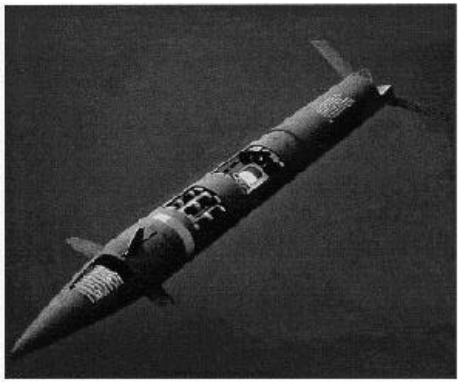


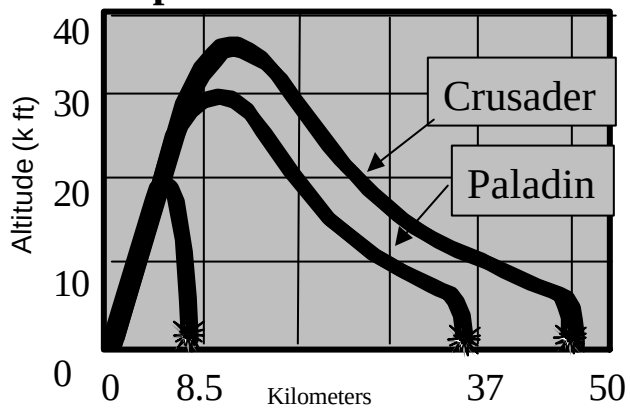
Guided Projectiles Theory of Operation

Chris Geswender - Raytheon
spock@raytheon.com

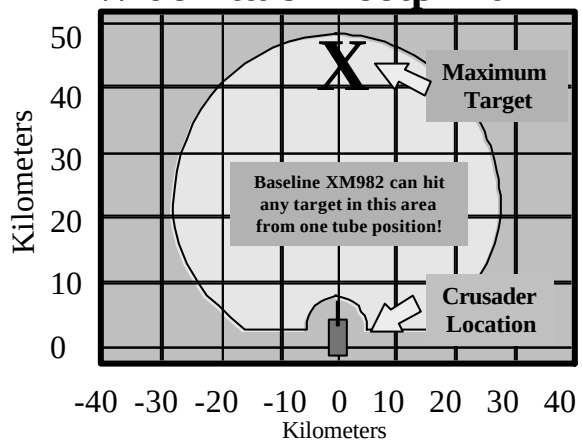
Warfighting Capabilities Enhanced by Guided Projectiles

NDIA Presentation

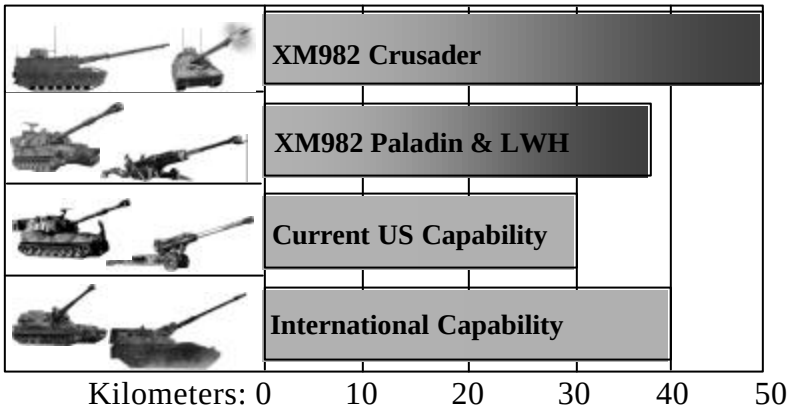
Improved Terminal Effects



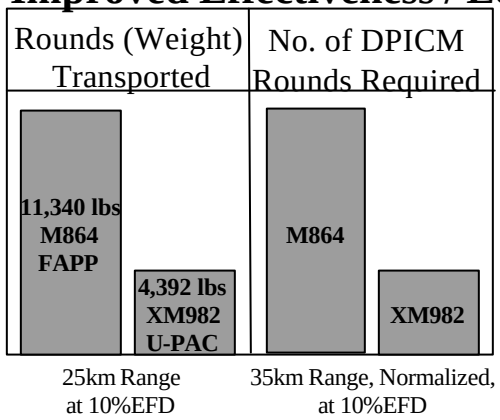
Wide Attack Footprint



Enhanced Range - Artillery Range Overmatch



Improved Effectiveness / Lethality



Data from Public Released presentation

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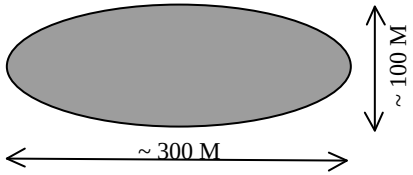
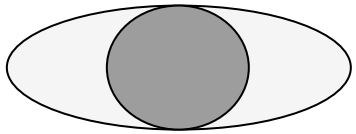
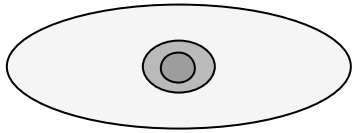
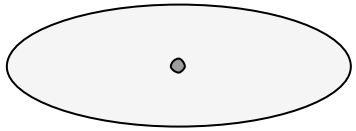
Potential Solutions for Projectile Guidance

NDIA Presentation

	Configuration	Range	Accuracy
Unguided			
1-DOF Correction *Controls X*			
2-DOF Correction *Controls X, Y*			
7-DOF Correction *Controls time, X, Y, Z, pitch, yaw, roll*			

