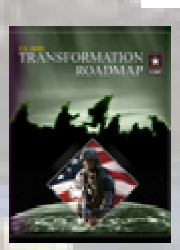
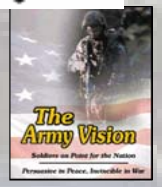

PEO Tactical Missiles
Sensor to Shooter Timeline Equation
PRECISION FIRES
PRECISION FIRES
ROCKET & MISSILE SYSTEMS
TACTICAL
PROGRAM EXECUTIVE OFFICE
PRECISION STRIKE
MISSILES
Non-Line of Sight Launch System
Close Combat Weapon Systems
CCWS
One Shot - One Kill
JOINT COMMON MISSILE
ARM
Aviation Rockets and Missiles
BG Mike Cannon

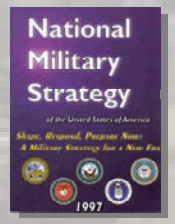
Operational Background

- **THREAT TRENDS**
  - Asymmetric / Paramilitary
  - Seeks cover in reinforced structures and vehicles
  - Nonlinear battlefield
  - Seeks sanctuary in urban and complex terrain

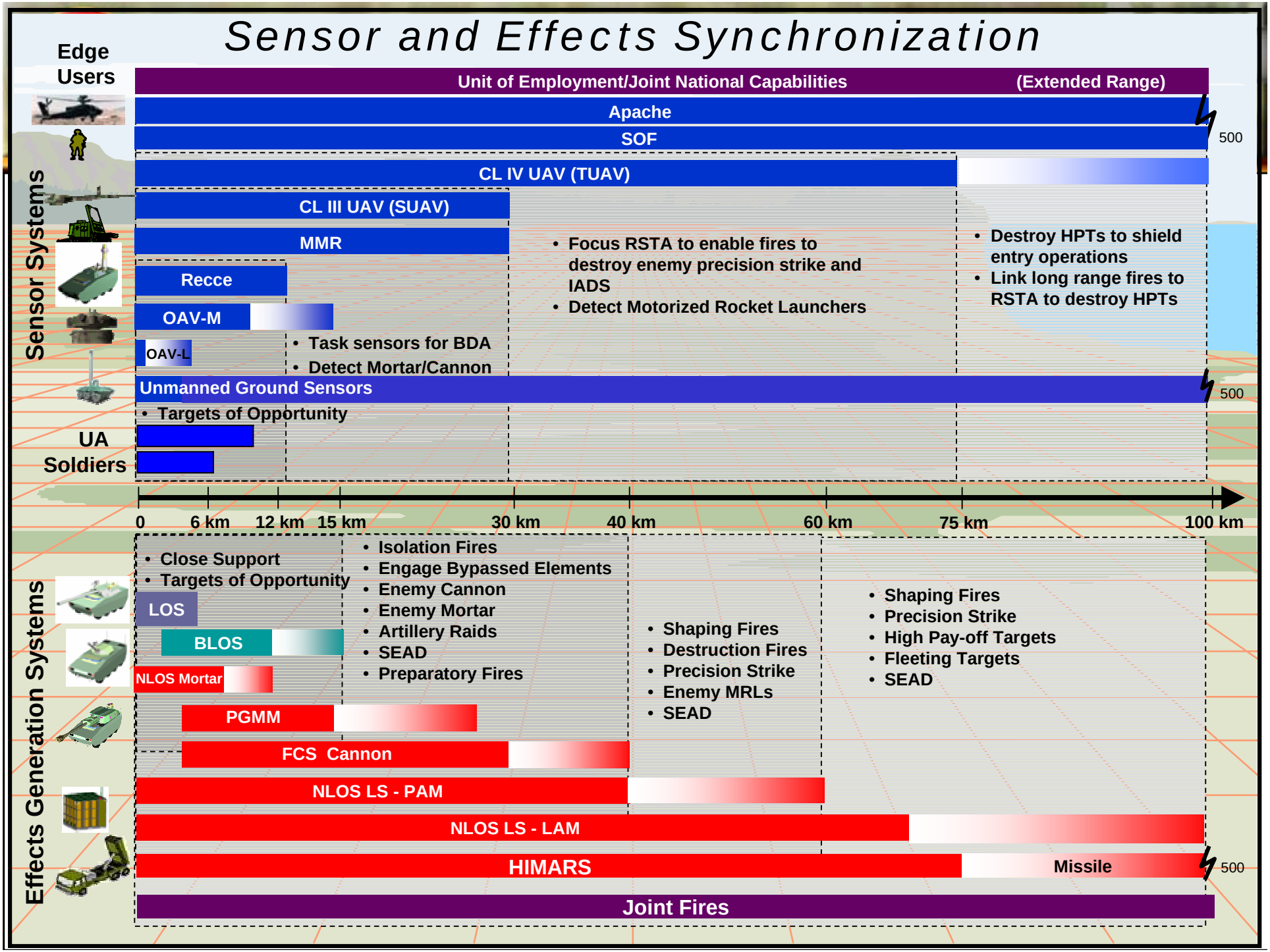
- **DOCTRINE and TTP EVOLUTION**
  - Network centric warfare (Fires and Effects)
  - Reduced collateral damage
  - More efficient fires
  - Reduced logistics/footprint
  - Standoff range
  - Scaleable effects
  - Special purpose fires (non-lethal)
  - Proliferation of targeting systems







