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NDIA 46th Annual Armament Systems:
Gun & Missile Conference & Exhibition

Netted Smart Precision Engagement Autonomous Rounds (NetSpears) for Navy and Army Weapons

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13 April 2011

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SUBJECT DATA GENERATED DURING PERFORMANCE OF NAVY CRADA (NCRADA-NAWCWDCL-04-124) BETWEEN RAYTHEON COMPANY AND NAVAL AIR WARFARE CENTER WEAPONS DIVISION.

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Overview

- This smart submunition was designed to be utilized by both existing Army and Navy weapon platforms in order to deliver a lower cost and more capable munition to increase warfighter effectiveness.

- Briefing Objective:
  - Overview of the Small Boat Attack Problem
  - Describe the smart submunition, subsystem components, design trades and predicted simulation performance results
  - How the weapon system can be delivered by current Army and Navy weapon platforms and the CONOPS for its employment

The benefit to the gun and missile community is that this type of weapon enables a capability equivalent to massed fires with precision lethality against both asymmetric and conventional threats.

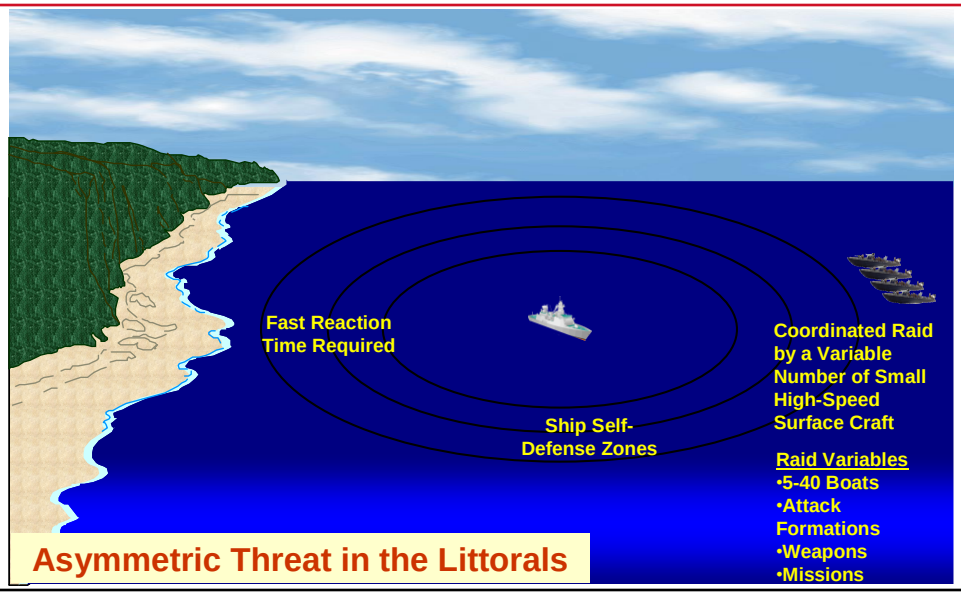
Small Boat Attack Problem

NEED: Countering the Small Boat Attack Problem is Still a Top World Problem

US APPLICATIONS:

- **ASuW Mission Module for LCS**
- **Littoral Battle Space**
  - **Air Launched: JSOW**
  - **Ship Launched Helos**

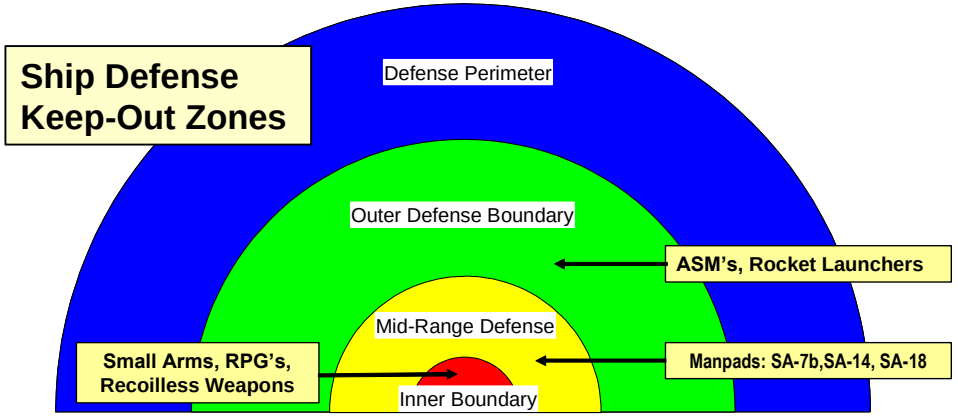
DoD Movie



Littoral ASuW Requirements

1. **A Layered Defense is Required for the "Many-on-One" Attack**
2. **Guided Weapons Are Needed to Defeat The Small High Speed Boat Threat**
3. **Weapon Load-Out is One of the Most Important Factors**
   - **The More the Better!**
4. **The Farther Out You Start to Engage Them, The Better**
   - **If You Wait Too Long, You Don't Have the Reaction/Engagement Time Available**

- **Zone Descriptions**
  - **Defense Perimeter: Lowest Risk Defense (15 nm Radius)**
  - **Outer Defense Boundary: Moderate Risk Defense (8-10 nm Radius)**
  - **Mid-Range: Threshold for Surface-to-Surface Missile Threat (5 nm Radius)**
  - **Inner Boundary : Highest Surface-to-Surface Missile Threat (2.5 nm Radius)**



The Small Boat Threat

- **Wide Spectrum of Asymmetric Threats**
  - Detection Issues
  - Large and Small Raid Sizes
  - Multitude of Attack Scenarios
  - Numerous Weapon Keep-Out Ranges
- **Compressed Timelines**
- **Restrictive Rules of Engagement (ROE)**
- **Likelihood of Collateral Damage**