Data expanded from NDIA Web site

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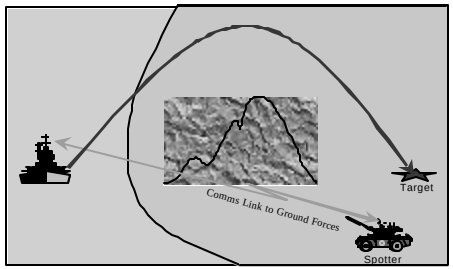
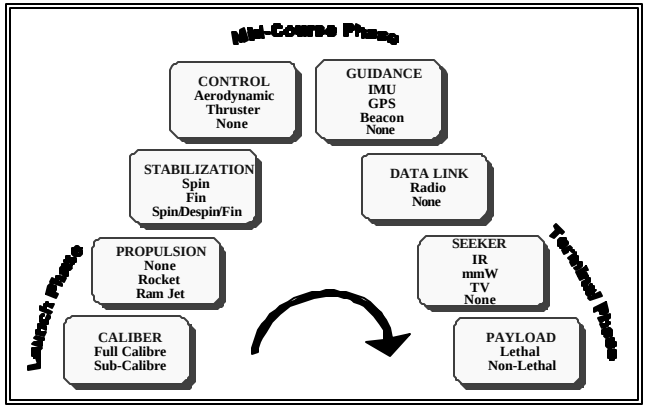
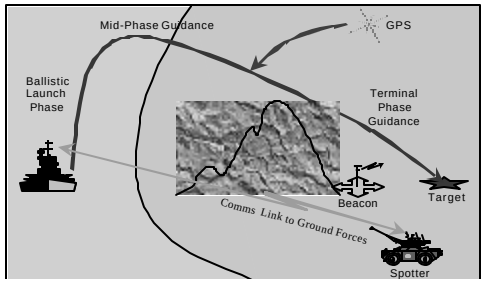
Various Guidance Options



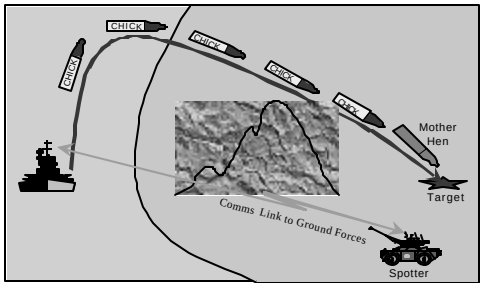
Ballistic



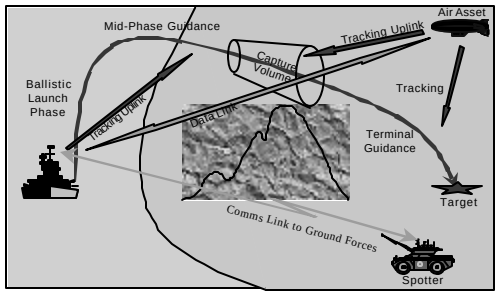
Self Guided



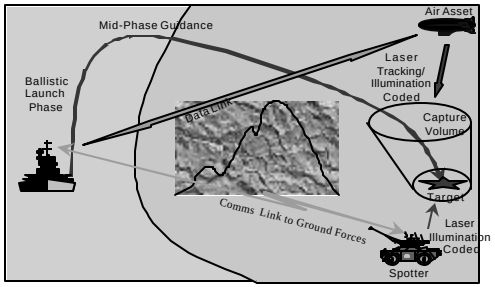
Follow Me



Command Guided



Laser Guided



Data from NATO document

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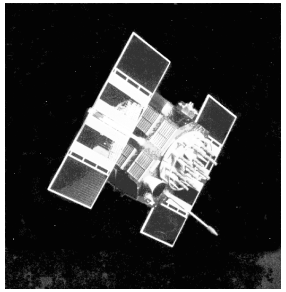
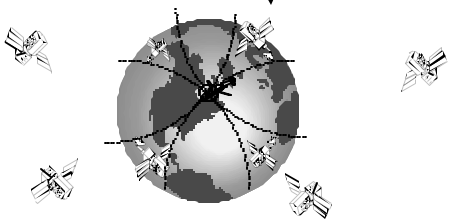
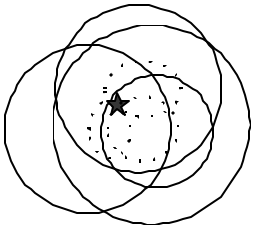
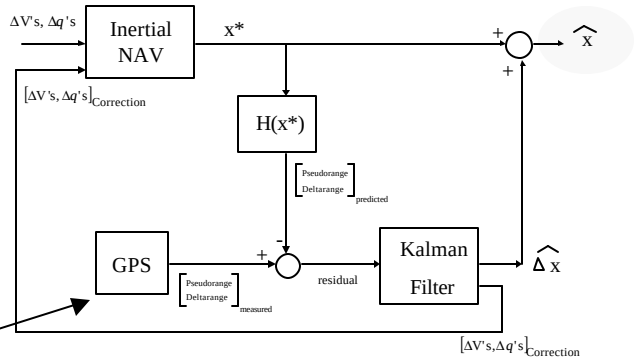
Tightly Integrated GPS/INS Guidance



IMU provides very accurate body based rate and acceleration data





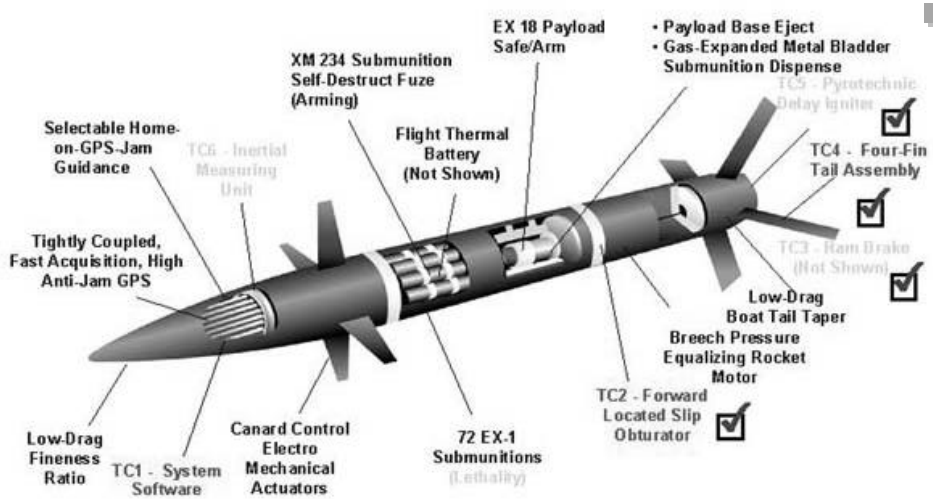


GPS / IMS provides very accurate projectile inertial data

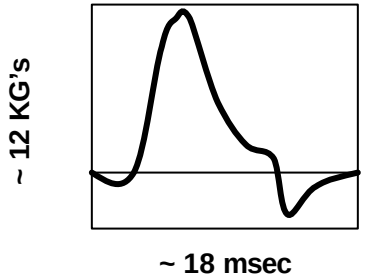
GPS provides very accurate Earth based position and velocity data

