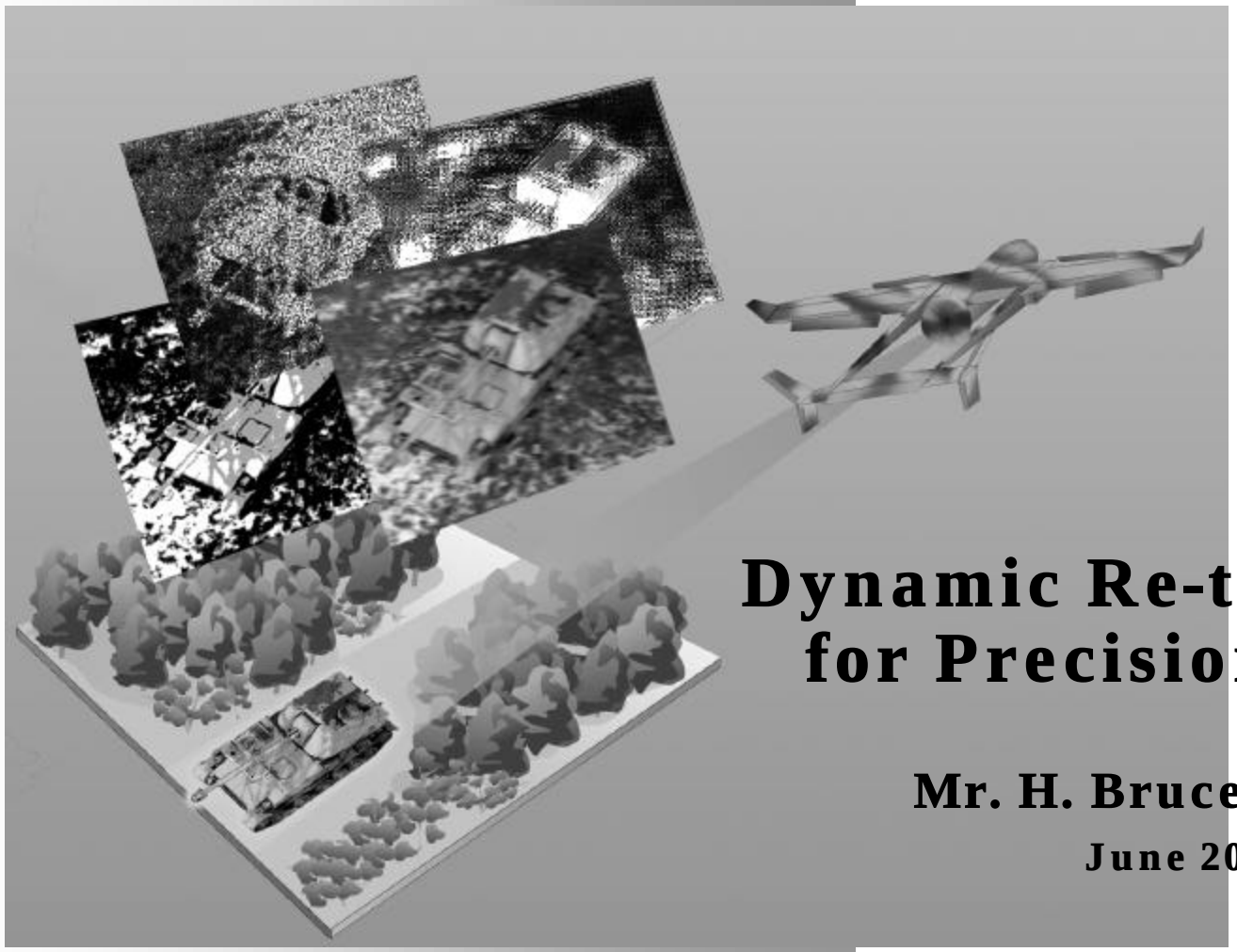
6th International Cannon Artillery Firepower Symposium & Exhibition



