

Guided Projectiles Theory of Operation

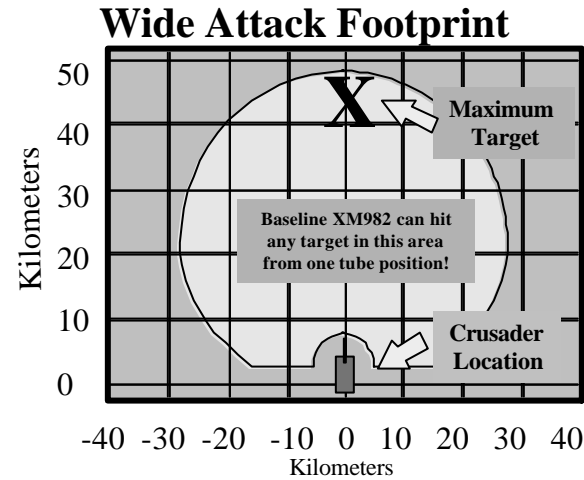
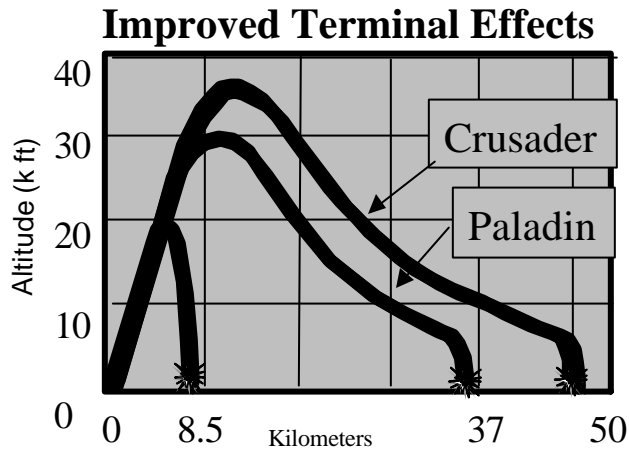
Chris Geswender - Raytheon

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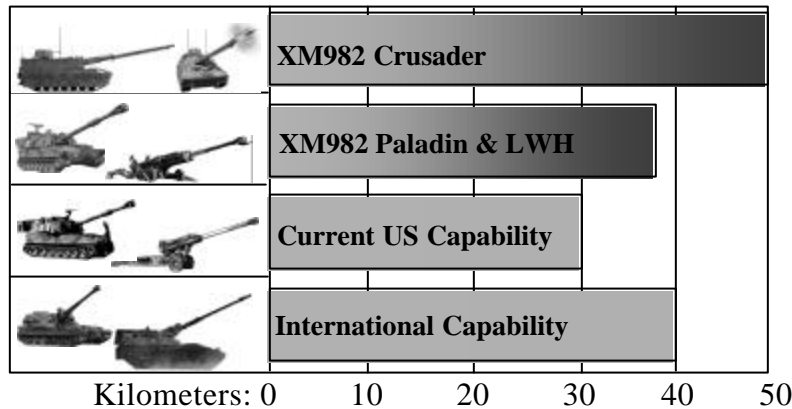
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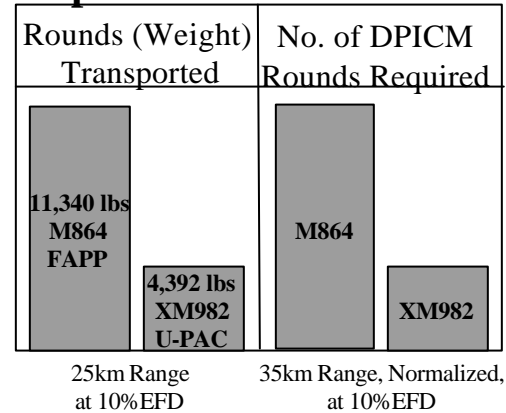
Warfighting Capabilities Enhanced by Guided Projectiles NDIA Presentation