Data from GPS web site

Example - Rocket Assisted Design



The Gun Envionment



Projectile In Bore Acceleration vs Time

Projectile Attributes

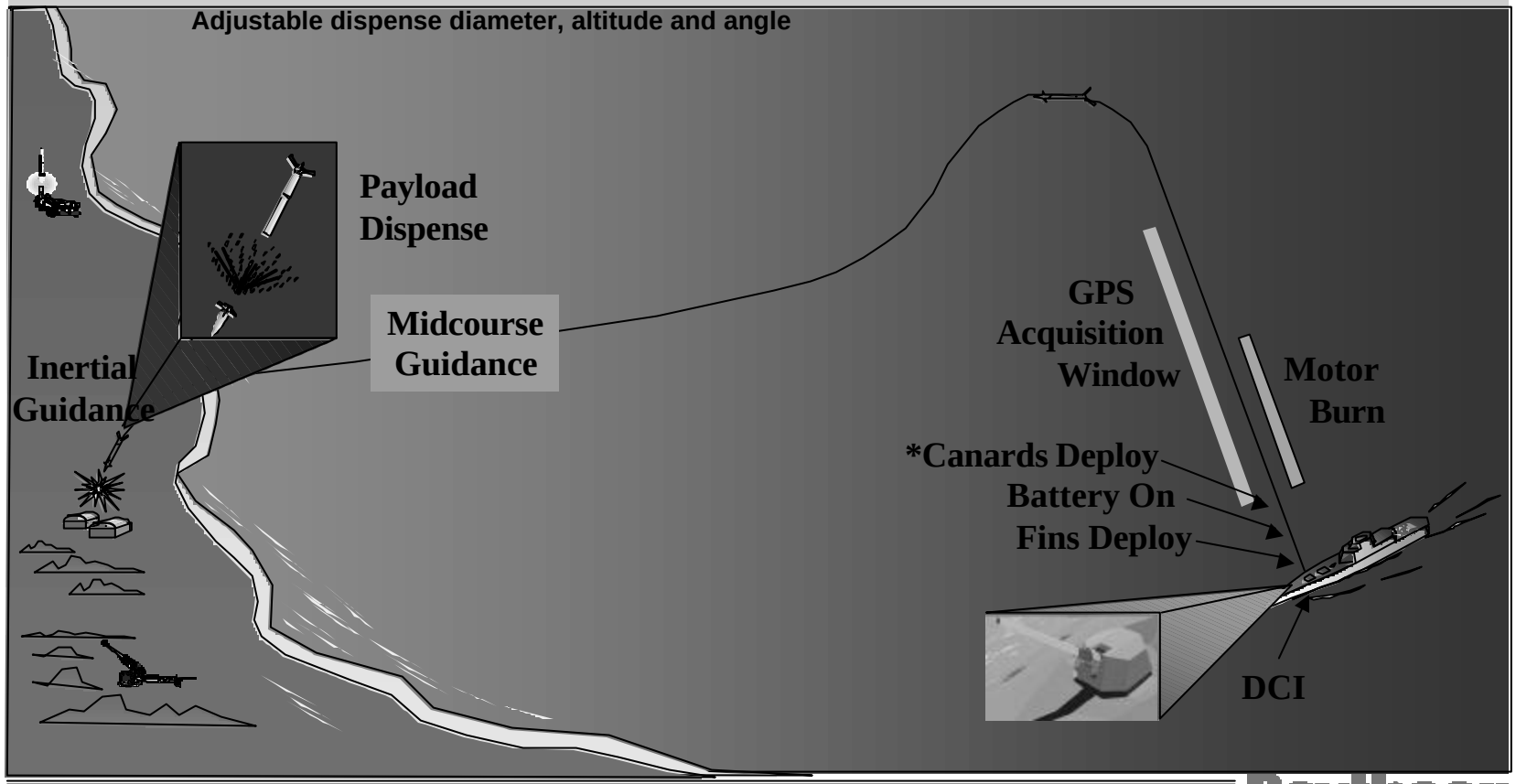
CHALLENGE - Build a projectile with all the functionality of a missile but robust enough to gun fired

Data from Surface Warfare Web site

General Concept of Operations

Baseline Capabilities

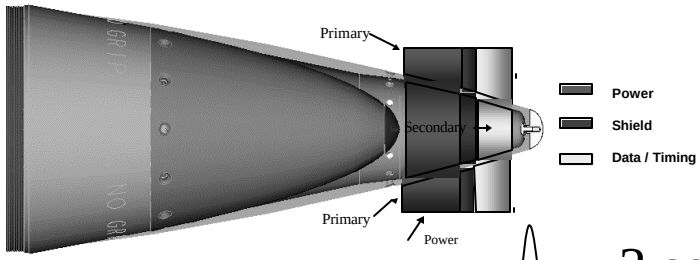
- On and off axis target attack (large downrange/ cross-range envelope)
- Trajectory optimized for aerodynamic efficiency
- Wind estimator to offset dispense for target area winds
- Moderate GPS jamming immunity / moderate effectiveness after jamout
- Adjustable dispense diameter, altitude and angle