Dynamic Re-targeting for Precision Strike

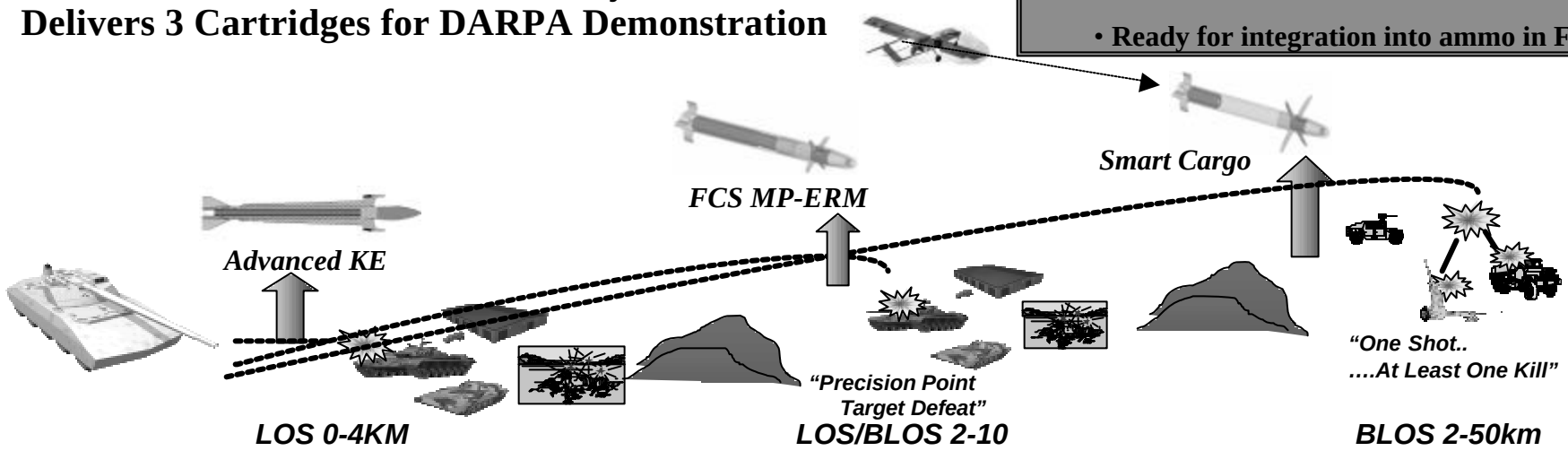
Mr. H. Bruce Wallace

June 2000

ARD-07 Ammunition Suite for FCS Multi-Role Cannon STO

Objective: **Develop and Demonstrate an Ammunition Suite that provides FCS with the lethal response against the spectrum of threats at LOS, Extended LOS and BLOS engagements (0-50km).**

- **Multi-Role, Multi -Mission Munition Family**
  - ***Advanced KE:*** **Defeats all future heavy armor threats**
  - ***FCS MP-ERM*****: Defeats high value point targets**
  - ***Smart Cargo*****: High accuracy delivery of lethal payloads**
- **Multi-purpose Warhead Development**
  - **Small, lightweight and more lethal**
- **Advanced Explosives Development**
  - **More energetic, less sensitive**
- **Feeds Multi-Role ETC Armament System STO**
- **Delivers 3 Cartridges for DARPA Demonstration**



(enabled by the "Ammunition Suite for FCS Multi-Role Cannon" Proposed STO)

ETC Multi-Role Cannon, with Advanced KE/EFP & Smart Long Range Munitions Consistent with ASB 99 Summer Study Lethality Recommendations

Initial Assumptions for BLOS Engagement

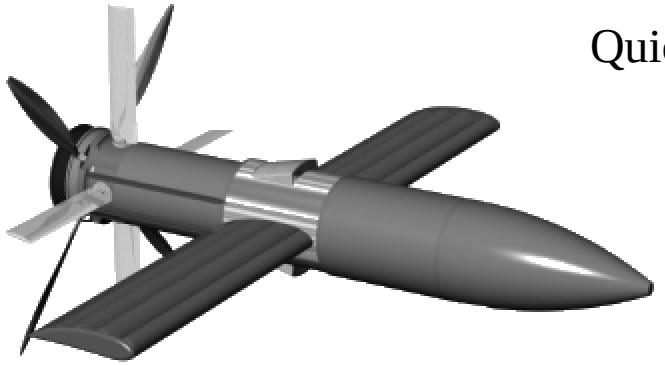
- 1 meter CEP out to 50 km
- Precision fire against moving hard targets
- FO/Scout functions are continuously available
- Launch platform and FO/Scout can communicate with munition
- Once an engagement begins, normal comms and GPS may be jammed