Enhanced Range - Artillery Range Overmatch



Improved Effectiveness / Lethality

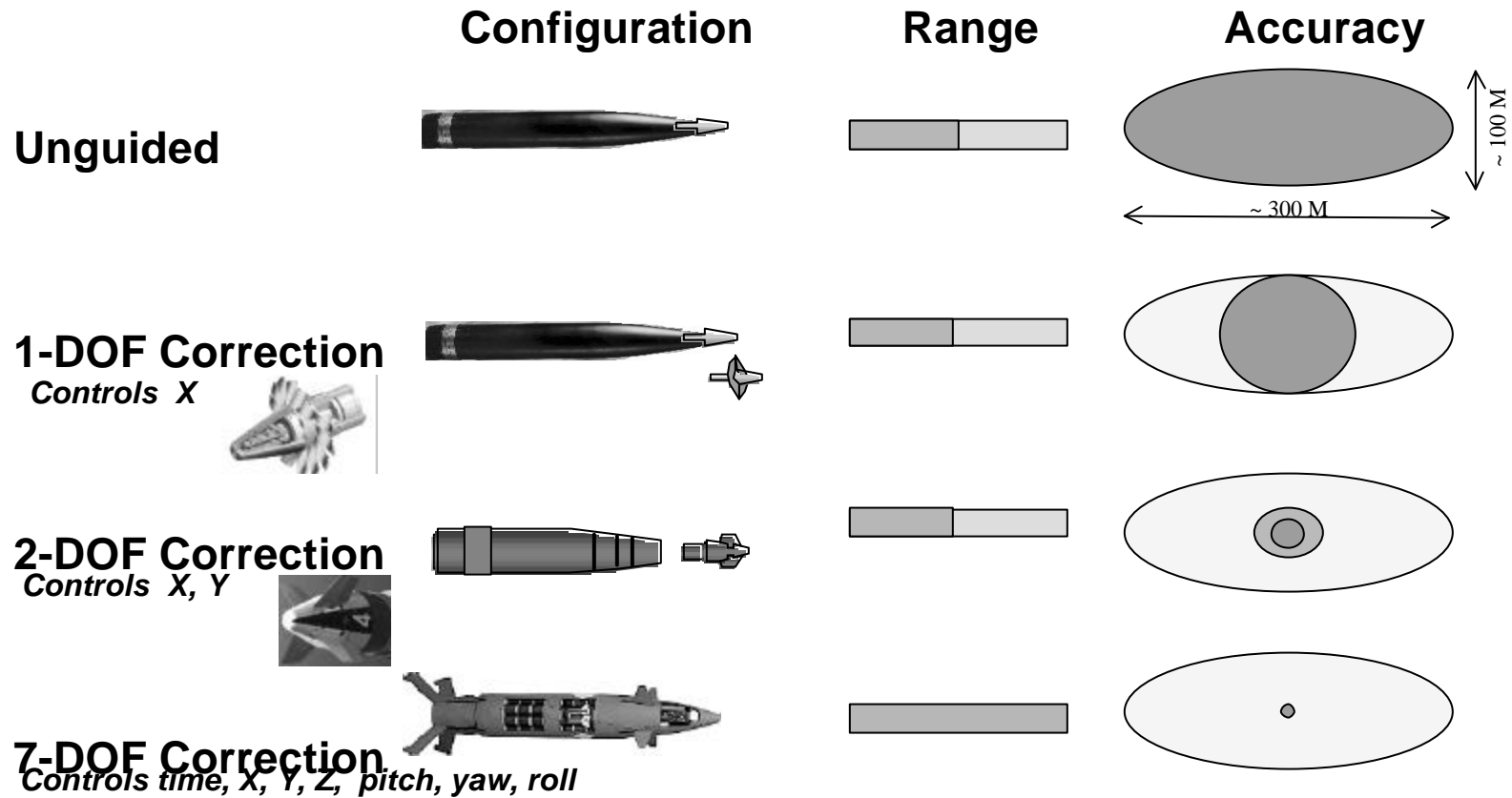


Data from Public Released presentation



Potential Solutions for Projectile Guidance

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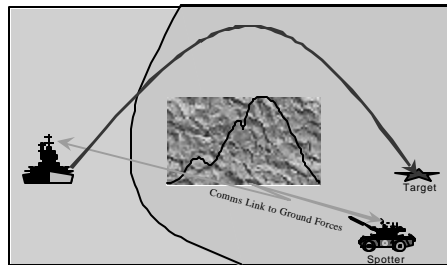


Data expanded from NDIA Web site

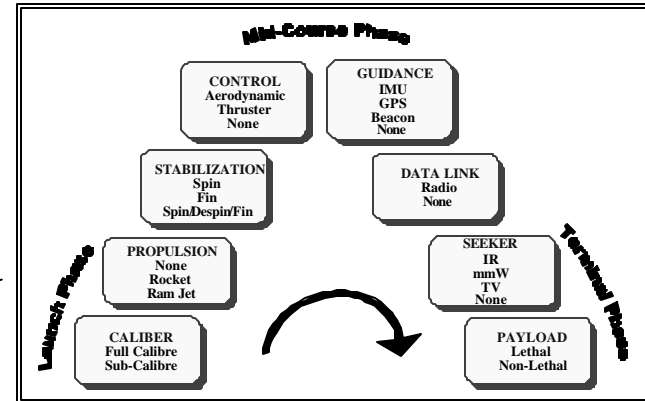
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Various Guidance Options

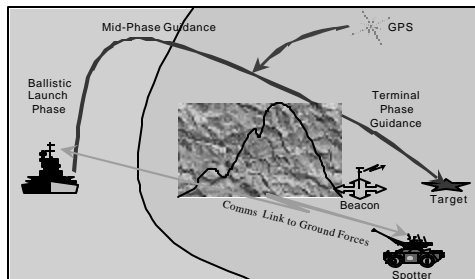
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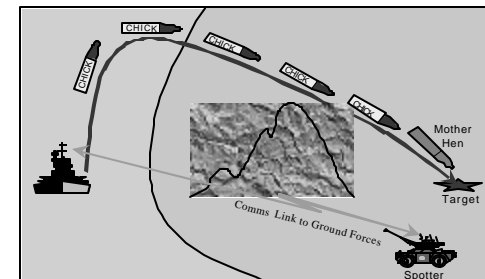
Ballistic



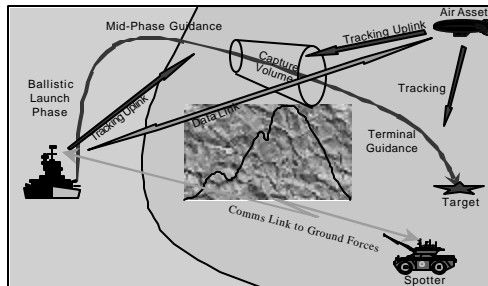
Self Guided



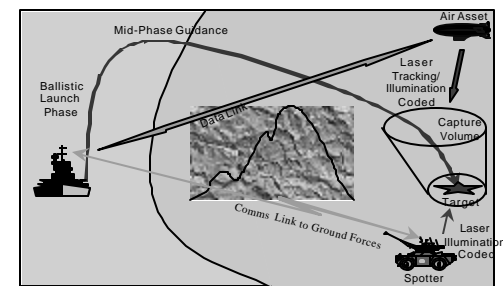
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Command Guided