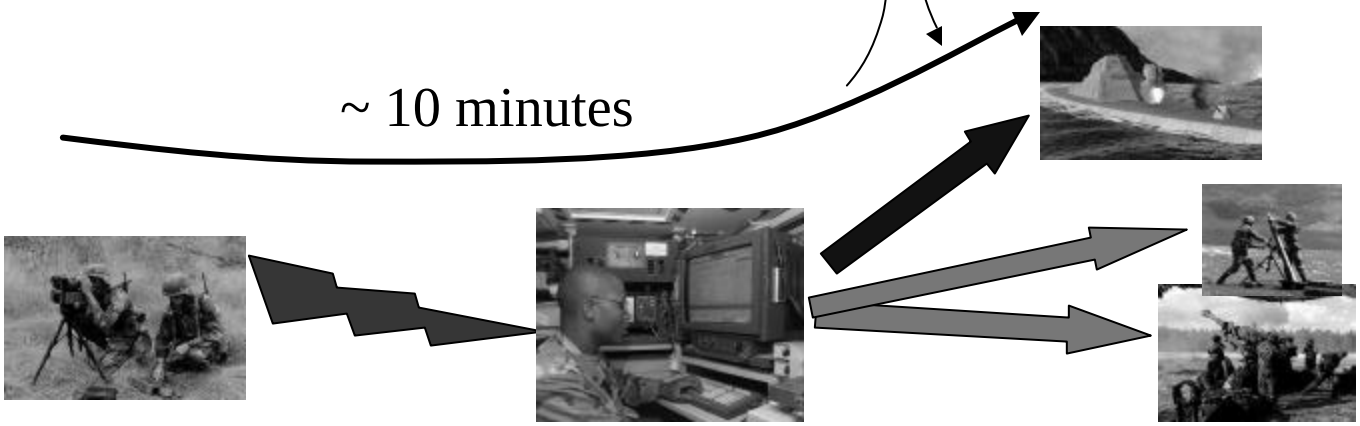


Data redrawn from Surface Warfare Web site

Pre-Fire Timeline

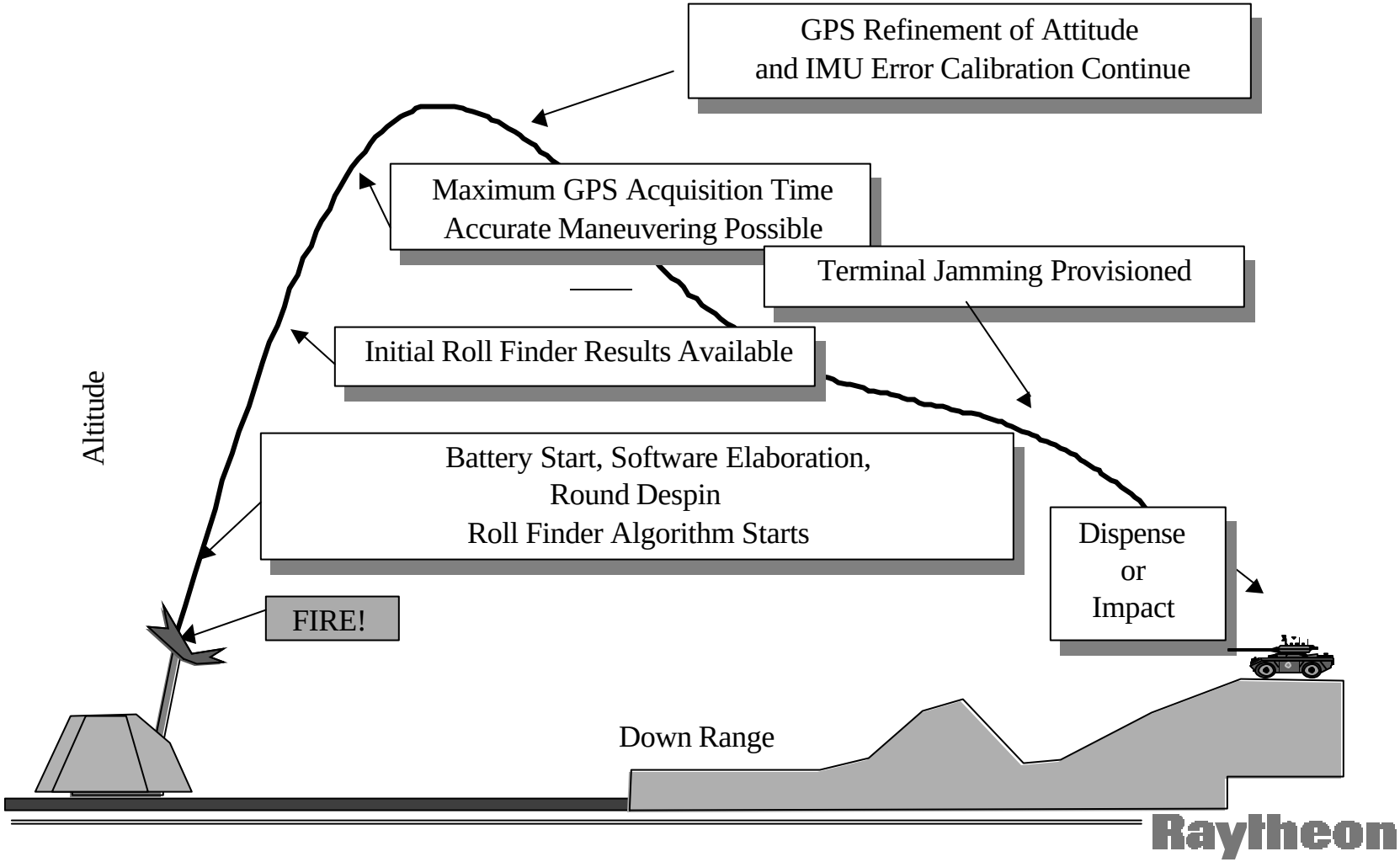
Projectile Initialization requires very aggressive timelines to meet firing rates comparable to "dumb" projectiles