Sequence of Events and Sources of Error

- FO/Scout identifies target with GPS/time stamp
  - Errors associated with position of FO/Scout
  - Correct ID of Target
  - Prediction of path of travel
- Communications back to Fire Control with Decision
- Weapon brought to bear and munition fired
  - Ballistic errors
- Time of flight 30-600 sec
  - Target continues to move or stops
- Terminal homing - semi-/autonomous homing
  - Search area is a function of TLE, Ballistic Errors, target motion
  - Increasing search area creates increasing probability of false alarm for autonomous seekers (non-SAL)

FO/Scout Assets

Heavy Thermal Weapon Sight



QuickLook

TUAV

Future Scout Vehicle

Typical Errors Associated with Platforms

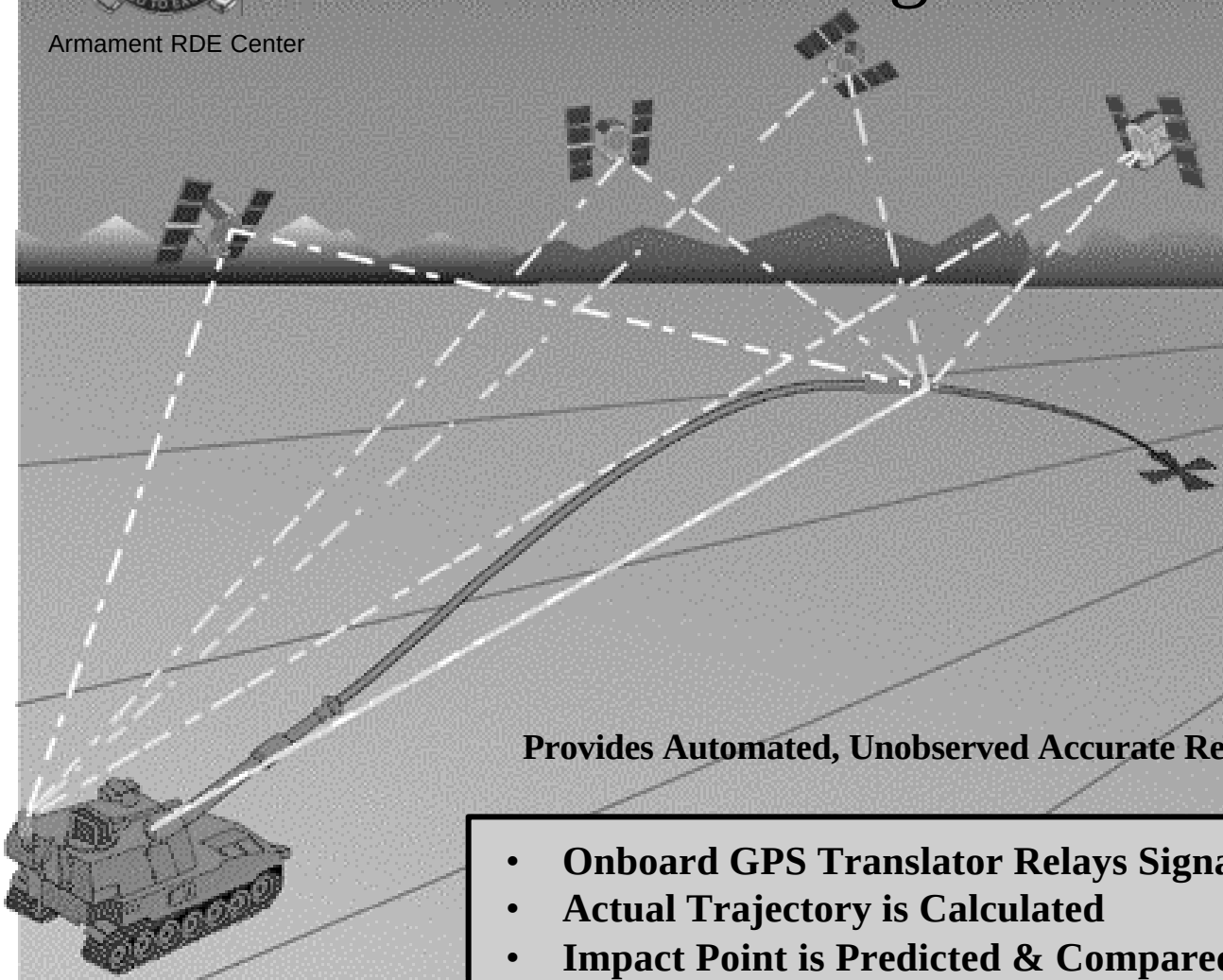
Launch Platform Errors		
Sensor Component	**Mean**	**Standard deviation**
POS/NAV	0	3.00%
GPS	0	4 meters
Heading	0	1 degree
Turret Azimuth (relative to hull)	0	0.01
Gun Elevation	0	0.01
Pitch and Roll	0	0.2 degrees
Scout Errors		
GPS	0	4 meters
Heading	0	1 degree
Pitch and Roll	0	0.2 degrees
Range to Target	0	10 meters