Laser Guided

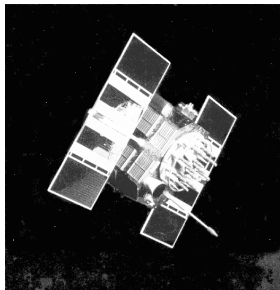


Data from NATO document

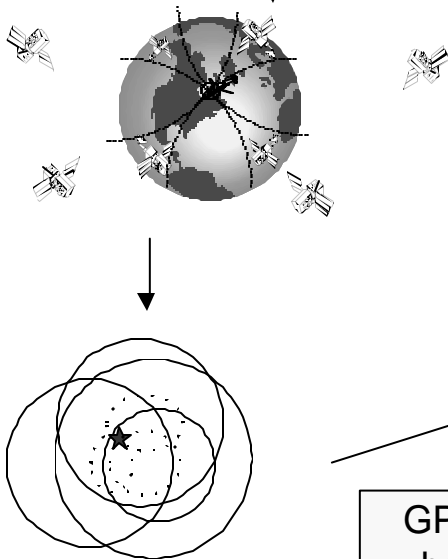
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Tightly Integrated GPS/INS Guidance

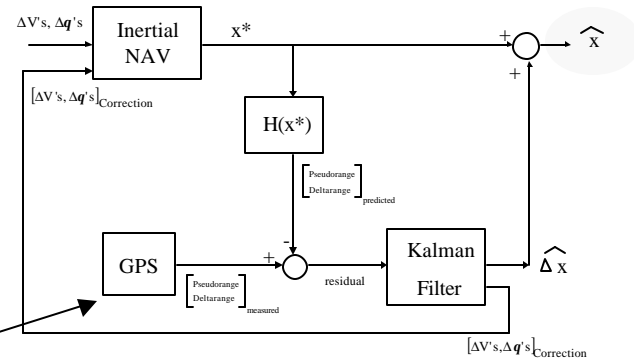
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IMU provides very accurate body based rate and acceleration data



GPS provides very accurate Earth based position and velocity data



GPS / INS provides very accurate projectile inertial data

Data from GPS web site

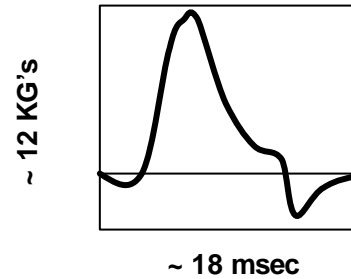


Example - Rocket Assisted Design

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The Gun Environment



Projectile In Bore Acceleration vs Time

Projectile Attributes

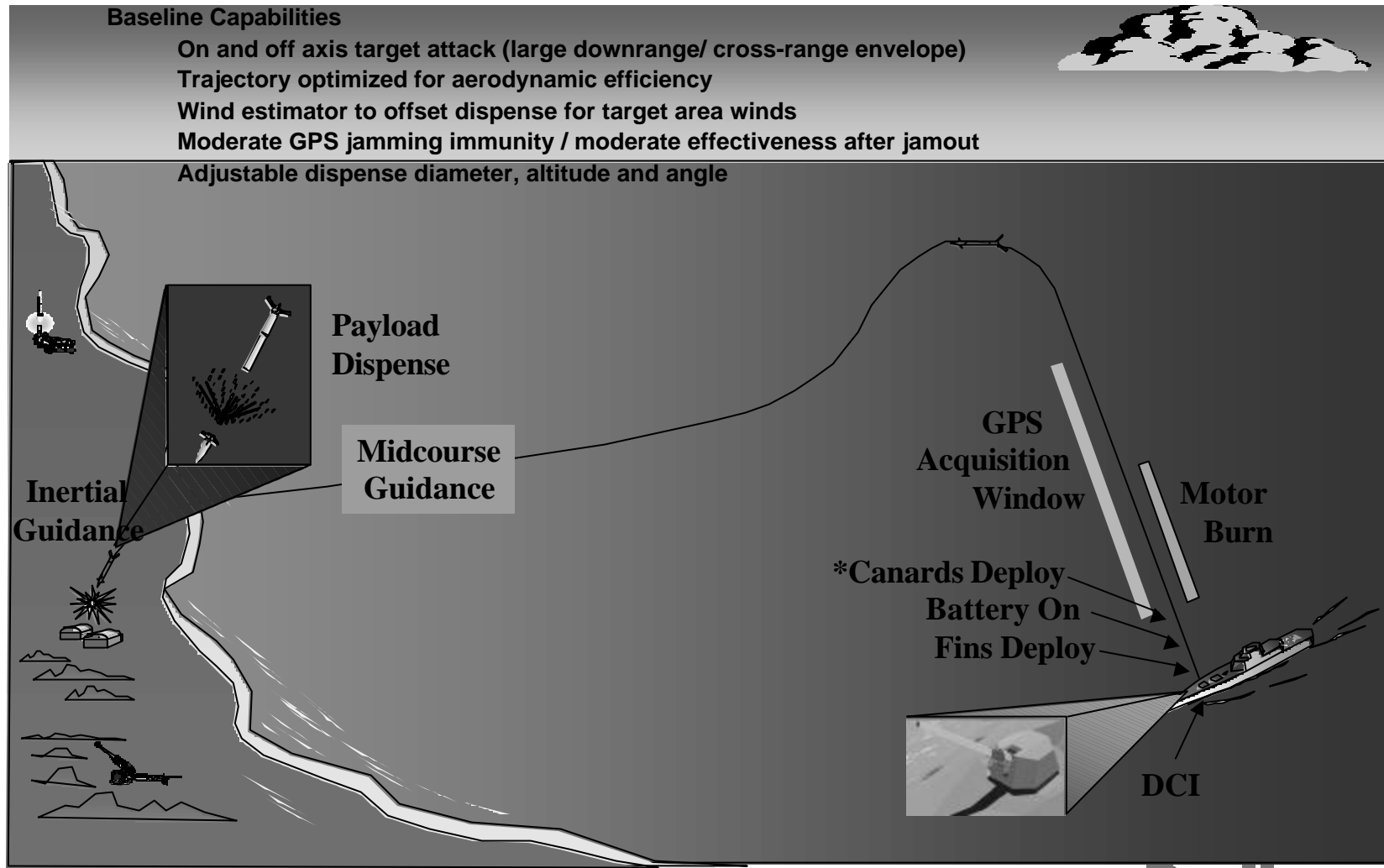
CHALLENGE - Build a projectile with all the functionality of a missile but robust enough to gun fired