Data from Web sited NSFS presentation

Navigation/Midcourse Timeline



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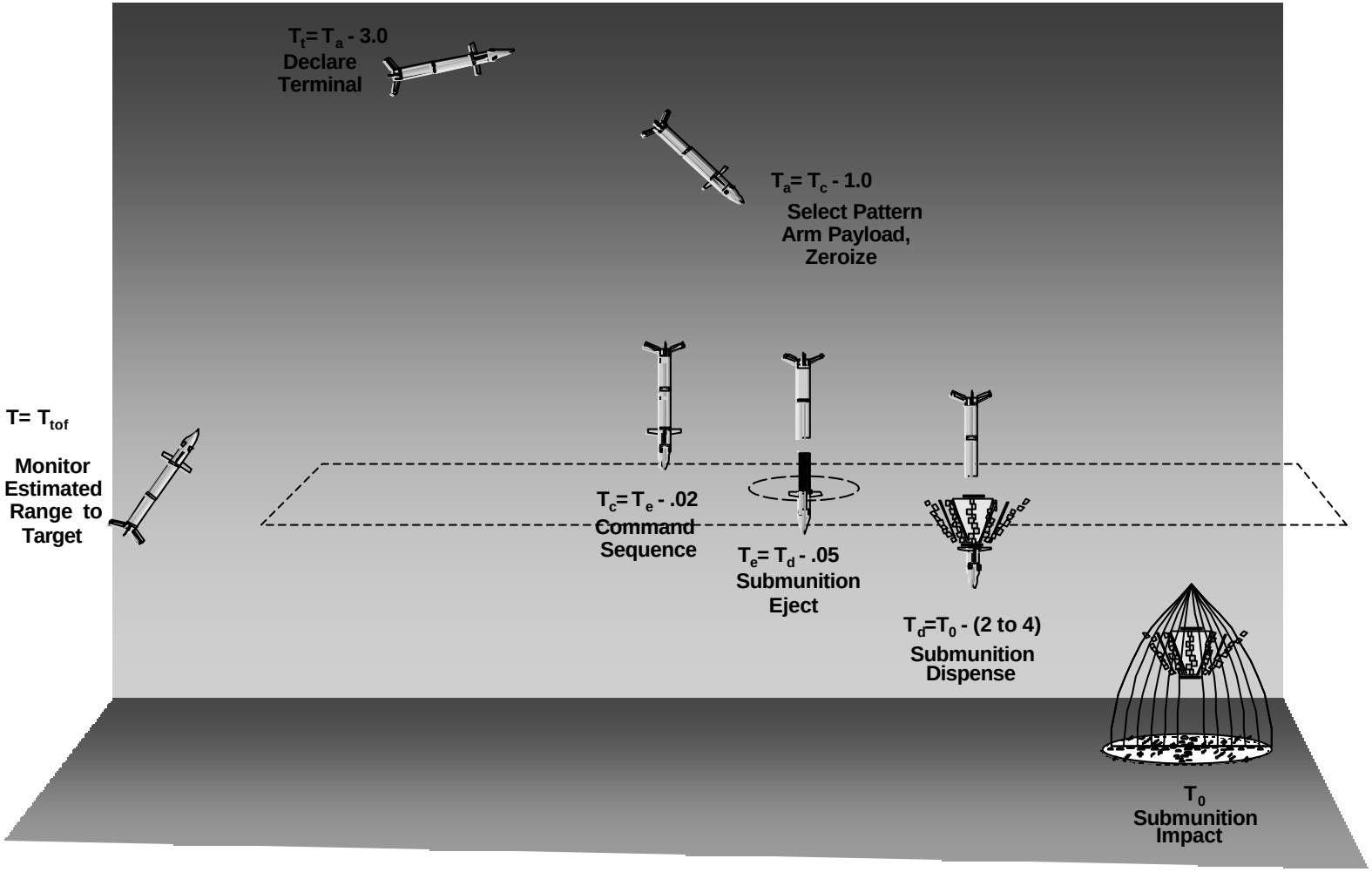
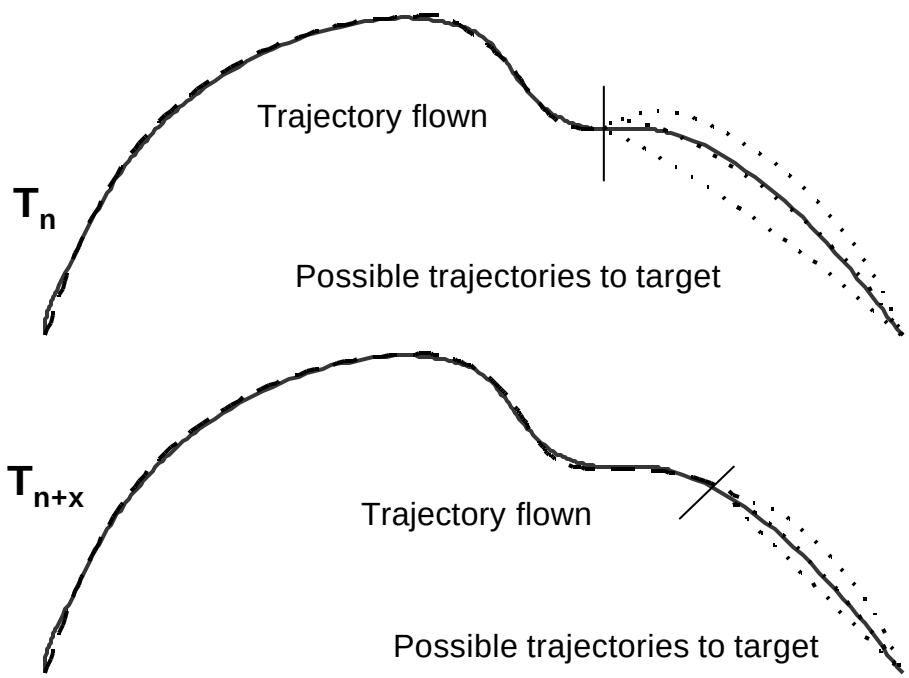
Terminal Time Line



Multiple Rounds Simultaneous Impact

Closed form TOA solutions from Fire Control do not work

To supply MRSI, each projectile must both:
- **accurate estimate time to target**
- **control it continuously**