By having accurate knowledge of the munition location, errors associated with the launch platform are eliminated

Armament RDE Center

Army Research Laboratory

Auto Registration



Component Technology
- **GPS Translator**
- **Ground Based Receiver**

Provides Automated, Unobserved Accurate Registration

- **Onboard GPS Translator Relays Signals to Ground Receiver**
- **Actual Trajectory is Calculated**
- **Impact Point is Predicted & Compared to Aimpoint**
- **Ballistic Computer Generates Corrections for Immediate Transfer to Subsequent Fire**

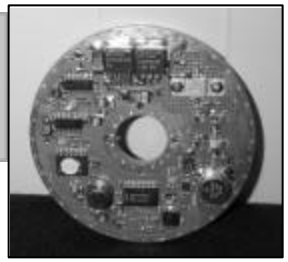
Responsive Targeting & BDA

Airframe
- CAES Lead
- High-Strength Composites
- Modular Sectional Design
- Proven Gun-Hardening Expertise
- 30 minunte Endurance
- 500-fpm Climb; 185 mph
- All-Weather Capable

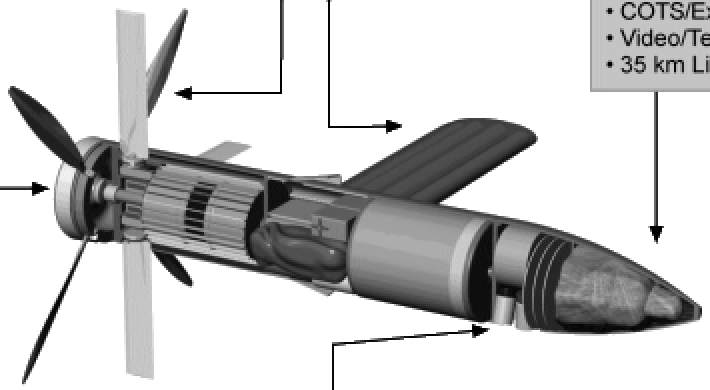
Inflatable Wings and Tail
- Vertigo Lead
- Minimum Stored Volume
- High Lift-to-Drag Ratio
- High Stiffness
- Full-Span Flaperons

Ground Station and Controller
- SAIC Lead
- Real-Time Video
- Real-Time Targeting/BDA
- Demonstrated Hardware Base
- Demonstrated Software Base
- Traceable to Handheld/Wearable

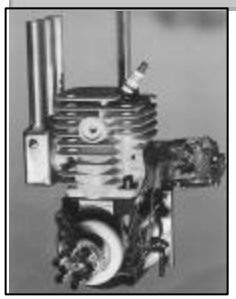
Communications Links
- SAIC/Xybion
- COTS/Existing Technical Base
- Video/Telemetry/Commands
- 35 km Link



Airtronics Actuators

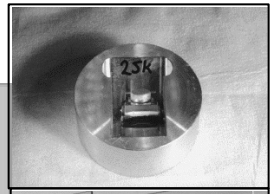


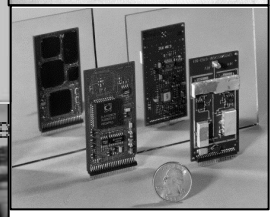
Engine and Propeller
- CAES/SAIC Lead
- COTS Approach
- High Efficiency
- Lightweight/Compact
  10 hp; 0.7 sfc



Sensors
- SAIC/Xybion Lead
- Low-Cost Modular Approach
- COTS Components
- 50-m Targeting Precision

Guidance and Control
- SAIC Lead
- Low-Cost Modular Approach
- COTS Components
- **BAES/Collins IMU/GPS**
- Autonomous Flight
- Real-Time Ground Redirect