- **RULES OF ENGAGEMENT TRENDS**
  - Minimize collateral damage to protect:
    - ✓ Noncombatants
    - ✓ Religious and cultural landmarks
    - ✓ Socio-economic infrastructure
  - Conduct less-lethal operations


Sensor and Effects Synchronization
Edge Users
Unit of Employment/Joint National Capabilities
(Extended Range)
Apache
SOF
500
Sensor Systems
CL IV UAV (TUAV)
CL III UAV (SUAV)
MMR
Recce
OAV-M
OAV-L
• Focus RSTA to enable fires to destroy enemy precision strike and IADS
• Detect Motorized Rocket Launchers
• Destroy HPTs to shield entry operations
• Link long range fires to RSTA to destroy HPTs
• Task sensors for BDA
• Detect Mortar/Cannon
Unmanned Ground Sensors
500
• Targets of Opportunity
UA Soldiers
0
6 km
12 km
15 km
30 km
40 km
60 km
75 km
100 km
Effects Generation Systems
• Close Support
• Targets of Opportunity
LOS
BLOS
NLOS Mortar
PGMM
FCS Cannon
NLOS LS - PAM
NLOS LS - LAM
HIMARS
Missile
500
• Isolation Fires
• Engage Bypassed Elements
• Enemy Cannon
• Enemy Mortar
• Artillery Raids
• SEAD
• Preparatory Fires
• Shaping Fires
• Destruction Fires
• Precision Strike
• Enemy MRLs
• SEAD
• Shaping Fires
• Precision Strike
• High Pay-off Targets
• Fleeting Targets
• SEAD
Joint Fires

Timeline Equation

- **Total System Error = sqrt [(Target Location Error)*2 + (Velocity Estimation Error X Time)*2 + (Delivery Error)*2]**

$$TSE = \sqrt{TLE^2 + [(VEE)T]^2 + DE^2}$$

- **Error sources: Usually measured in 'circular probable errors', or 'standard deviations in downrange and cross range'. Whatever measure is chosen, it must be common throughout the expression.**
- **Target Location Error (TLE): The error associated with the sensor itself, whether radar, IR, LADAR, etc. Sensor developer responsibility.**
- **Velocity Estimation Error: Error associated with estimating the target velocity. Sensor developer responsibility.**
- **Time: Elapsed time beginning when sensor senses target and ending at munition (effector) function.**
- **Delivery Error: The accuracy with which the projectile or missile can be delivered to a desired aimpoint. Missile and launch platform developer responsibility.**

Total System Error for a stationary target:

$$TSE = \sqrt{TLE^2 + DE^2}$$

Timeline Equation Example

NOMINAL SCENARIO: Observer with Global Positioning System (GPS) and a Laser Range Finder / Laser Designator (LRF / LD) observes a moving target on road, calls in mission, and a GPS / Inertial Navigation System (INS) missile equipped with a Semi-Active Laser (SAL) seeker is launched to a predicted aimpoint. Range from launcher to target is approximately 40 kilometers.