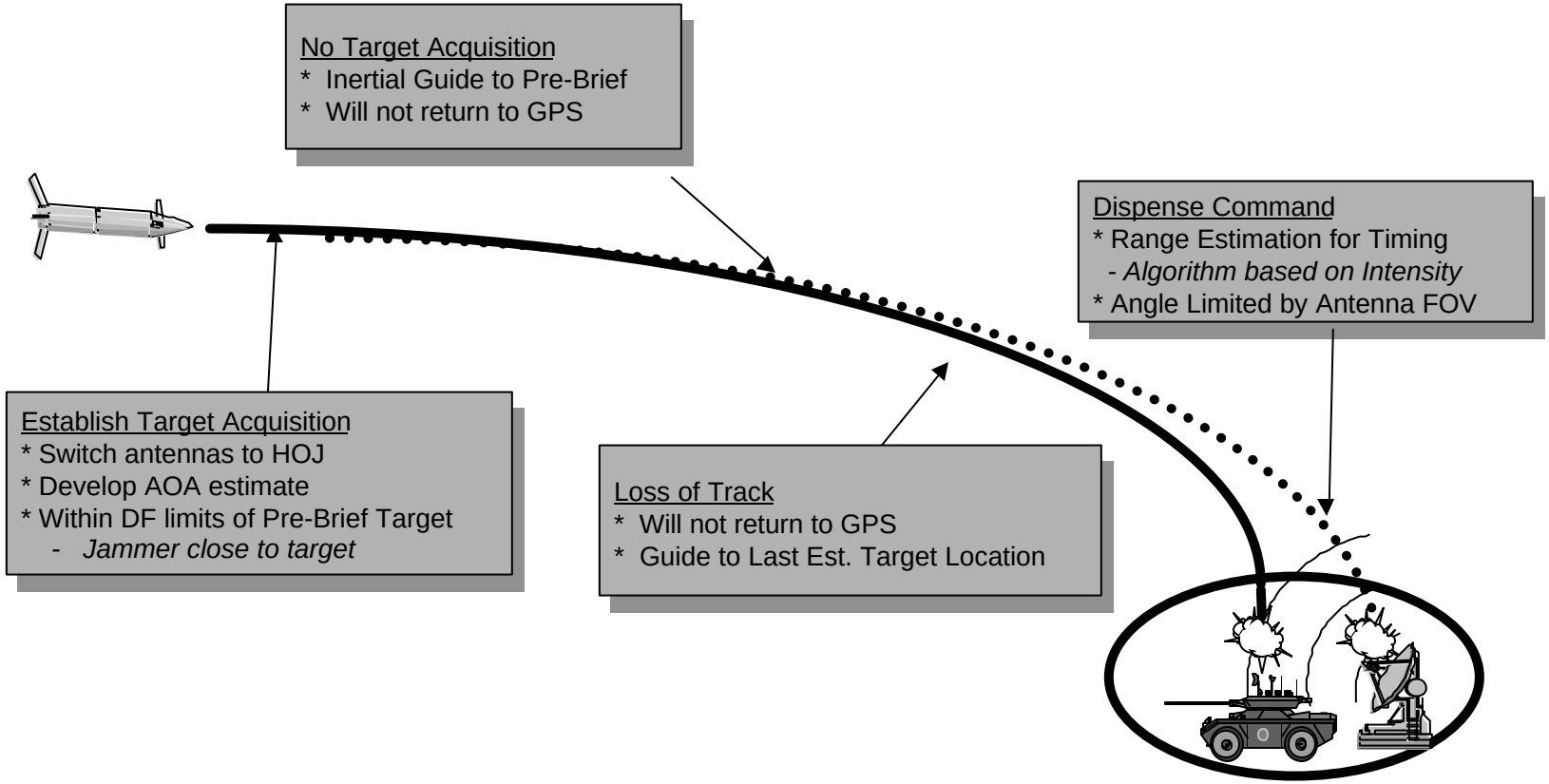


Biases error sources
(errors which dominate the time of flight)
- **Propellant performance**
- **Firing time errors**
- **Non standard Atmosphere**
- **Dominant wind direction**
- **Aerodynamic variations**

Colored noise sources
(errors which confuse active time of arrival control)
- **Wind shears**
- **GPS error shifts**

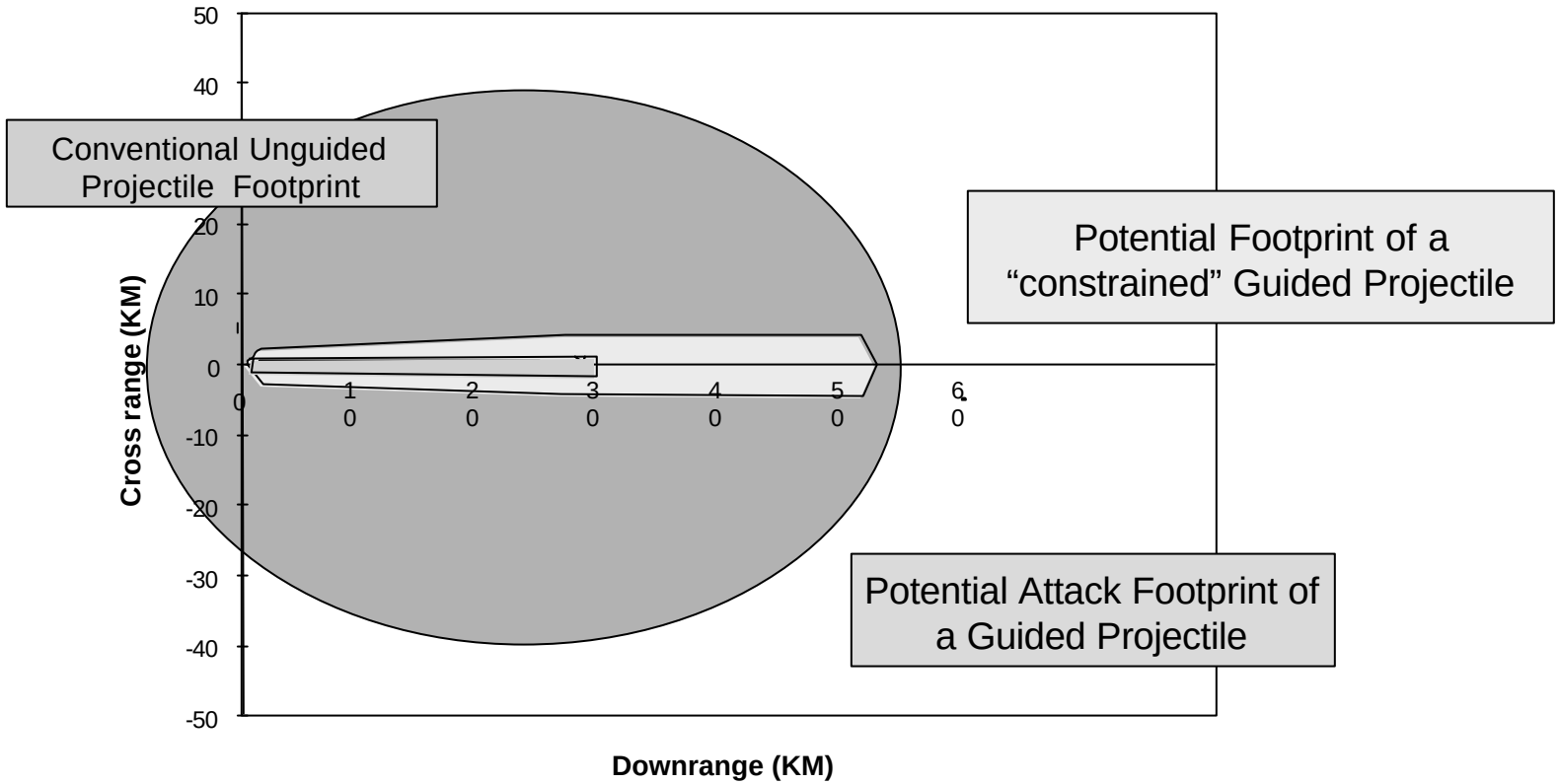
White noise sources
(errors which just "stimulate" any control)
- **Wind gusts**