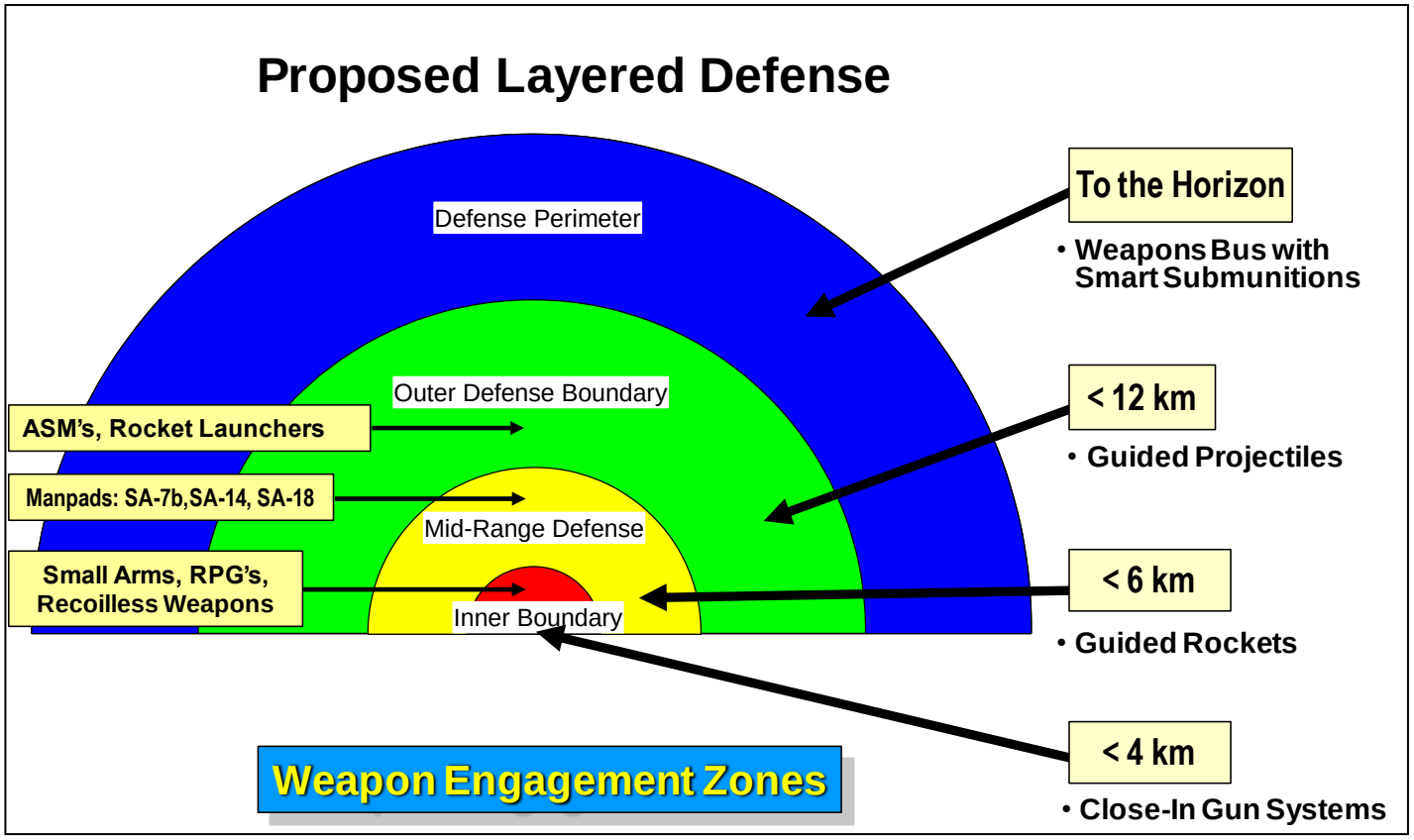
- **Small Craft Threats Range In Size, Agility And Load-Out Capacity**
  - **Craft sizes range from 20 to 70 feet**
  - **Speeds range from 25 to 70+ knots**
  - **Payloads range from 300 to 1000 pounds**
- **Craft As Launch And Attack Platforms**
- **Missile Threats Include Surface-to-Surface and Land-Combat Weapons**
- **Small Arms, RPG's, Explosives**

"A formation of warships is ill-suited to fight a swarm of small craft, because powerful missiles are wasted in overkill while the swarm sucks the large warships dry of their ordnance." *

* "Take the Small Boat Threat Seriously", Capt Wayne P. Hughes Jr., US Navy (Ret), U.S. Naval Institute Proceedings, October 2000

NetSPEARS Program Overview

- **OBJECTIVES:** Develop a Design for a Low-Cost Smart Submunition That Employs an Optimized Weapon-Target Pairing Concept to Increase Probability of Kill (P_k). Determine Optimum Delivery Bus and CONOPS
- **APPROACH:** Cooperative Effort (CRADA) with NAWCWD China Lake to Employ Their Smart Swarming Algorithms in a Future Weapon System for the Outer Defense Layers
  - Smart Submunition Design
  - Applicable Weapon Delivery Platforms & CONOPS



NetSPEARS Concept

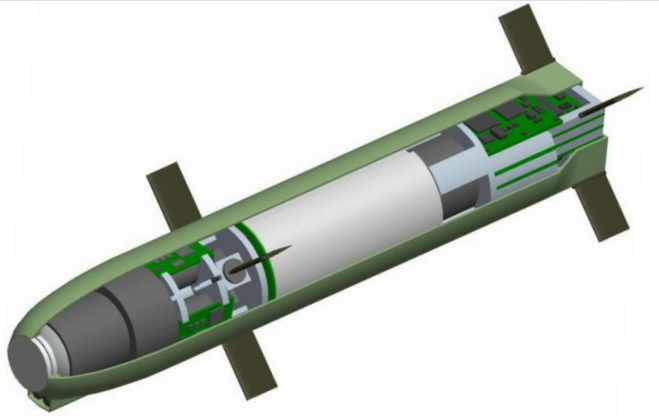
Weapon Bus Dispensing Large Number of Inaccurate Dumb Submunitions