TLE = 10 meters
VEE = 1.2 meters/sec
DE = 10 meters (CEP)

T = Battle Command time + launcher time + time of flight
= 20 sec + 20 sec + 240 sec
= 280 sec

$$TSE = \sqrt{TLE^2 + [(VEE)T]^2 + DE^2}$$

$$TSE = \sqrt{10^2 + [(1.2)\,280]^2 + 10^2}$$

$$TSE = \sqrt{100 + 112{,}896 + 100}$$

TSE = 336.3 Meters

Stationary Target

$$TSE = \sqrt{TLE^2 + DE^2}$$

$$TSE = \sqrt{10^2 + 10^2}$$

TSE = 14.1 Meters

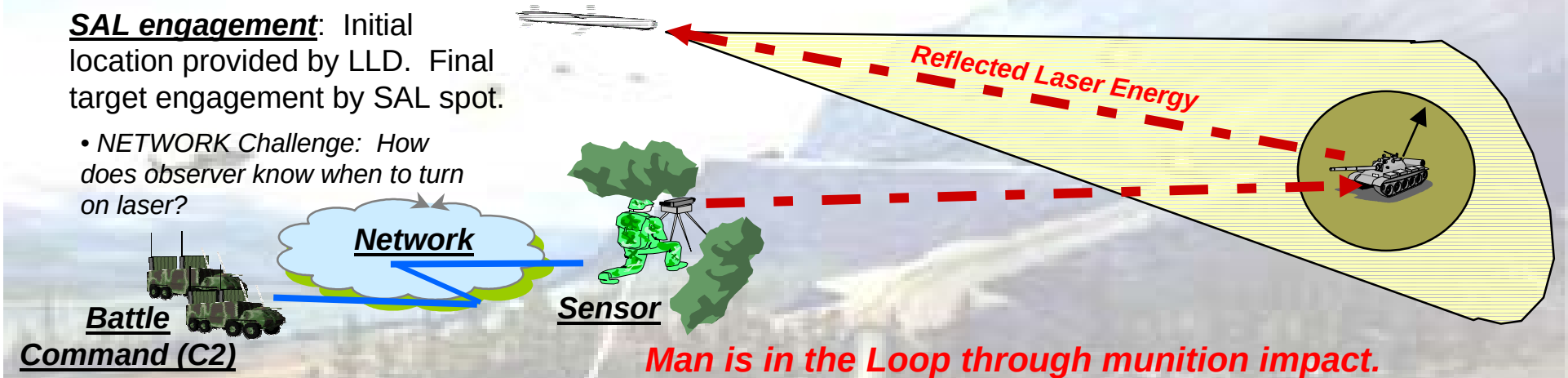
Assuming a SAL seeker with a Field of View of 13 degrees and sensitivity to start acquiring reflected energy from the LD at approximately 4 kilometers, the cross range dimension of the SAL basket will be greater than 900 meters, and the down range dimension greater than that.

BOTTOM LINE: The SAL seeker should be able to acquire the laser spot and guide the missile to impact on target, or Imaging Infrared (IIR) / Millimeter Wave (MMW) acquires, guides missile to target.

Timeline Equation Example View

SAL engagement: Initial location provided by LLD. Final target engagement by SAL spot.