HOJ Operational Timeline



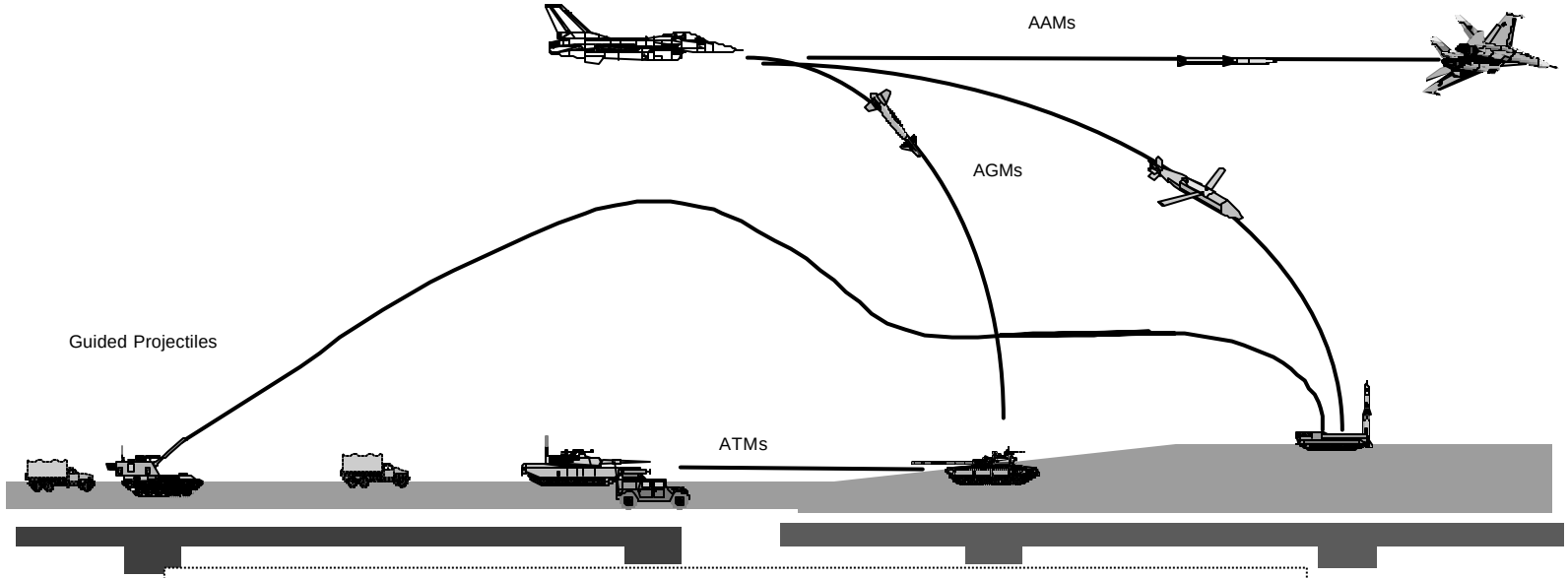
Off Axis Attack Capability provided

The ability to “fly” (example assumes 7-DOF guidance solution) means a gun can execute many firings missions from a single surveyed site without repositioning barrel