To

Loitering Bus Dispensing a Small Number of Low-Cost Smart Submunitions

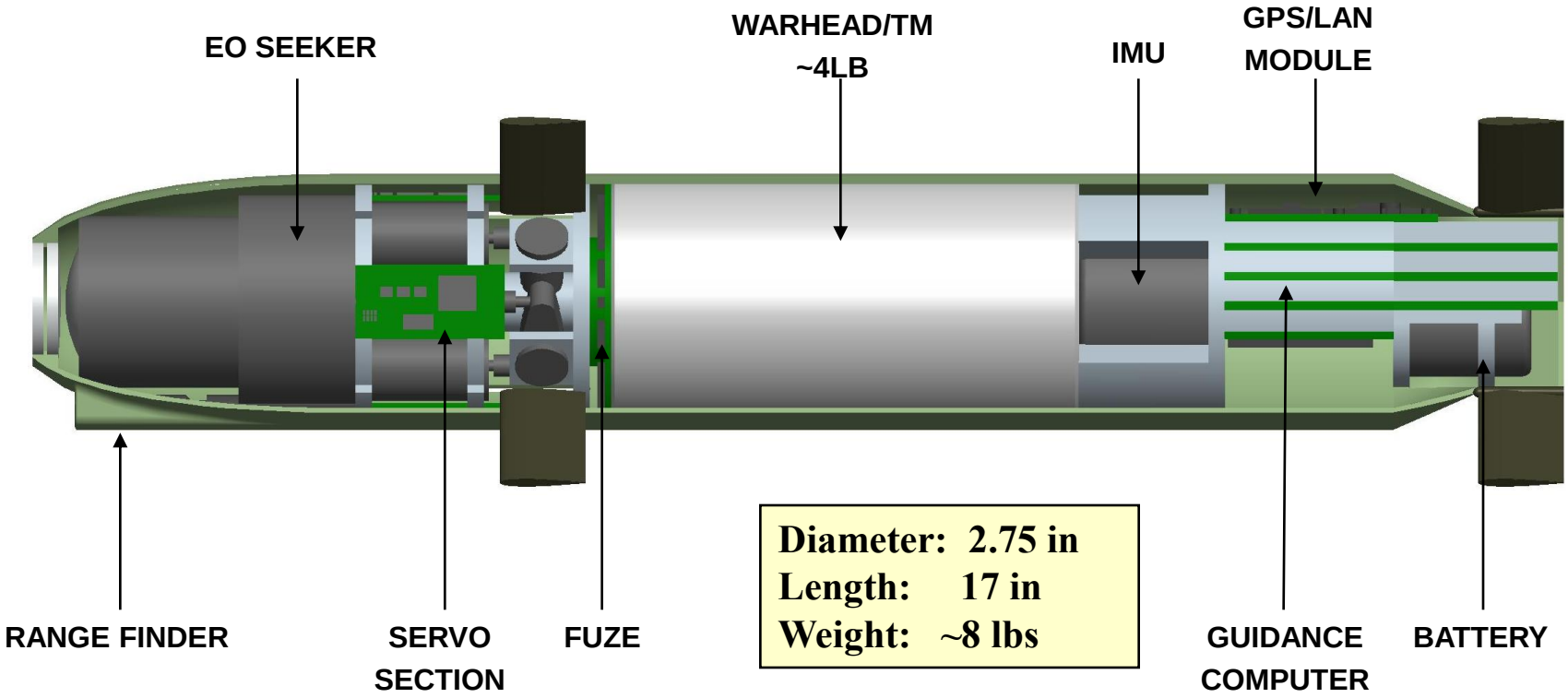
Smart Submunition Features

- A Fast Acting LAN for Communications Between Submunitions
- Optimized Weapon-Target Pairing Algorithms
- Low-Cost Electro-Optical Sensor Form Factored for the Weapon
- A Miniaturized Laser Altimeter for Submunitions
- Effective Warhead Technology
- All Other Relevant Subcomponents Such as IMU, G&C, GPS



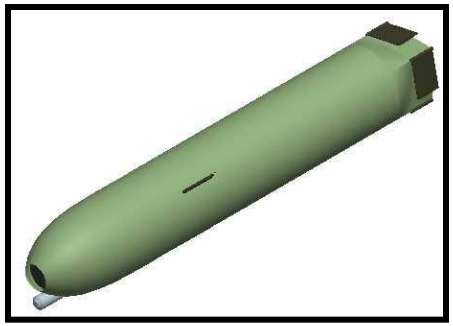
Cut-Away of the Smart Submunition

Submunition Model



Diameter: 2.75 in
Length: 17 in
Weight: ~8 lbs

- Articulated Canards Offer Directional Control
  - Four Channels Provide Roll Control
- Fixed Pop-Out Tailfins For Longitudinal Stability
- Typical Deployment from 1000' AGL Horizontally at M=0.8
- Approximate 1.5-g Endgame Maneuverability



Stowed Configuration

Swarming Algorithms Overview

- **NAWCWD China Lake Has Developed and Simulated the Algorithms for a Smart Submunition Concept Which Have the Following Key Features:**

- **Submunition-to-Submunition Communication via Wireless LAN**

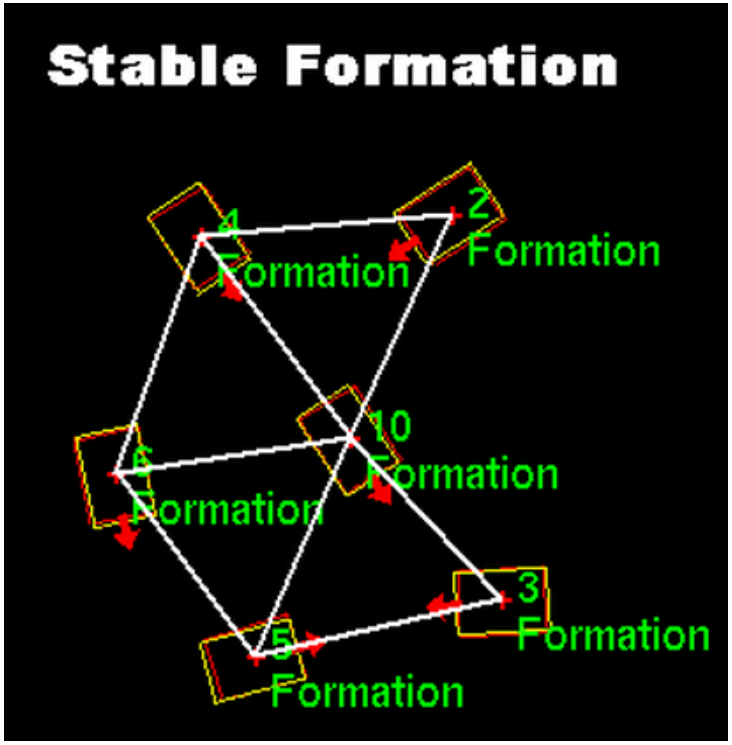
- **Forms a Stable and Cohesive Formation in Space (Virtual Coupling)**
  - Based on the idea of a virtual network of inter-connecting spring forces.

- **Robust Weapon-Target Pairing**
  - Algorithms for Optimally Assigning Submunitions to Targets with Capability to:
    - Maximize the global probability of intercepting all targets
    - Maximize the probability of intercepting a specific high-value target at the expense of missing a lower value target
    - Distribute impacts on the target to maximize the probability of a submunition entering a vulnerable volume

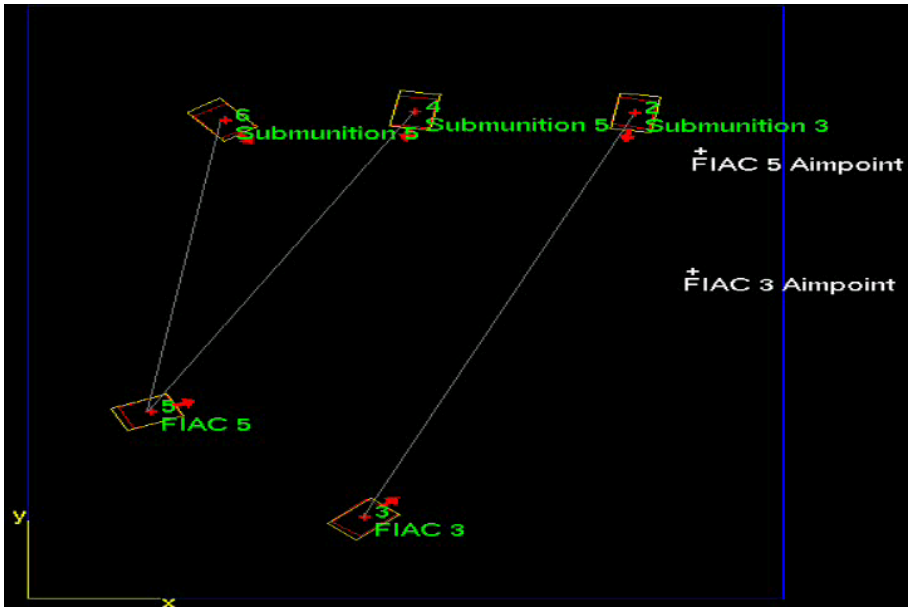
Distributed information sharing via the Wireless LAN is key to achieving cooperation and is essential for maintaining: group cohesion, avoiding submunition collisions, pursuing multiple targets and optimally assigning submunitions to engage maneuvering targets.