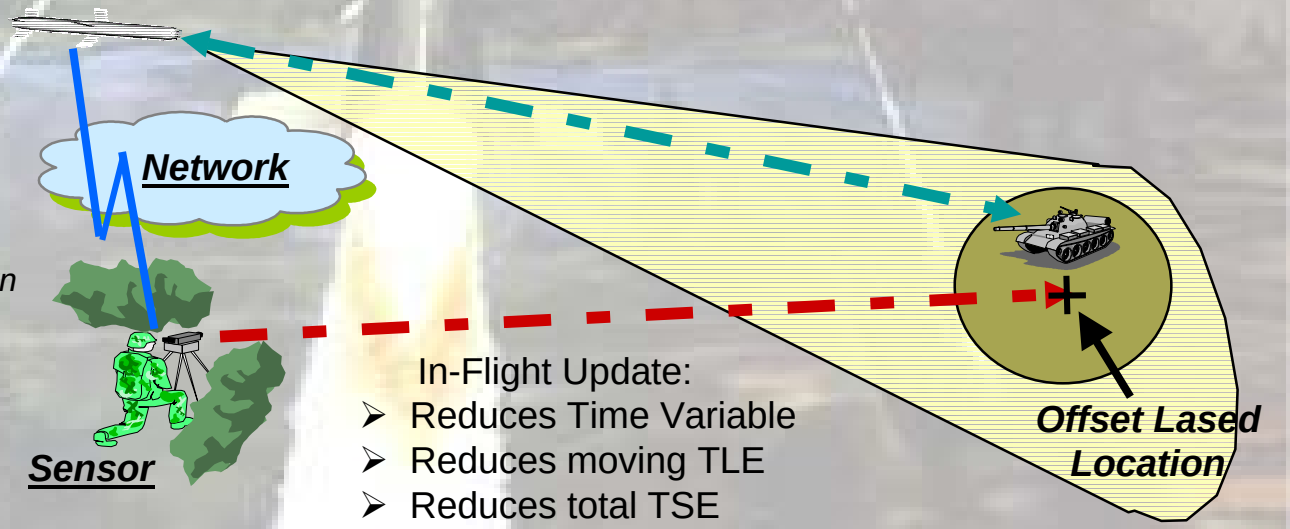
- *NETWORK Challenge: How does observer know when to turn on laser?*



Man is in the Loop through munition impact.

IIR / MMW engagement variant: Initial target location and update by LLD. Final target engagement by IIR / MMW.

- *NETWORK Challenge: How does observer know when to turn off laser?*



In-Flight Update:

- Reduces Time Variable
- Reduces moving TLE
- Reduces total TSE

Non-Line of Sight
Sensor to Sensor Handoff

Network Challenges

- *NCES versus legacy communication processes, data base storage, retrieval*
- *XML versus VMF, Link-16*
- *Inherent latencies versus point-to-point links*
- *Bandwidth*
- *Emerging Waveforms*
- *JTRS versus SINCGARS*