Data from Surface Warfare Web site

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General Concept of Operations

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Data redrawn from Surface Warfare Web site

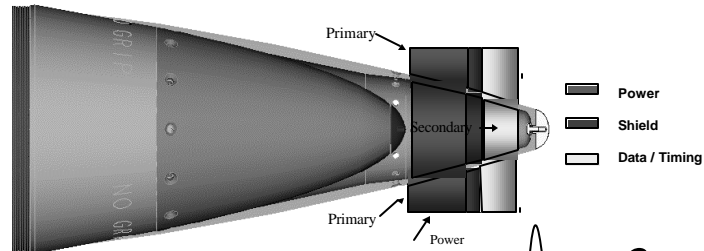
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Pre-Fire Timeline

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



~ 3 seconds

~ 10 minutes

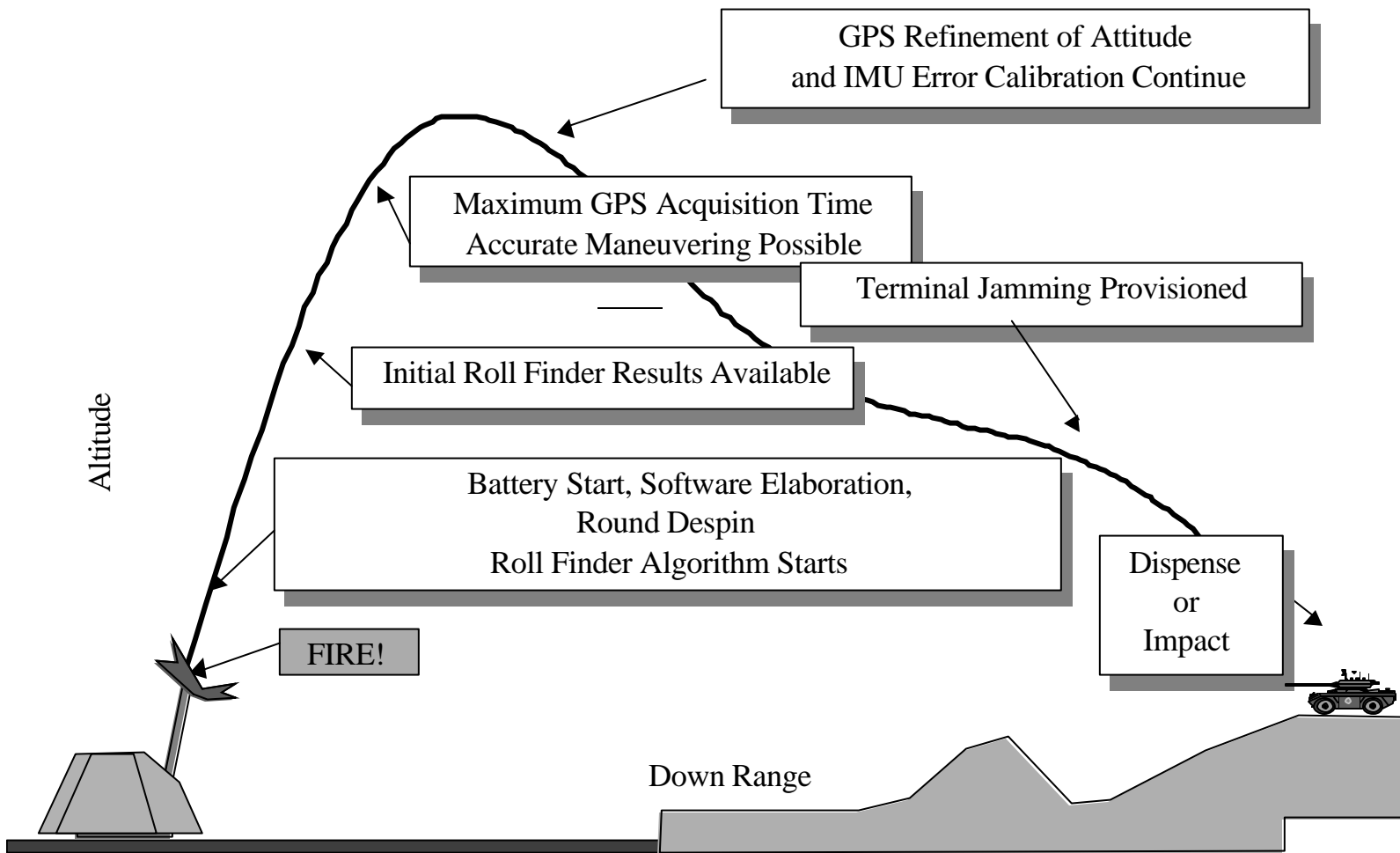


Data from Web sited NSFS presentation

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Navigation/Midcourse Timeline