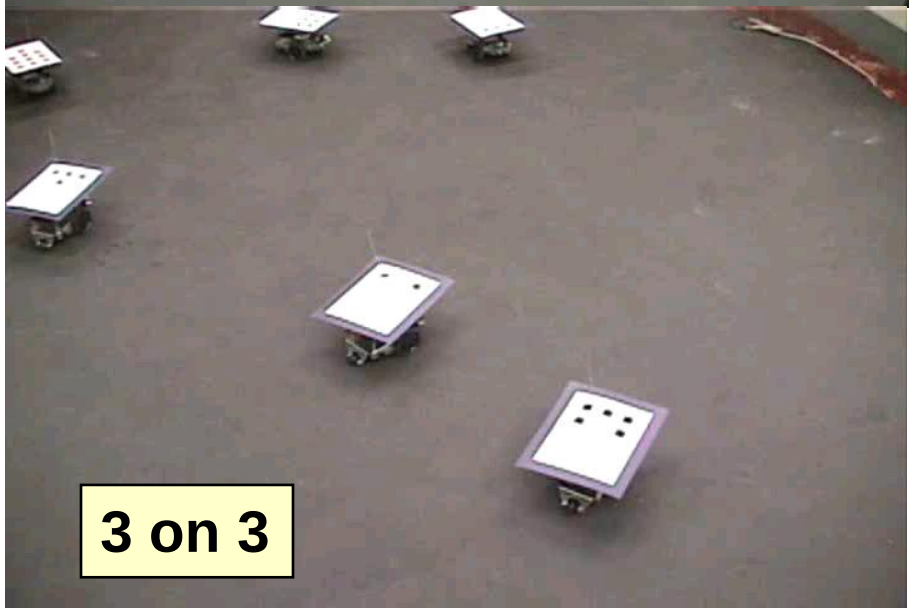
Virtual Coupling Demo

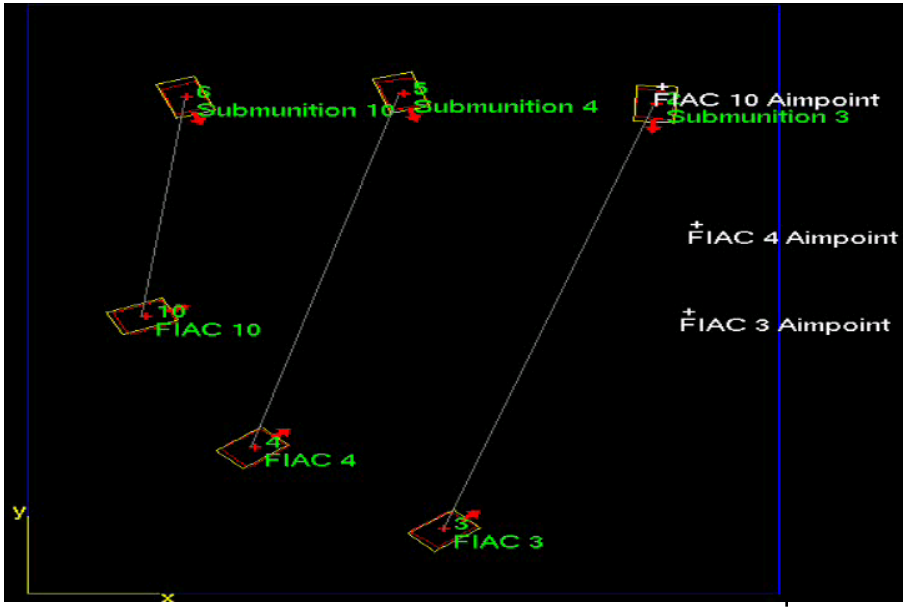
- **Convergent Network Formation Example**
  - The robots begin separated from each other and converge toward the center of the arena.
  - As the robots approach the center of the arena, they begin to enter each other's local neighborhoods and autonomously alter their respective courses.
  - An ad-hoc network forms near the center of the arena as the robots' virtual springs reach their rest distances.



Weapon-Target Pairing Examples



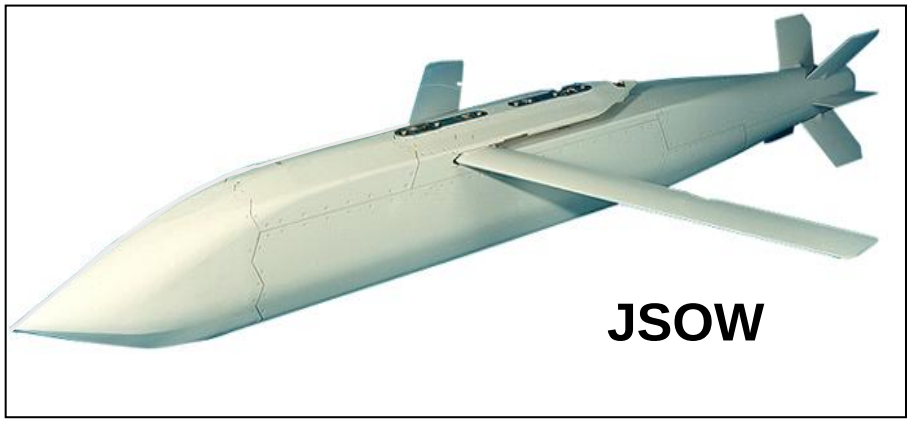




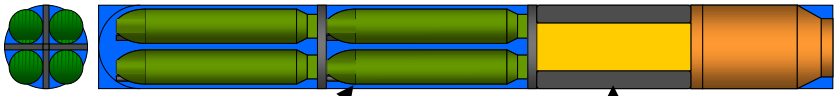
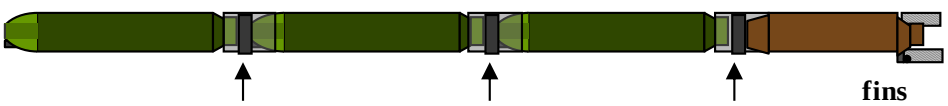
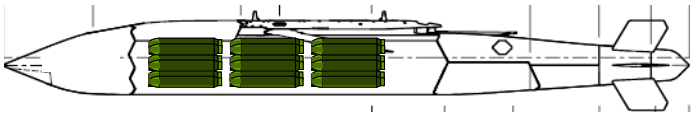
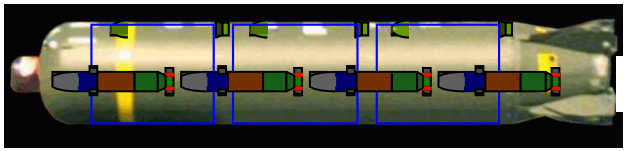
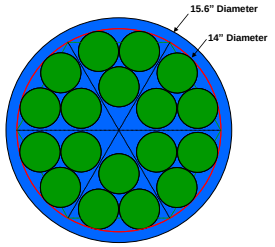
Approach to Meeting Low-Cost Goals for E-O Sensor

- **Strap-Down Illuminated CMOS Visible Sensor**
  - Provides Short Range Night Performance Using a Pulsed Laser Diode
  - Added Benefit: Provides Ranging Capability for
    - Detection & Tracking Algorithms
    - Warhead Fuzing