Probabilities

$$P_{defeat} \cong P_{kill} * P_{hit} * P_{detect}^{N} * (1 - P_{FA}) * P_{encounter} * P_{function} * P_{launch}$$

where

$$P_{launch} = 1$$

$$P_{function} = .9$$

$$P_{hit} = 0.97$$

$$P_{FA} = \frac{A_{search} * D_{false_alarm}}{N * P_{detect} + A_{search} * D_{false_alarm}}$$

then

$$P_{defeat} = .87 * P_{kill} * P_{detect}^{N} * (1 - P_{FA}) * P_{encounter}$$

Moving Target Errors

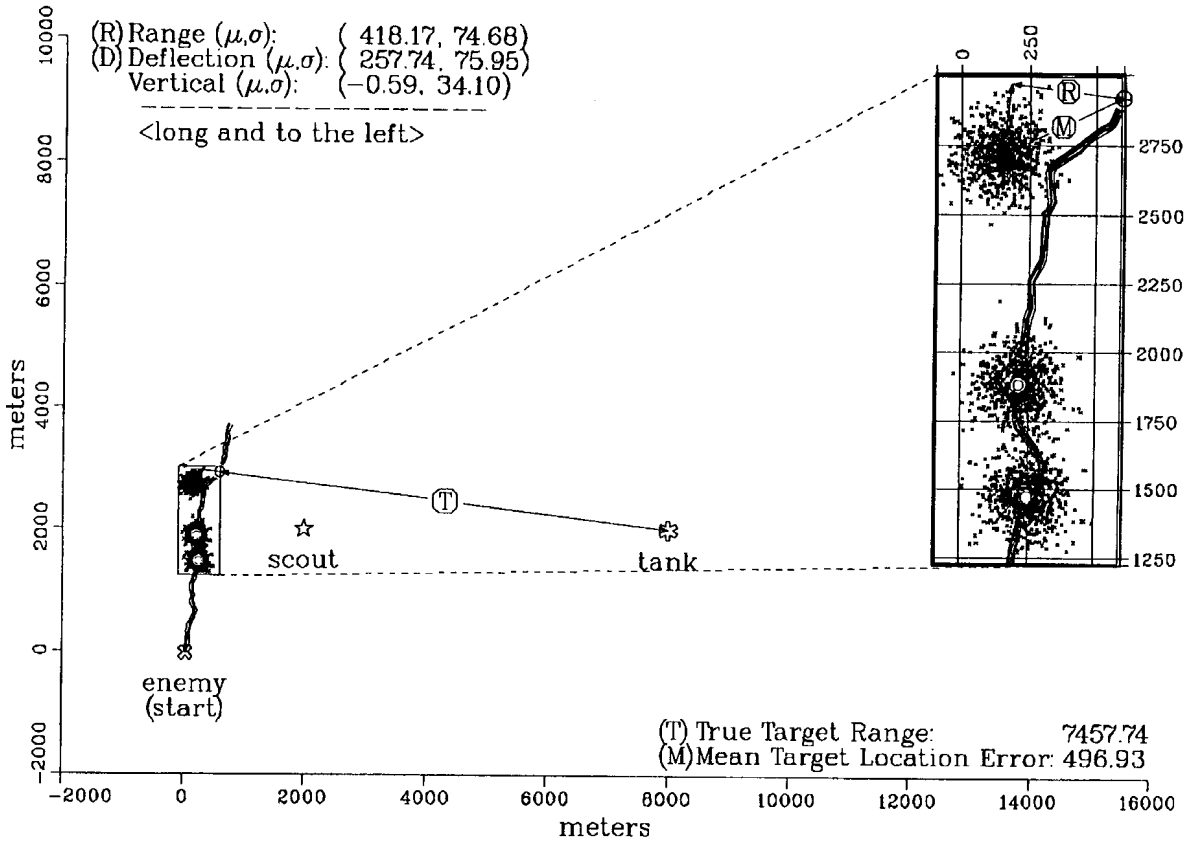


Figure 22. The Effect of Drift: Tank Drift - 5 Kilometers.