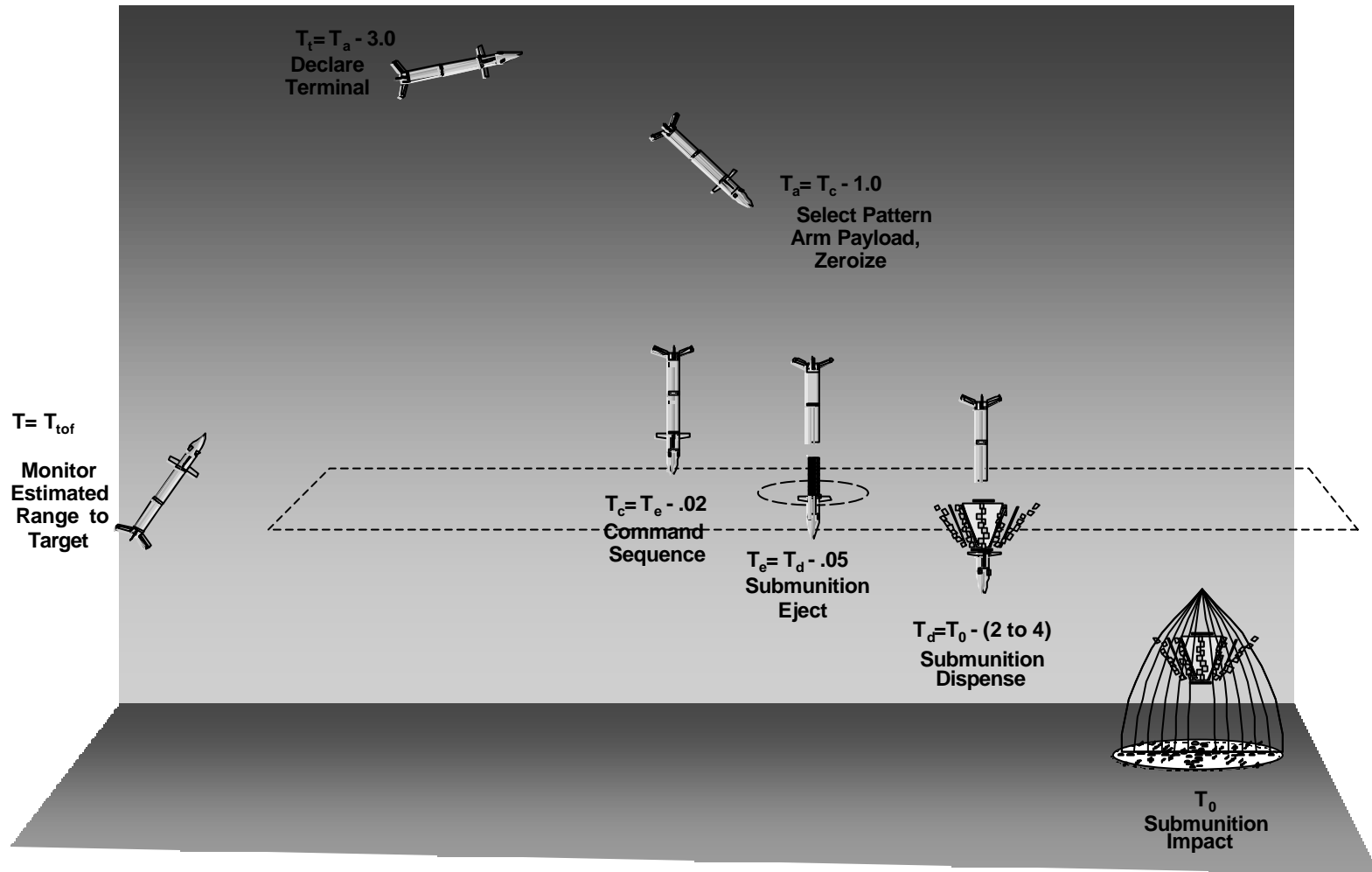
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Terminal Time Line

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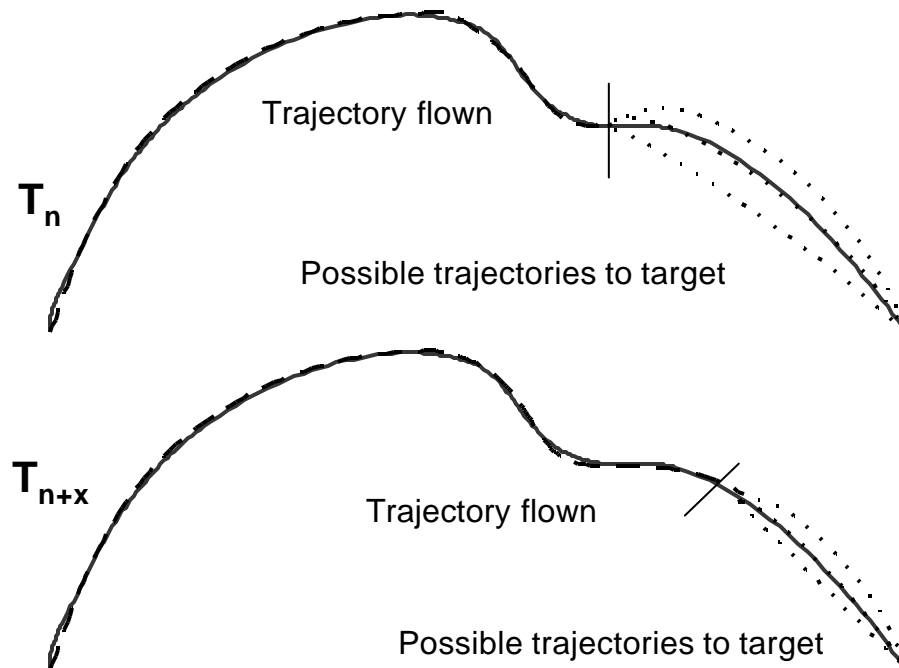
Multiple Rounds Simultaneous Impact

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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