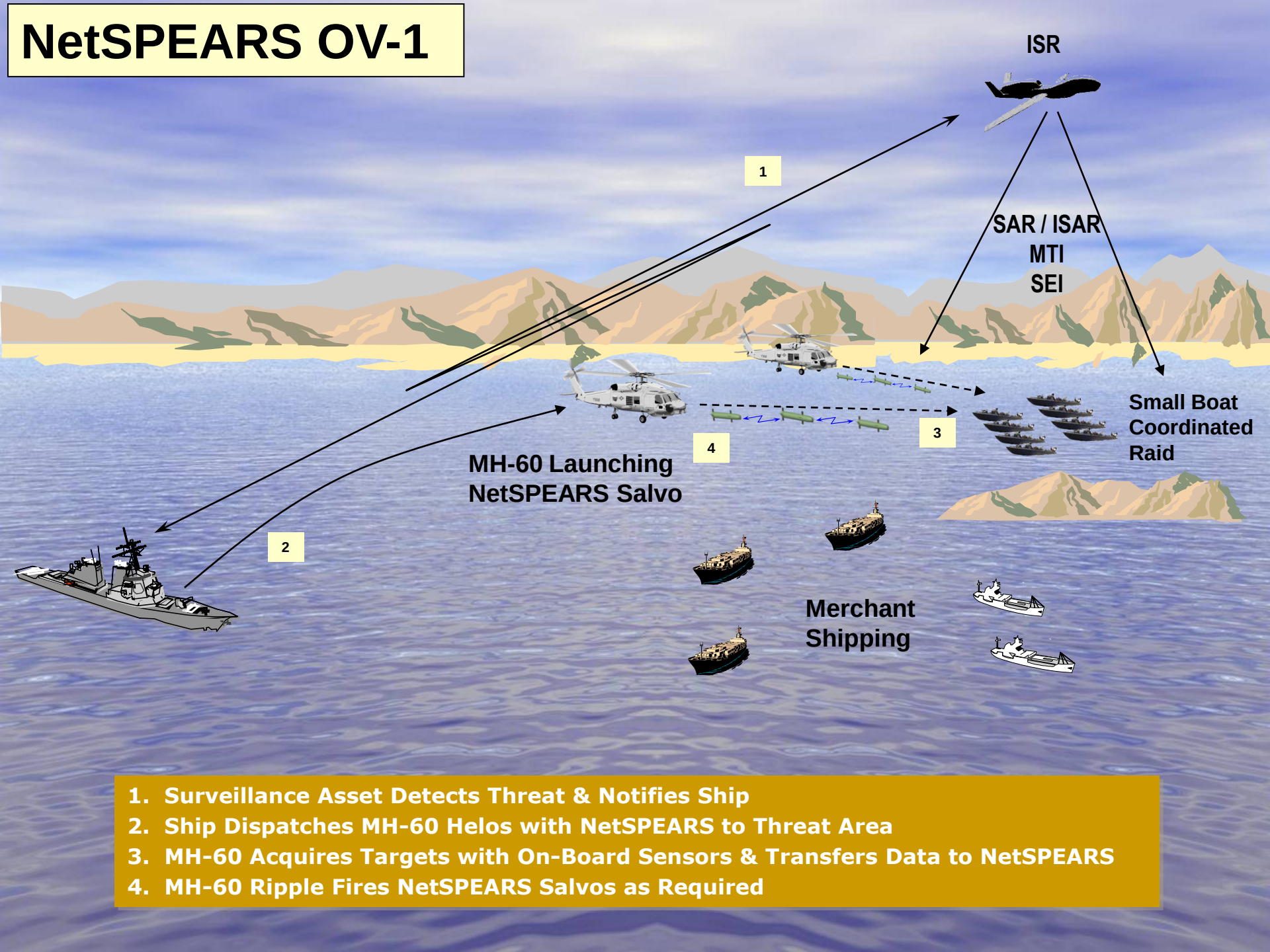
Candidate Delivery Platforms



Delivery Weapon Concepts

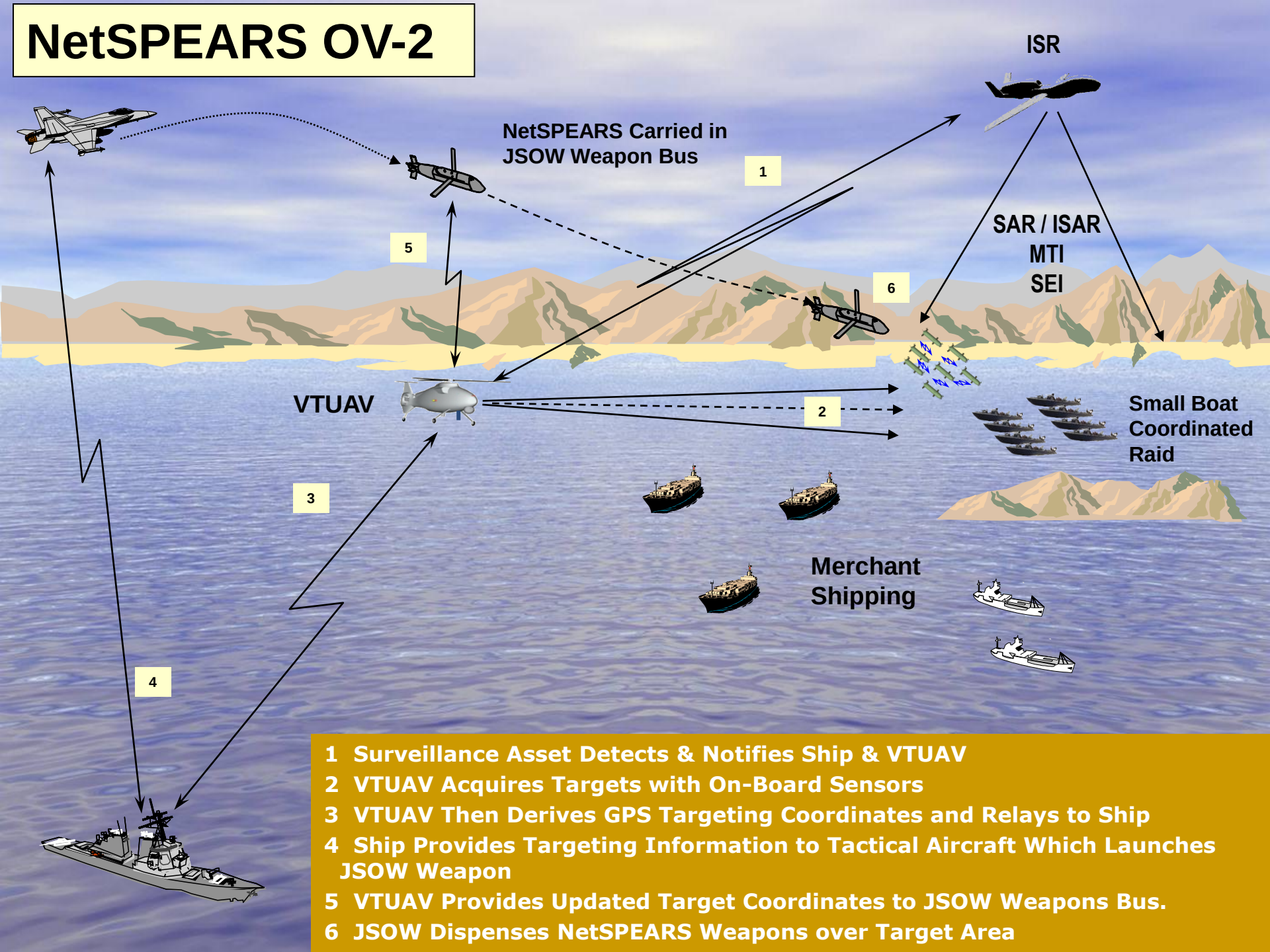
Hellfire-Like Bus Airframe for Rail Launched	 Submunitions, 2 bays of 4 each Sustain propellant 7" OD by 70" Long Notional Fitment Volume Boost propulsion to provide design release speed for submunition
Coupled for Helo or UAV Rocket Pod Launched	 Submunition Submunition Submunition Propulsion fins Interconnect/Interface Connector Mechanisms 72" Three Coupled, 36.5 lbs. Helo Launched: 114 with Nominal Range or 76 with Extended Range
Munitions Truck & Cruise Missile Like Airframes	 MALD Carry Up to 8 Submunitions JSOW 36 Smart Submunitions 
Dispenser Munition for Tactical Aircraft	 15.6" OD 92" 72 total Submunitions in 4 bays of 18 Submunitions each CBU-105 (CBU-97) Fitment Volume  15.6" Diameter 14" Diameter