UAV

In-Flight Update

- Reduces Time Variable
- Reduces moving TLE
- Reduces total TSE

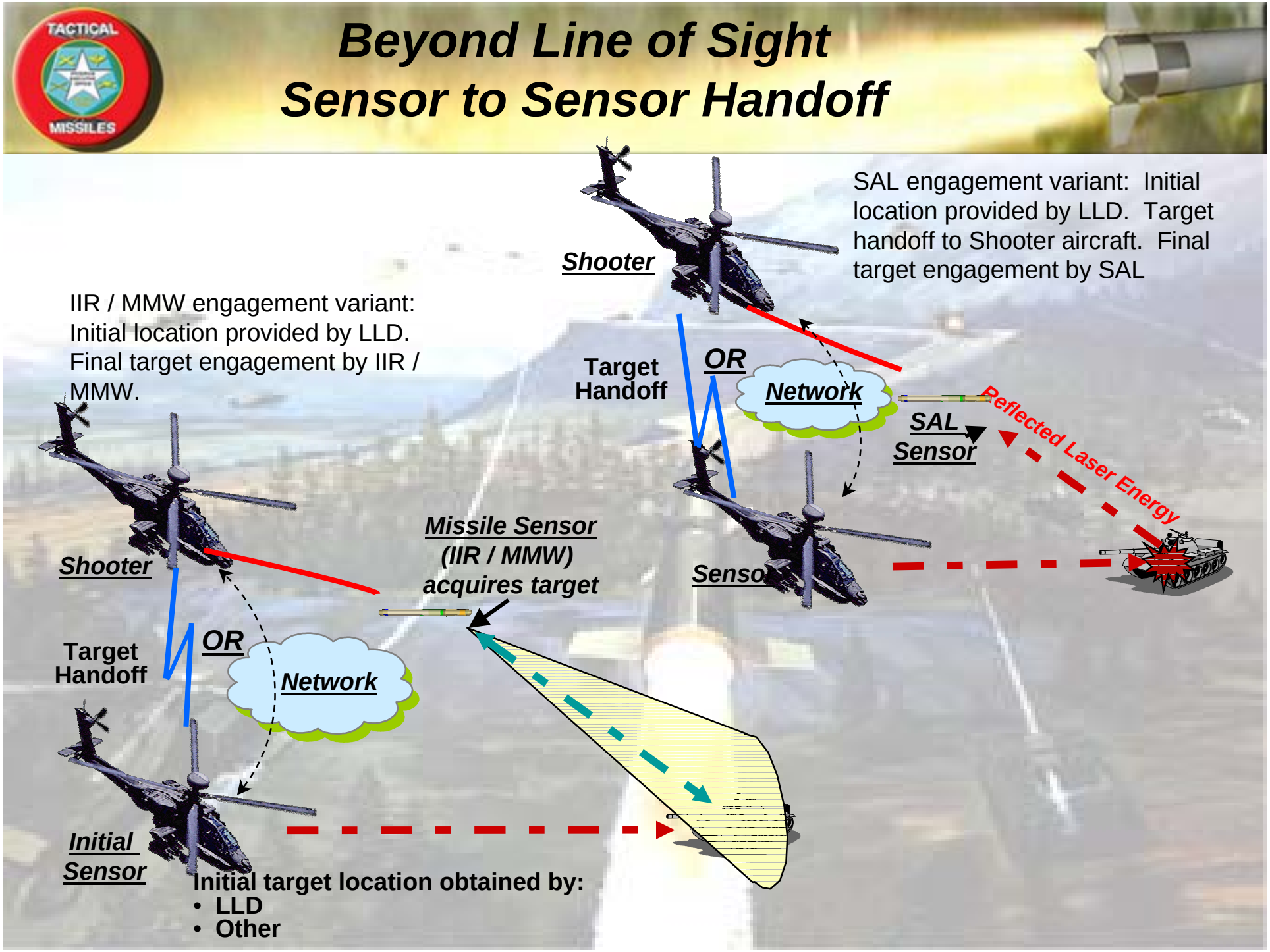
Other than at UAV Common Ground Station, Man is out of the Loop after missile launch.

IIR / MMW ATR acquires target, guides missile to target

Launcher

Sensor to Sensor Handoff occurs through Sensor to Shooter pairing IAW Battle Command System Commander's Policies.

Beyond Line of Sight
Sensor to Sensor Handoff



Tri-Mode Seeker Logic
BLOS Fire& Forget LOAL Mission
Sensor Synergy

IMU

MMW

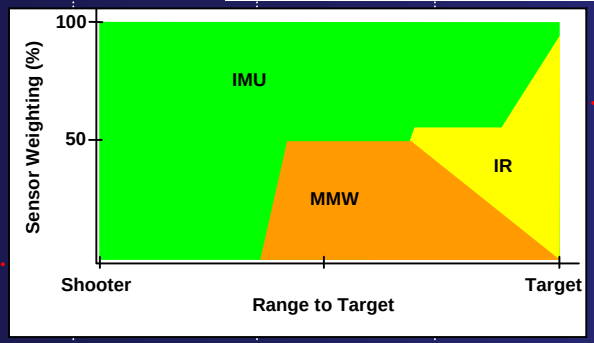
IIR

Phase 1: Inertial Navigation
The missile will navigate to the predicted target location using the IMU. Based on target type and other factors, the MMW and IIR will probably not be active during this phase.