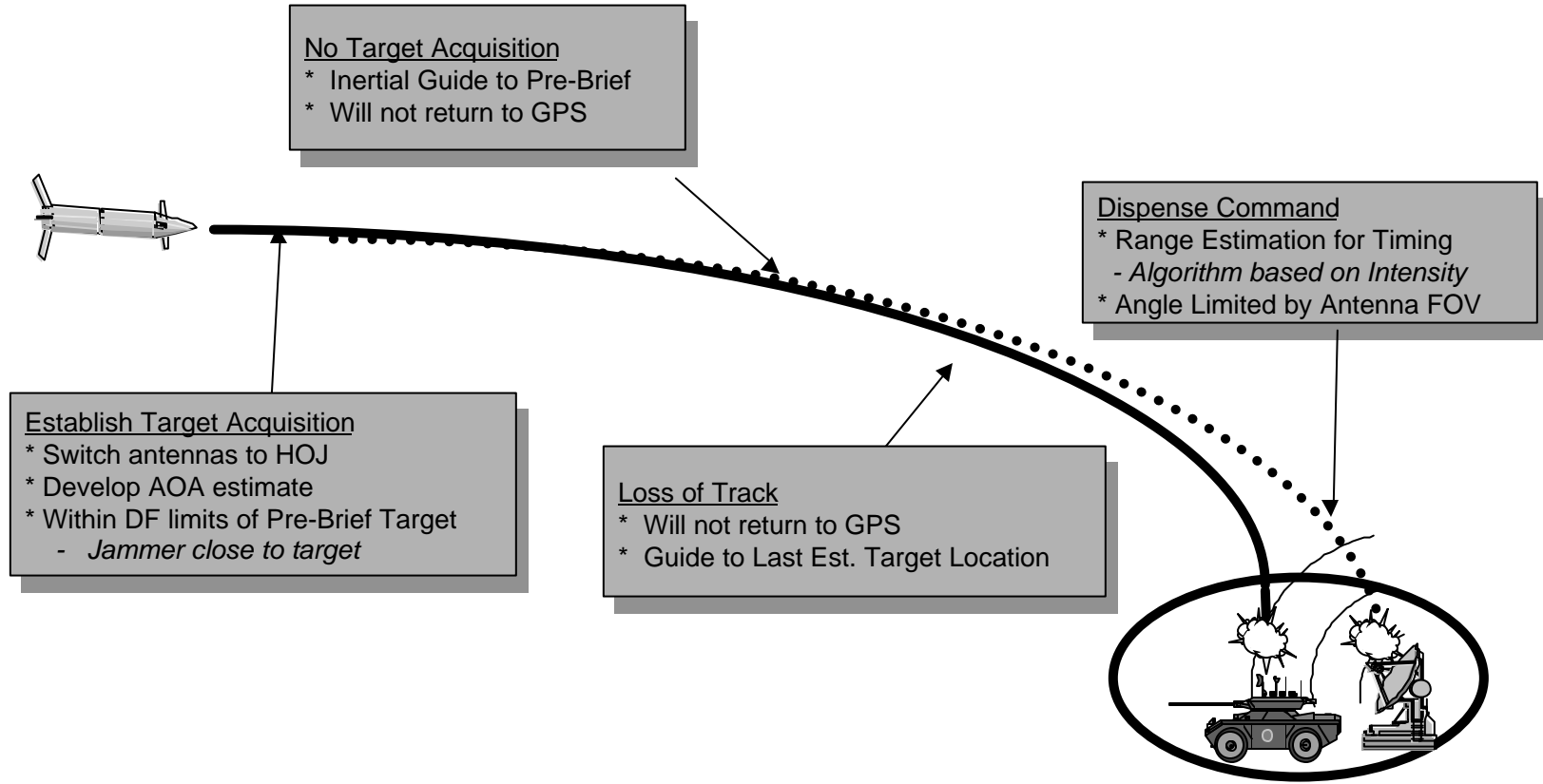
(errors which just "stimulate" any control)

Wind gusts

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HOJ Operational Timeline

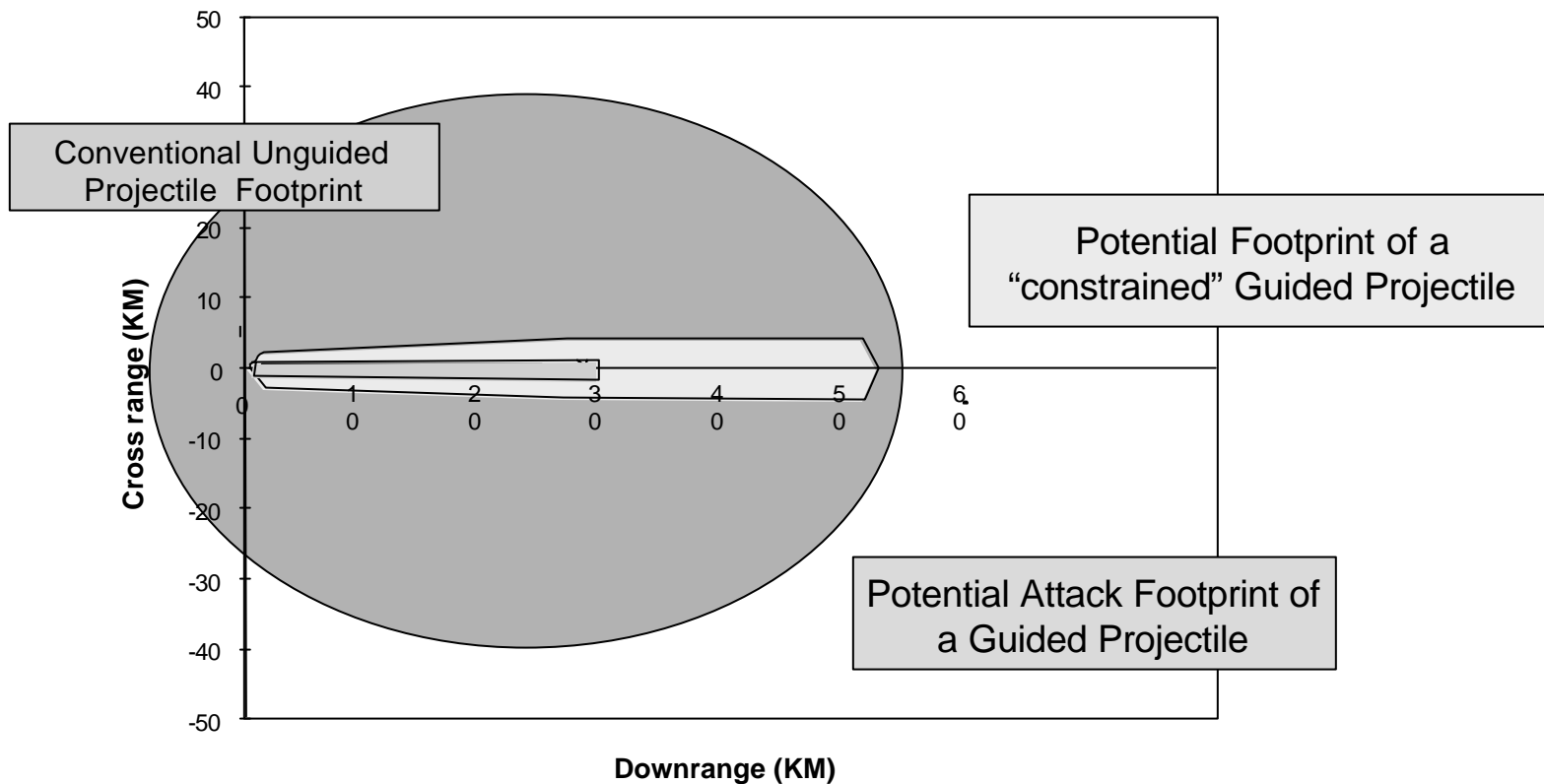
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Off Axis Attack Capability provided