NetSPEARS OV-1



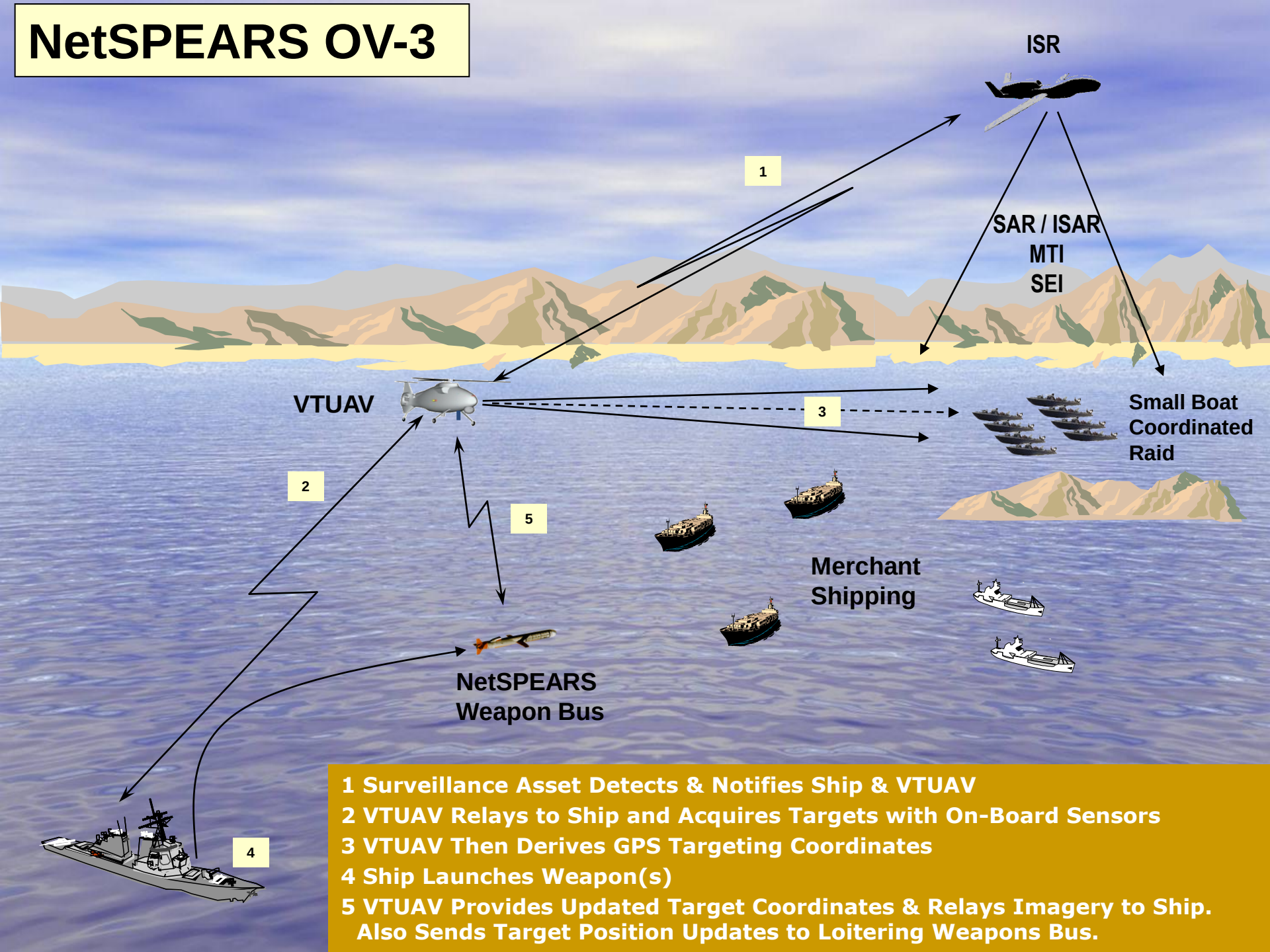
1. Surveillance Asset Detects Threat & Notifies Ship
2. Ship Dispatches MH-60 Helos with NetSPEARS to Threat Area
3. MH-60 Acquires Targets with On-Board Sensors & Transfers Data to NetSPEARS
4. MH-60 Ripple Fires NetSPEARS Salvos as Required

NetSPEARS OV-2



1 Surveillance Asset Detects & Notifies Ship & VTUAV
2 VTUAV Acquires Targets with On-Board Sensors
3 VTUAV Then Derives GPS Targeting Coordinates and Relays to Ship
4 Ship Provides Targeting Information to Tactical Aircraft Which Launches JSOW Weapon
5 VTUAV Provides Updated Target Coordinates to JSOW Weapons Bus.
6 JSOW Dispenses NetSPEARS Weapons over Target Area

NetSPEARS OV-3



1 Surveillance Asset Detects & Notifies Ship & VTUAV
2 VTUAV Relays to Ship and Acquires Targets with On-Board Sensors
3 VTUAV Then Derives GPS Targeting Coordinates
4 Ship Launches Weapon(s)
5 VTUAV Provides Updated Target Coordinates & Relays Imagery to Ship.
Also Sends Target Position Updates to Loitering Weapons Bus.