From "Target Location Error Methodology for the Tank Extended Range Munition", Joseph Wald, ARL-TR-1433, September 1997

TLE for Moving Targets

Table 4. Target Location Error Standard Deviations: Three Target Motions, 8000-meter Target Range

Total Delay Time / *Target Motion*	39.1 s		23.9 s		19.8 s	
	Range (m)	Deflection (m)	Range (m)	Deflection (m)	Range (m)	Deflection (m)
Mild Maneuver	142	141	83	83	67	70
Operational Maneuver	160	167	97	100	80	84
Evasive Maneuver	244	226	145	134	118	110

* Total delay time based on

12.5-second commo+decision+implementation time + TOF to 8 km for 300-, 700-, and 1100-m/s average velocity rounds

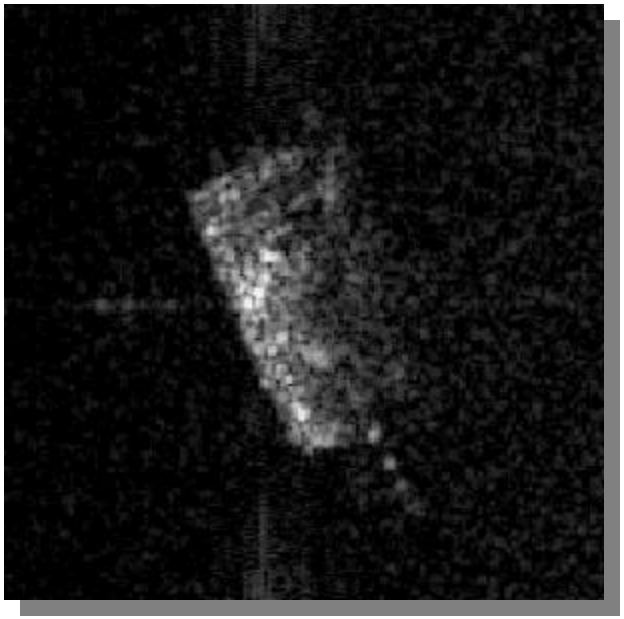
From "The Tank Extended Range Munition Probability of Encounter Study", Carolyn Patterson, ARL-TR-1612, August 1998

Receiver operating Curve (ROC) for Generic Seeker

ROC curve is affected by the complexity of the background and the complexity of the target mix

Images of T72 Targets Obtainable from FO/Scout Assets

MMW SAR



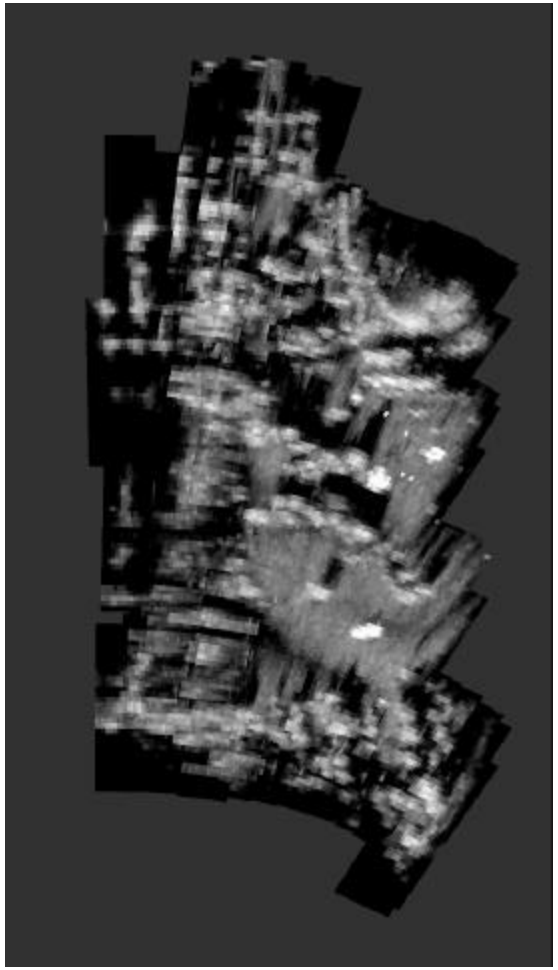
MWIR

By communicating to the seeker the specific target information, false alarms can be reduced and probability of detection enhanced

W-Band DBS Seeker Imagery

Target Area of NATO RSG20 MIMEX Experiment at Swinnerton, UK

T72 Image at 3.5 km



Probabilities

$$P_{defeat} \cong P_{kill} * P_{hit} * P_{detect}^{N} * (1 - P_{FA}) * P_{encounter} * P_{function} * P_{launch}$$