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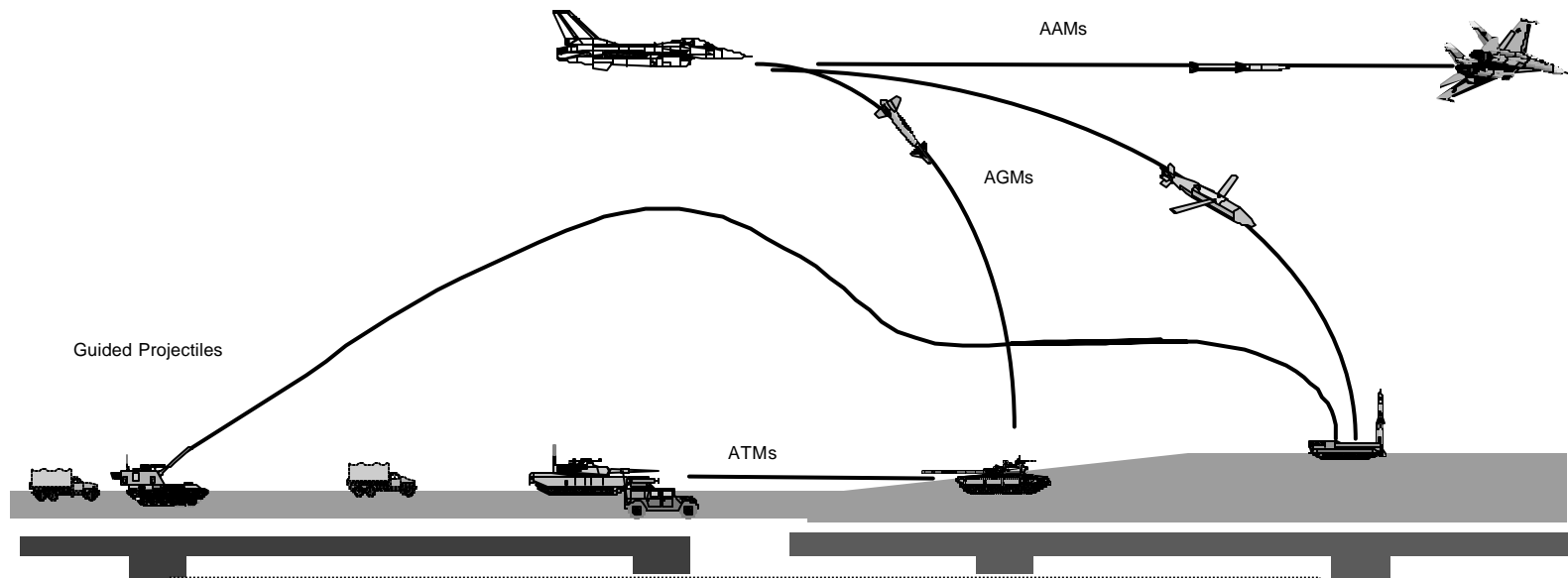
The ability to “fly” (example assumes 7-DOF guidance solution) means a gun can execute many firings missions from a single surveyed site without repositioning barrel



New requirement - Casualty function

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- **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.