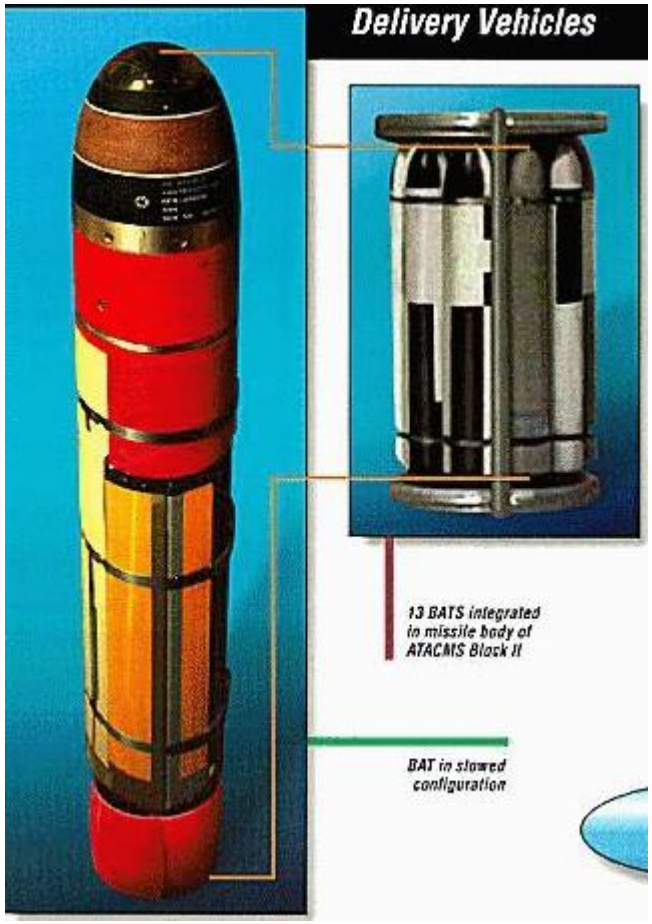
Application to Army Rocket Artillery Munitions

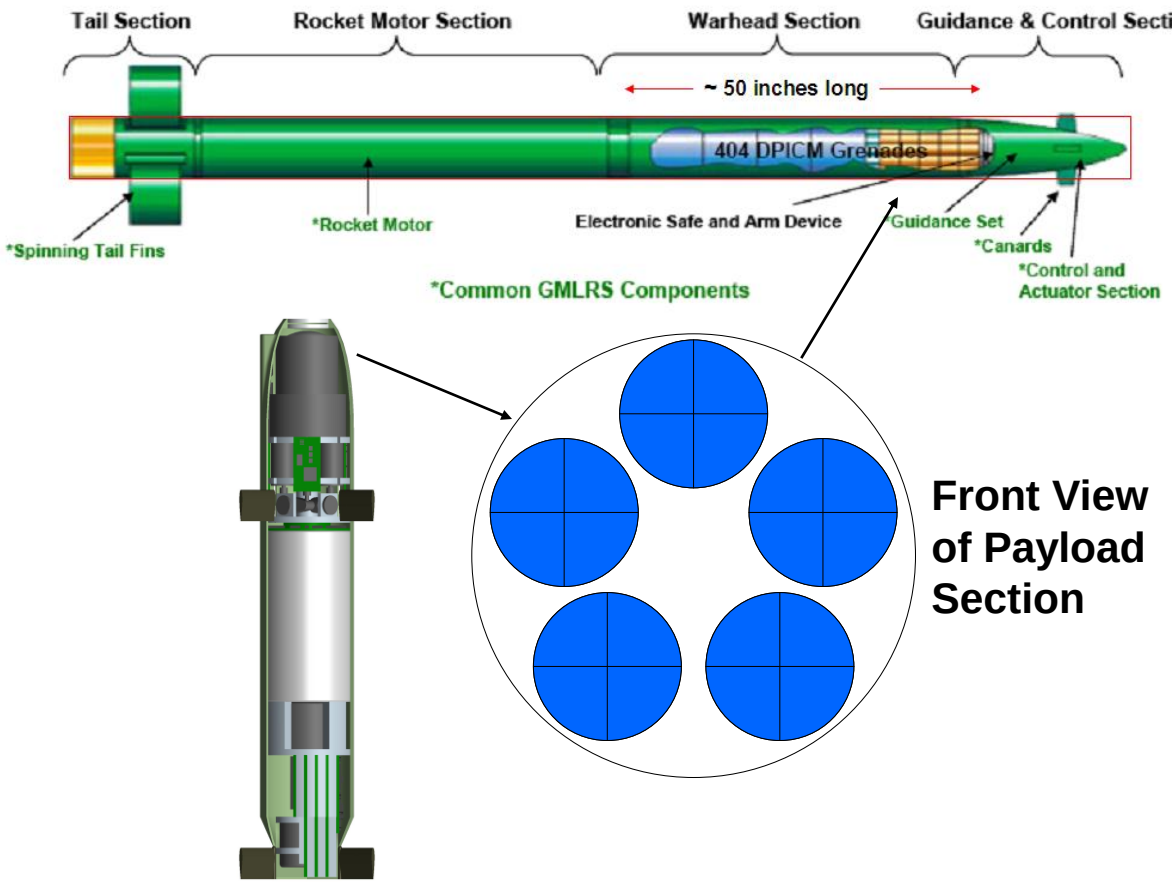
Photo: Lockheed Martin

M26 *MLRS* Rocket (M270 launcher)

http://www.fas.org/man/dod-101/sys/land/atacms.htm

Preliminary Fitment Results for NetSPEARS Submunition in MLRS & ATACMS





26 NetSPEARS in ATACMS
- Based on 13 BATS in MGM-164A (Two to a BAT Dispenser)

10-15 NetSPEARS in MLRS Based on Fitment of 2 to 3 Weapon Bays (5 each)

*http://www.fas.org/man/dod-101/sys/land/atacms-bat.htm

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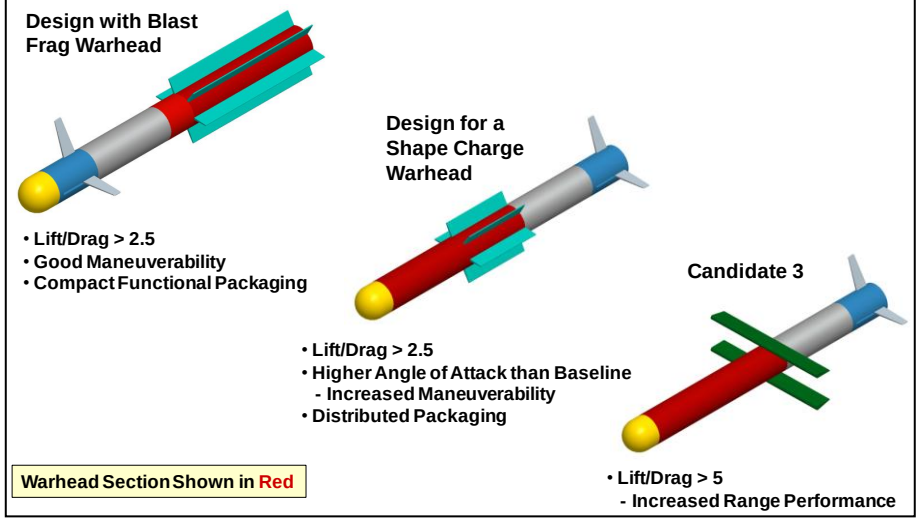
NetSPEARS Technology for Army Artillery