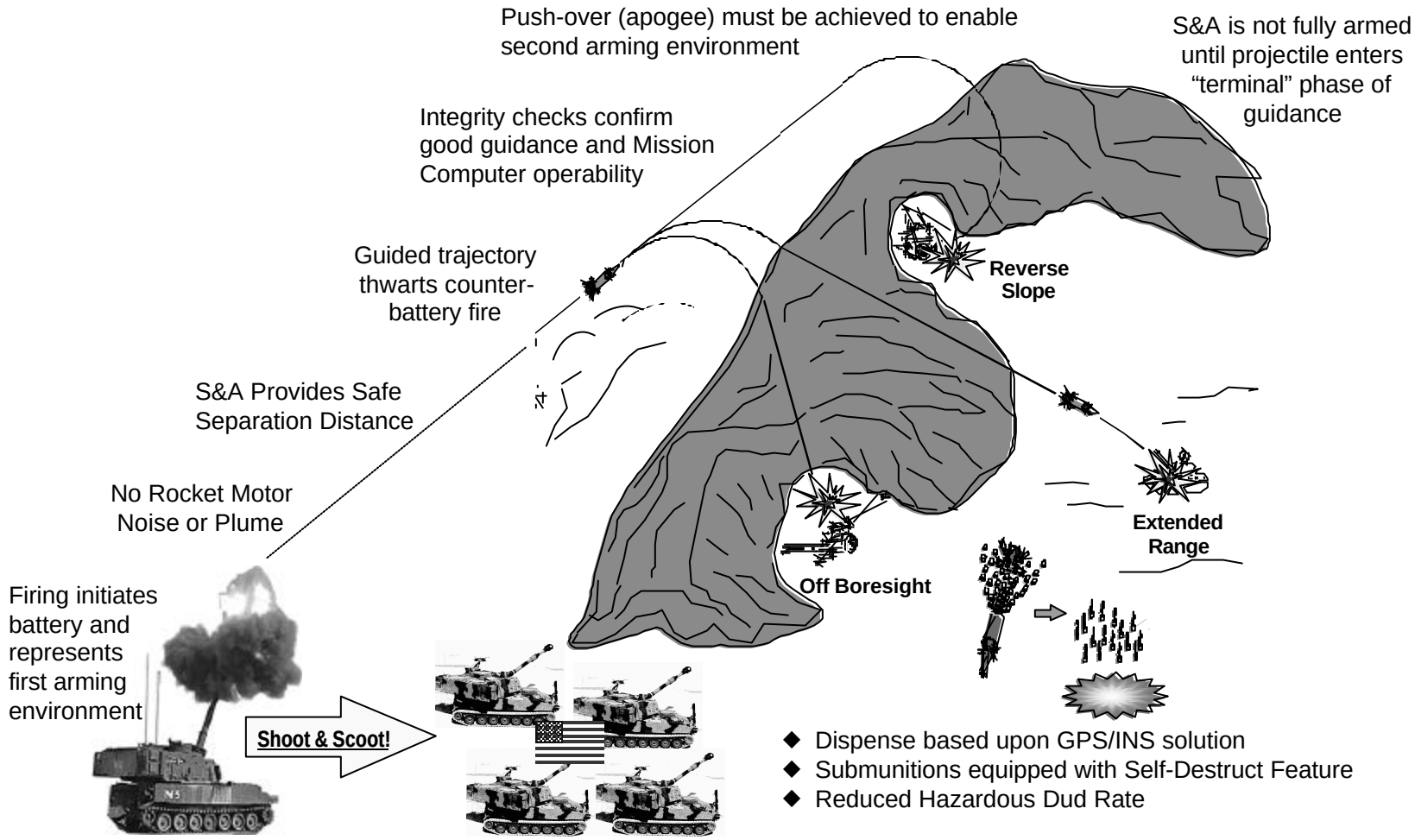
New requirement - Casualty function

- **Most guided weapons were not designed to be fired over friendly forces**(so provisions for operation as a failed weapons was not really considered in the design)
- **BLUE trajectories** represents the fact most guided weapons have been designed to be employed at or in advance of the battle front (called Forward Line Of Engagement or FLOE).
- **Red trajectory** represents the fact guided projectiles will operationally be employed such that they will be behind FLOE and will overfly all forces up to FLOE.



For the first time, overhead safety for EXTENDED ranges must be considered

Example - Safety Features Over a Mission



- Dispense based upon GPS/INS solution
- Submunitions equipped with Self-Destruct Feature
- Reduced Hazardous Dud Rate

Data from Public Released Presentation

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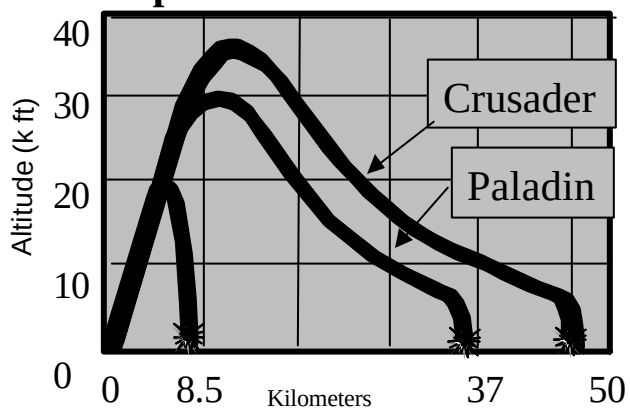
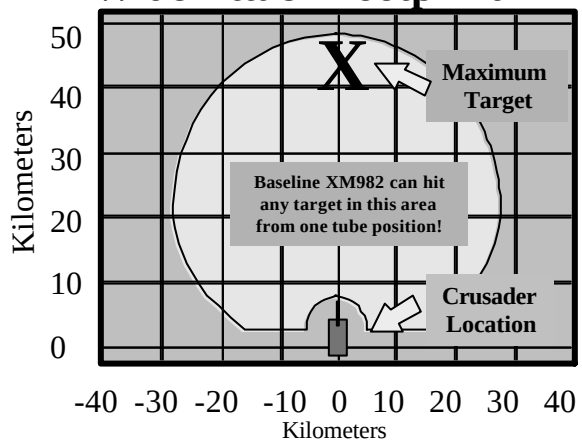
Summary - Guided Projectiles provides

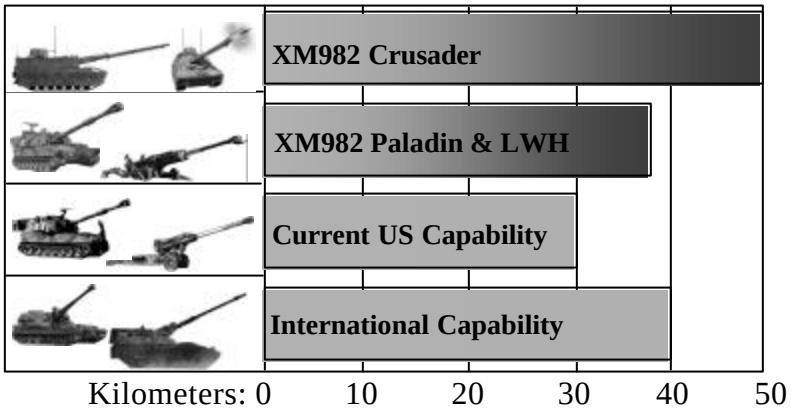
Improved Terminal Effects



Wide Attack Footprint



Enhanced Range - Artillery Range Overmatch



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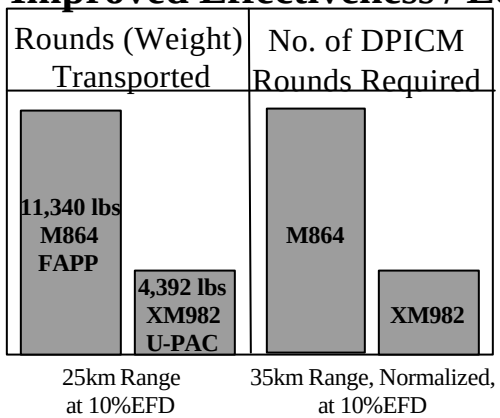

Data from Public Released Presentation

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