Phase 2: MMW Detection
The MMW will come on line and begin processing detections. Detections will then be prioritized based on the target location and velocity.

Phase 3: ATA
The IIR will come on line and MMW and IIR will work together to determine which detections are most target like. This phase is where selection of a target or ATA takes place.

Phase 4: Terminal Track
The IIR will take priority and transition to target track on the most target like detection that best matches the target handover. The MMW will transition to backup tracking.



Range to Target

The key to Fire & Forget LOAL is merging the different sensor outputs including the IMU to increase the probability of target acquisition.

LOAL – Lock On After Launch
MMW – Millimeter Wave
IIR – Imaging Infrared
IMU – Inertial Measurement Unit
ATA – Autonomous Target Acquisition

Total System Error

"WHAT CAN BE DONE TO REDUCE TOTAL SYSTEM ERROR?"

***TARGET LOCATION ERROR*: INS / GPS based systems provide accurate locations. *ROOM FOR IMPROVEMENT*: SMALL**

***VELOCITY ESTIMATION ERROR*: Very accurate – a calculation based on the sensor's ability to estimate a target velocity. Error is increased if velocity changes prior to munition function. *ROOM FOR IMPROVEMENT*: SMALL**

***DELIVERY ERROR*: Very accurate INS / GPS based systems provide very low delivery errors. Capability for in-flight update reduces error even further. *ROOM FOR IMPROVEMENT*: SMALL**

***TIME*: Biggest driver of the 'total system error' equation. *ROOM FOR IMPROVEMENT*: LARGE**

The Problem of Time

- **Many processes making up Battle Command time can be automated. Examples would be effects based weapon-target pairings and defeat criteria / target type.**

- **Some of the processes will not always lend themselves to automation. Measures related to rules of engagement, collateral damage, and fratricide are more likely to require human intervention, on a case-by-case basis.**

- **The operational scenario and the risks the Commander is willing to take, will drive which processes will be automated, and which processes will require human intervention.**

The more human intervention involved in the C2 process, the greater the TIME variable in the sensor-shooter timeline equation.

Division of Labor

Sensor System Developers

- Develop reliable ATA/ATR
- Develop reliable / robust sensors
- Reduce sensor TLE
- Integrate sensors into network

Network System Developers

- Integrate communications
- Develop reliable / robust platforms
- Develop effective Battle Management System software
- Manage the Spectrum (manage / expand available bandwidth)
- Develop reliable long-range radios

Weapons System Developers

- Develop multi-mode seekers
- Develop reliable ATA / ATR
- Improve IMU / INS / GPS systems to reduce delivery error
- Integrate platform / munitions into Network
- Develop more effective lethal mechanisms
- Improve propulsion reducing TOF

Operational / User Community

- Articulate requirements
- Develop appropriate TTP
- Staff / train Battle Command cells appropriately

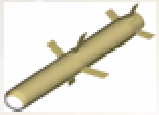
Each can reduce the Time variable

PEO Tactical Missiles Approach

- PEO TACTICAL MISSILE SYSTEMS UNDER DEVELOPMENT INCLUDE AUTONOMOUS AND MAN IN THE LOOP CAPABILITY.