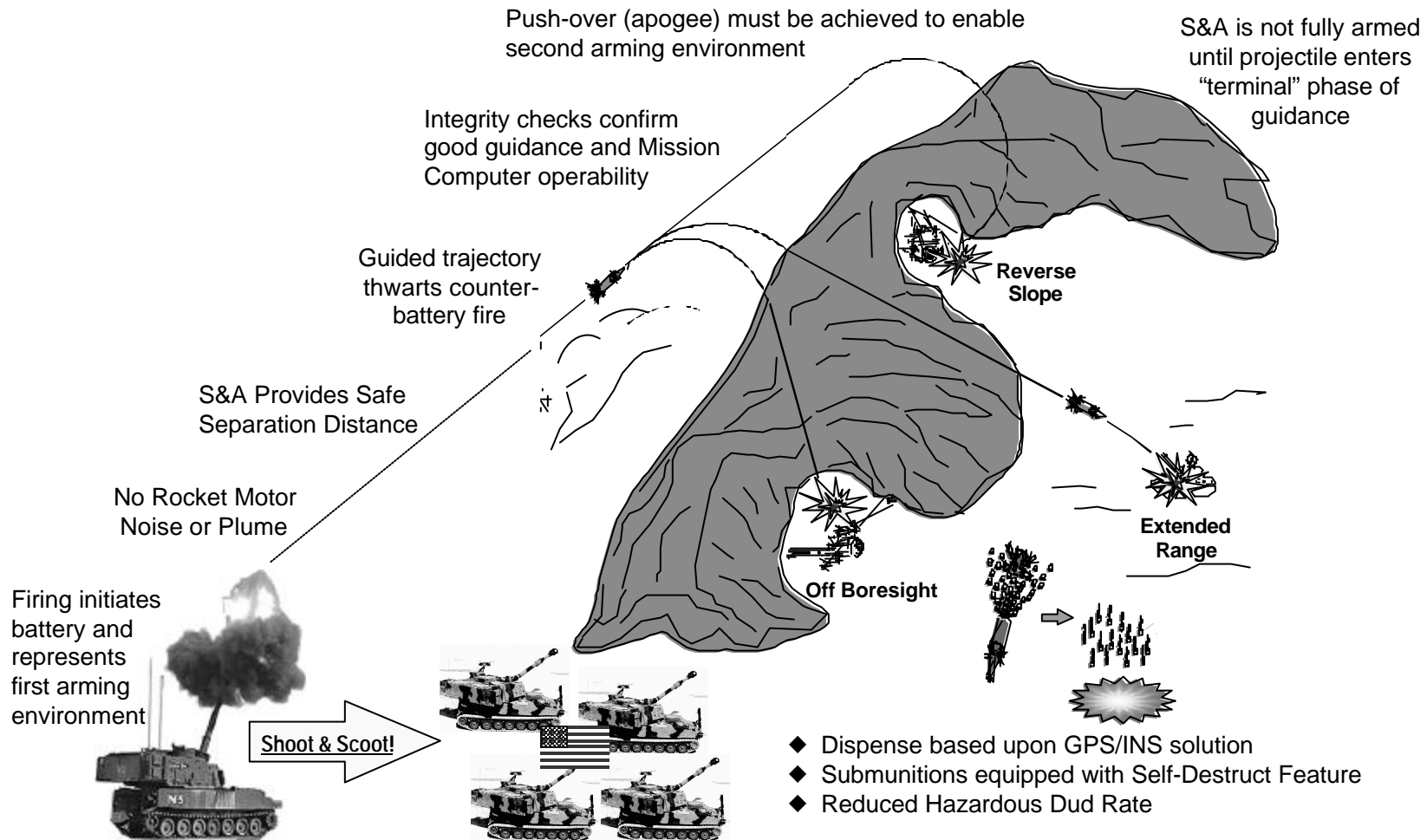


For the first time, overhead safety for EXTENDED ranges must be considered

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Example - Safety Features Over a Mission

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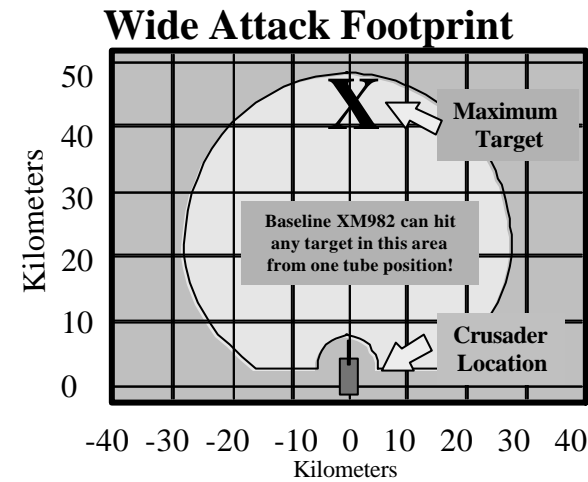
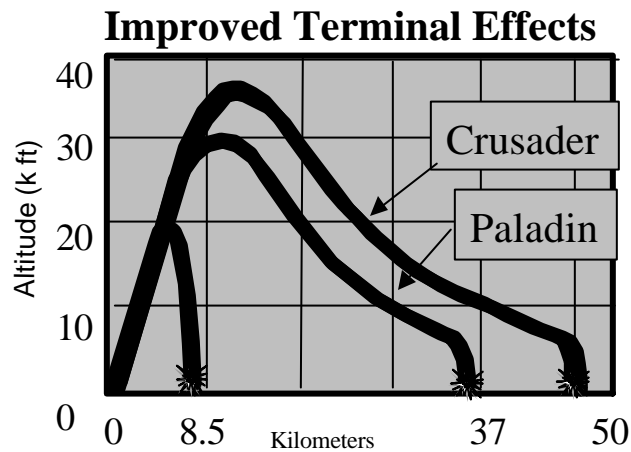


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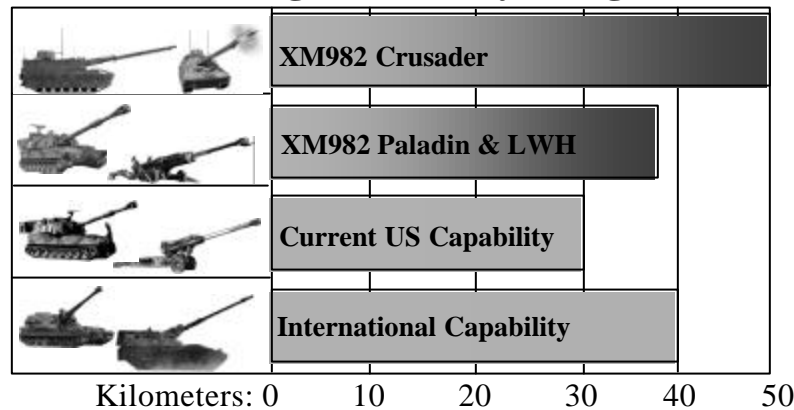
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Summary - Guided Projectiles provides

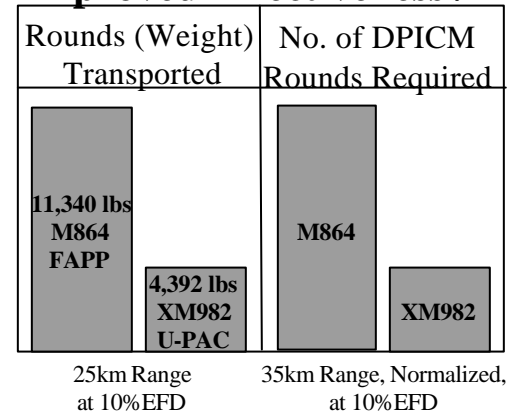
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Enhanced Range - Artillery Range Overmatch



Improved Effectiveness / Lethality



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