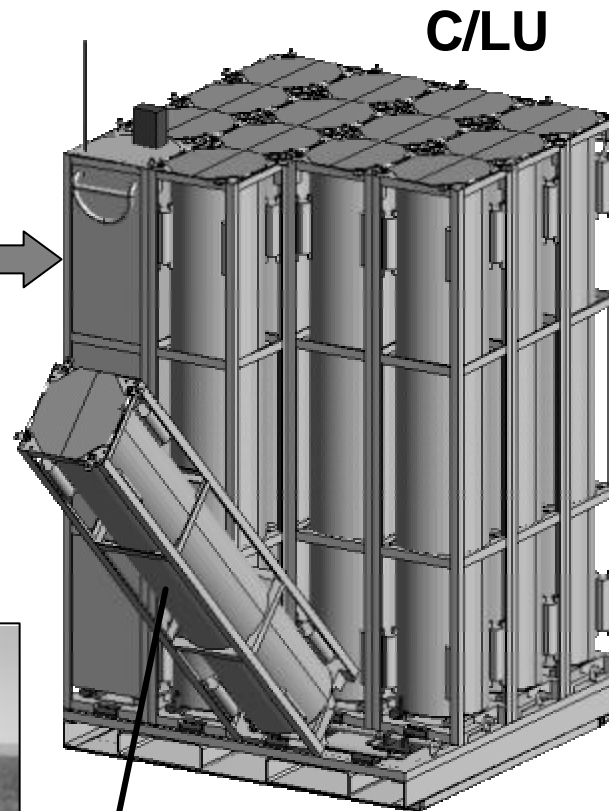


Launcher Compatibility Tests



HMMWV Compatibility

NDIA 18 JUNE 2001



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

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