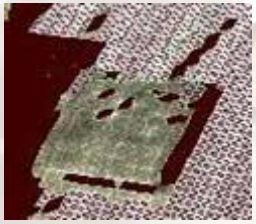
- JOINT COMMON MISSILE – MMW RADAR / IIR / SAL SEEKER

- NLOS-LS PAM – IIR / SAL SEEKER / GPS

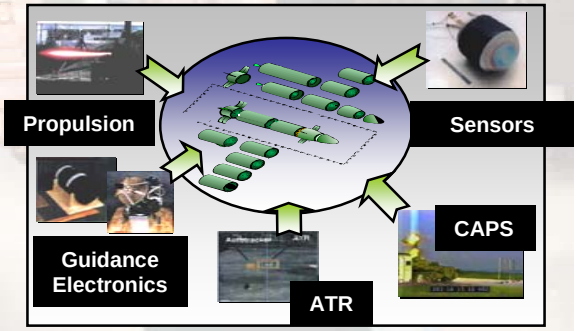


Multimode Seekers

- NLOS-LS LAM – Loitering / LADAR seeker / Send and Receive Comms / GPS



Lam Chiplet



- GMLRS – GPS

- APKWS – SAL SEEKER

- VIPER STRIKE / EAGLE EYES - SAL / IIR / MMW SEEKER

APPLICABLE TECHNOLOGIES

TECHNOLOGY	Maturity/ Resourcing	NLOS	CCWS	PFRMS	ARM	JCM
Large array (640x480) Dual Mode Uncooled IR/SAL Seekers	5	✓				
Enhanced Dual Mode LADAR/SAL Seeker technology (11 beam resolution)	5	✓		✓		
Controllable thrust propulsion	4	✓		✓	✓	✓
Automatic Target Acquisition Algorithms	5	✓	✓	✓		✓
Multi mode warhead technology	3	✓	✓	✓	✓	✓
IM compliant warhead and propulsion systems		✓	✓	✓	✓	✓
Tri-mode seeker dome with EMI and RCS reduction	5					✓
Remote Readiness Asset Prognostic/Diagnostics	6	✓				✓
CAPS	3	✓	✓		✓	✓
Gel Propulsion (focusing on IM)	5 / NA	✓	✓		✓	✓
Hi-G MEMS IMU	5	✓	✓	✓		

Resourcing: GREEN (G) = Adequate Funding AMBER (A) = Insufficient Funding RED (R) = No funding

APPLICABLE TECHNOLOGIES
(cont)

TECHNOLOGY	Maturity/ Resourcing	NLOS	CCWS	PFRMS	ARM	JCM
Uncooled IR	4	✓	✓			✓
IR Laser Hardened Countermeasures	4	✓	✓		✓	✓
Novel penetrators	4		✓	✓		
Alt msl guidance schemes (MMW, RF)	4		✓			
Alt low-cost power sources for missiles (other than thermal batteries)	5		✓			✓
In-Flight Reprogramming	4	✓		✓		✓
GPS Anti-Jamming	5	✓		✓		✓
Joint Interoperability		✓		✓		✓
MEMS IMU	5	✓		✓	✓	✓
LADAR	5	✓				

Resourcing: GREEN (G) = Adequate Funding AMBER (A) = Insufficient Funding RED (R) = No funding

THE PEO HAS NO R&D BUDGET TO TRANSITION THESE TECHNOLOGIES

EVOLVING ARMY TRANSFORMATION

Current to Future Force - Accelerate fielding of select Future Force capabilities to enhance effectiveness of Current Force. Army Transformation is part of constant change.

Countermeasures

Multi- Mode Seekers

IM Warhead & Propulsion

Multi-mode Warhead

ATA Algorithms

Controllable Trust Propulsion

CURRENT

MLRS

M270A1

LONGBOW HELLFIRE

HELLFIRE/ PREDATOR

APKWS

VIPER/UAV

IBAS

ITAS

HYDRA 70

JAVELIN

ATACMS

HIMARS

JAVELIN P3I

GMLRS

NLOS LS

PAM

LAM

LOSAT

FUTURE JAVELIN

JOINT COMMON MISSILE

FUTURE

CKEM

Developing the Future Force while Simultaneously Spiraling Future Capabilities into the Current Force

-- "The Way Ahead"

What's it all Mean?