where

$$P_{launch} = 1$$

$$P_{function} = .9$$

$$P_{hit} = 0.97$$

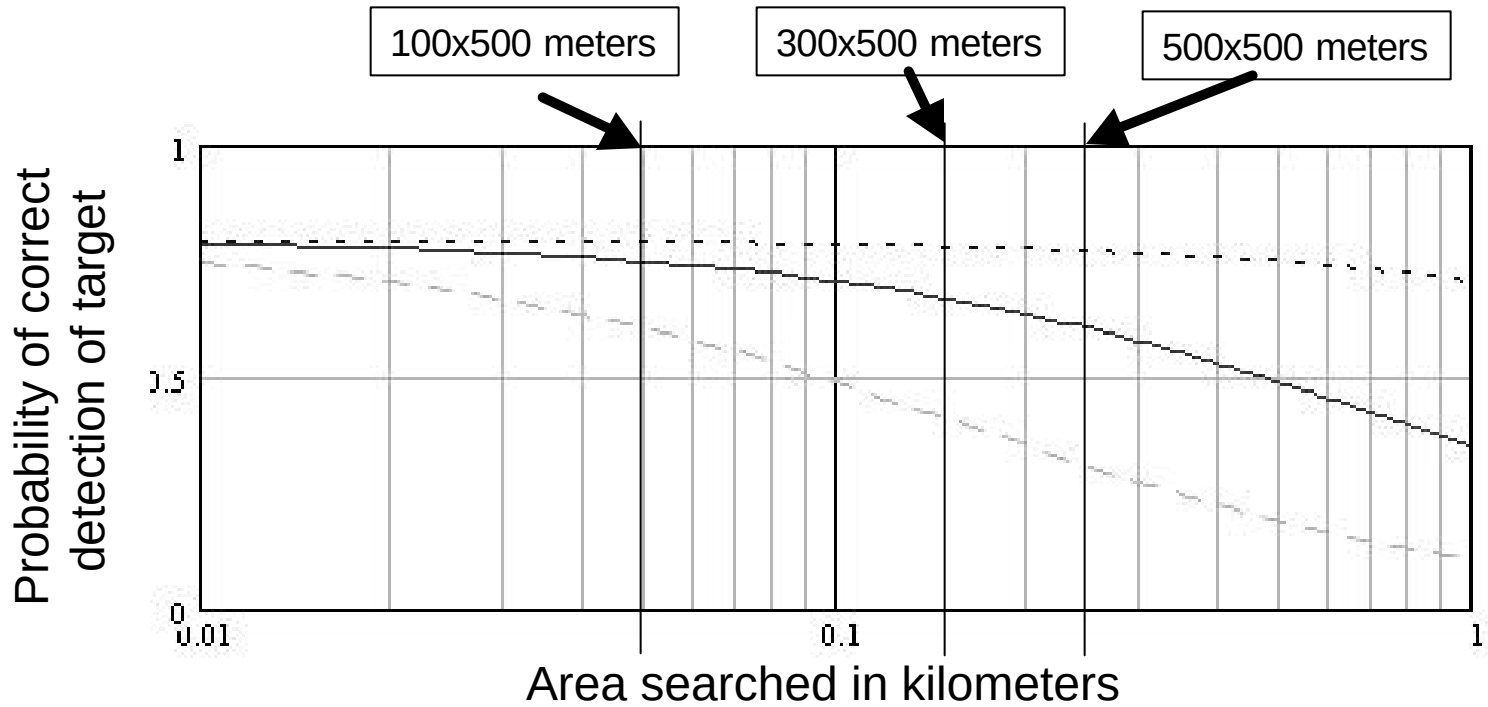
$$P_{FA} = \frac{A_{search} * D_{false_alarm}}{N * P_{detect} + A_{search} * D_{false_alarm}}$$

then

$$P_{defeat} = .87 * P_{kill} * P_{detect}^{N} * (1 - P_{FA}) * P_{encounter}$$

Probability of detection vs. Search Area

Assumed probability of detection for 1 target = 0.8



5 false alarms per km^2

1 false alarms per km^2

0.1 false alarms per km^2

Probability of Detection Vs.Probability of Engagement for a Moving Target

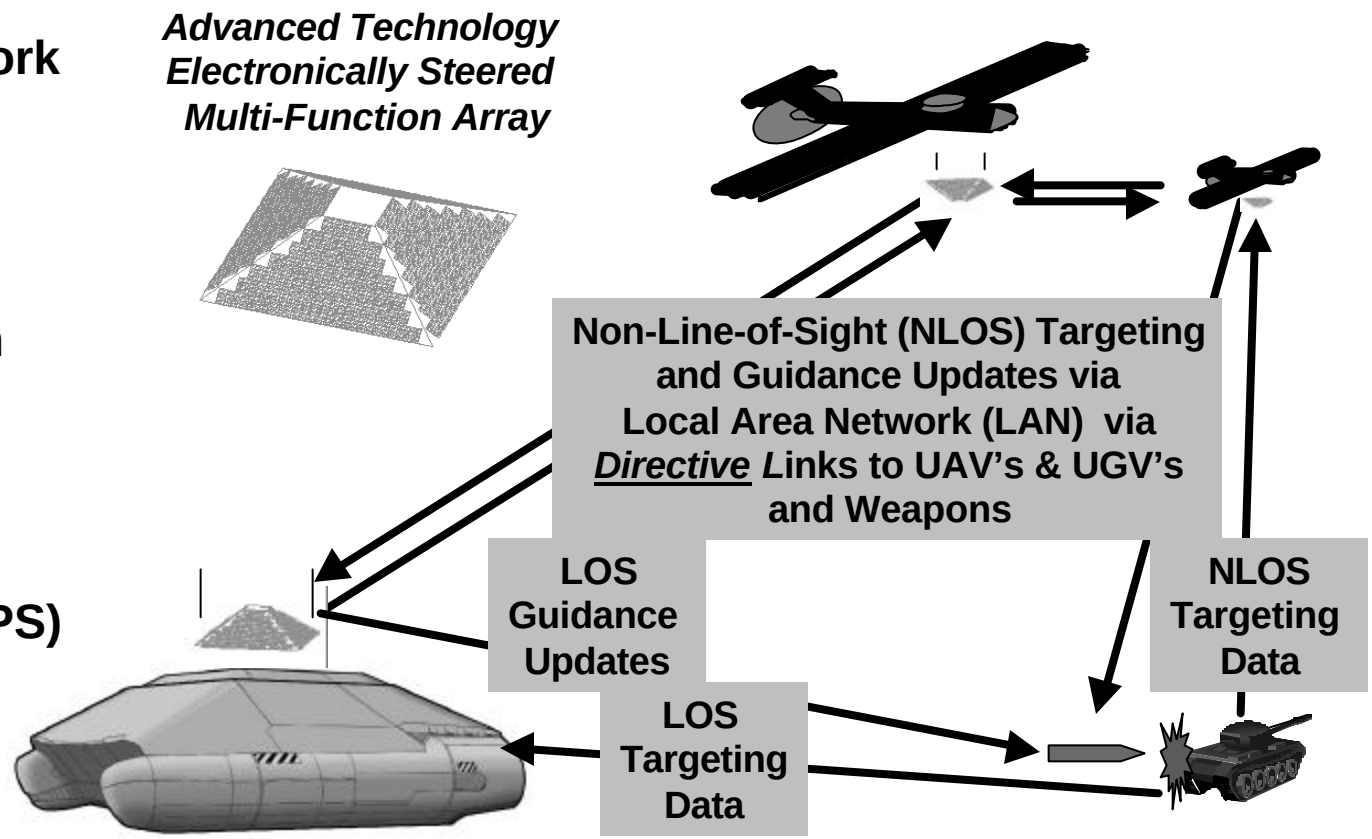
Search Area	Probability of Encounter*	False Alarms per Sq. Km	Effective Probability of Detect	Cumulative Probability
100mx500M	0.22	0.1	0.8	0.176
		1.0	0.75	0.165
		5.0	0.6	0.132
300mx500m	0.56	0.1	0.79	0.442
		1.0	0.7	0.392
		5.0	0.4	0.224
500mx500m	0.76	0.1	0.77	0.585
		1.0	0.6	0.456
		5.0	0.3	0.228

**** Probability of Encounter from Patterson for a 300 m/sec flight from 8 km***

The greatest improvement in performance can be realized by increasing Probability of Encounter through continuous re-targeting of the munition

Target Engagement Network Supports NLOS Guidance Updates (without GPS)

- **Wide bandwidth Directive Link Network for Targeting**
- **GPS/INS Used for Baseline Position Referencing System**
- **Provides Jam Resistant Weapon update on Target position (without GPS)**



NORTHROP GRUMMAN

What's the Point?

- In order to meet requirements for sufficient probability of kill for precision strike at extended ranges, re-targeting will be required because:
  - Large seeker search areas can significantly reduce probability of detection
  - Large seeker search areas are required to ensure an encounter without re-targeting
  - Communications with the munitions for location information and target descriptions can enhance performance significantly
  - Implementation of extended range precision engagements will require reassessment of asset authority - perhaps dynamic reallocation of control