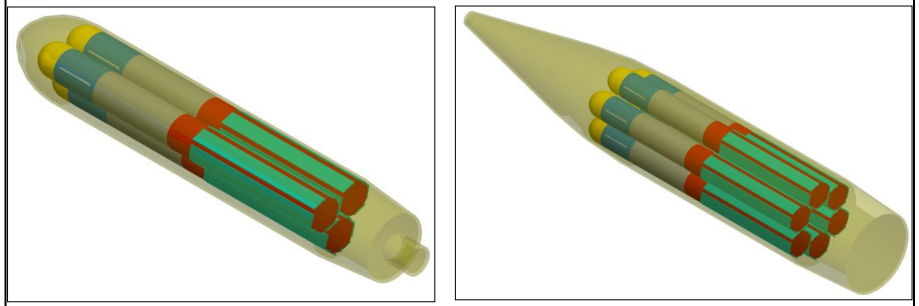
Trade Study Summary

- **Based on Preliminary Fitment Analysis of a Navy NetSPEARS Submunition**
  - Only One Would Fit in a 105mm Howitzer Shell
  - Only Two in a 155 mm Howitzer Shell
- **Based on Our Analysis, the Current Design Can be Modified for Artillery Applications**
- **Specific Design Areas to Trade for Artillery Applications**
  - Airframe Design Trades for Length/Diameter Changes (Aero Analysis)
  - Seeker Performance
  - Warhead Size & Lethality
  - Gun-Hardening Requirements
  - Packaging Ramifications
  - Shell Modifications (e.g. Nose Shape)
- **Analysis of New Submunition Footprints vs Shell Dispersion and TLE**
  - Needed to Derive the New Required Submunition Authority

Airframe Configuration Trades



Preliminary Fitment Results for Candidate Submunition

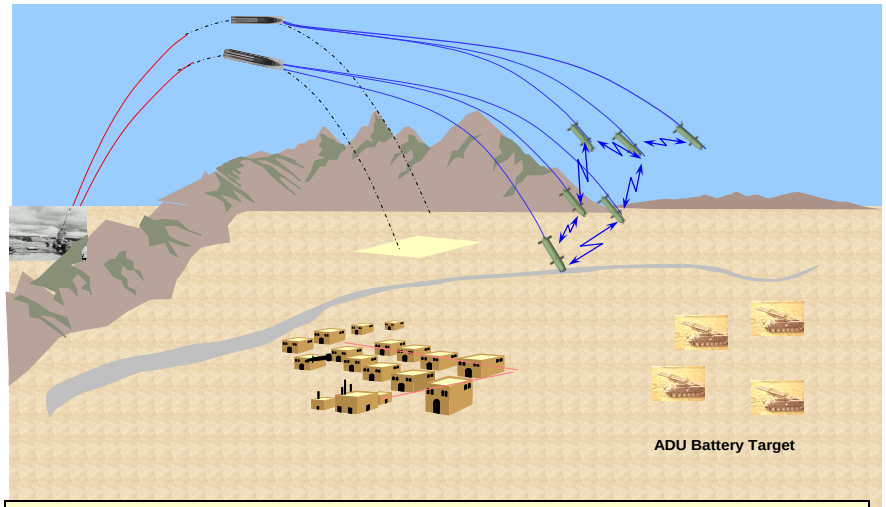


Fit 3 Submunitions Within the 105 mm

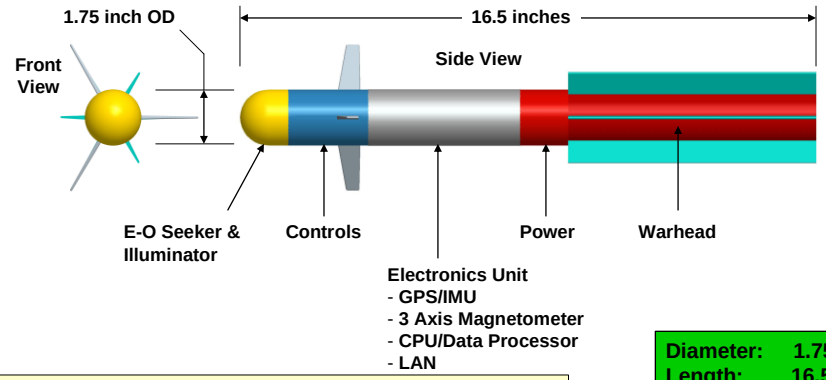
Fit 6 Submunitions Within the 155 mm

Folded Strakes and Pop-Out Canards

Army NetSPEARS for Conventional Artillery (DPICM Replacement)

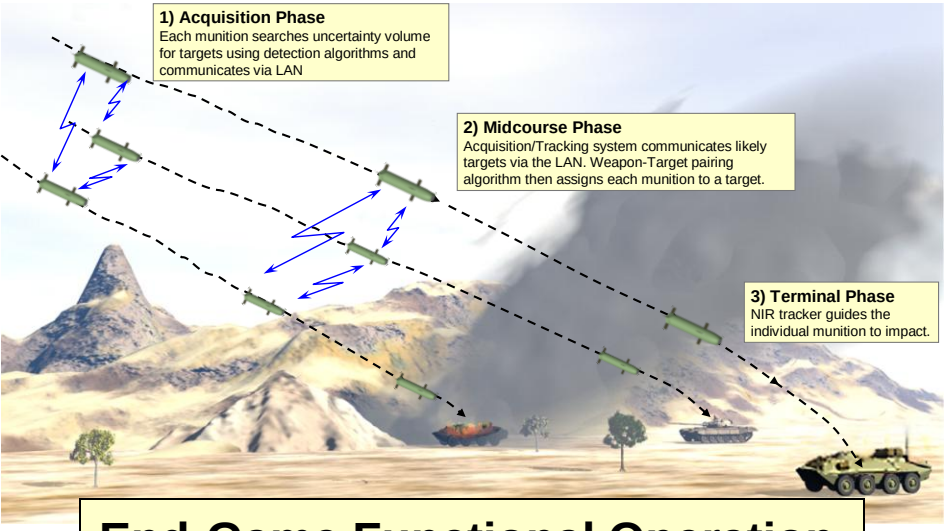


Concept of Operation for Artillery

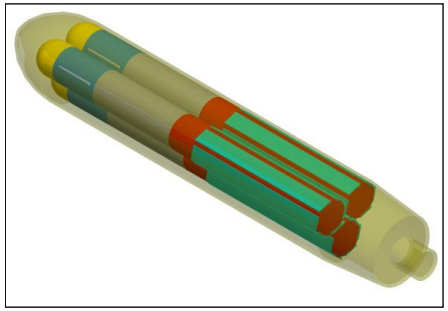


- Fixed Pop-Out Tail Stakes For Longitudinal Stability
- Canards for Directional Control
  - 3-Axis Control
- Gun-Hardened
- NAWCWD LAN Technology and Algorithms
- Dispensed Near Ballistic Apogee for Maximum Range

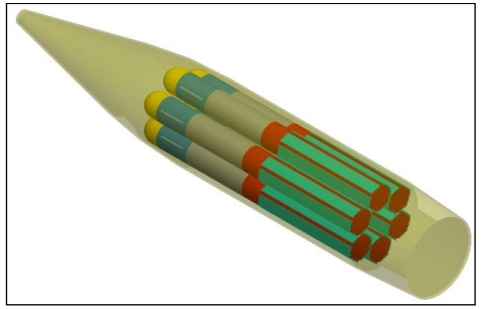
Diameter:	1.75 in
Length:	16.5 in
Unit Weight:	7.2 lbs
Warhead:	1.6 lbs



End-Game Functional Operation



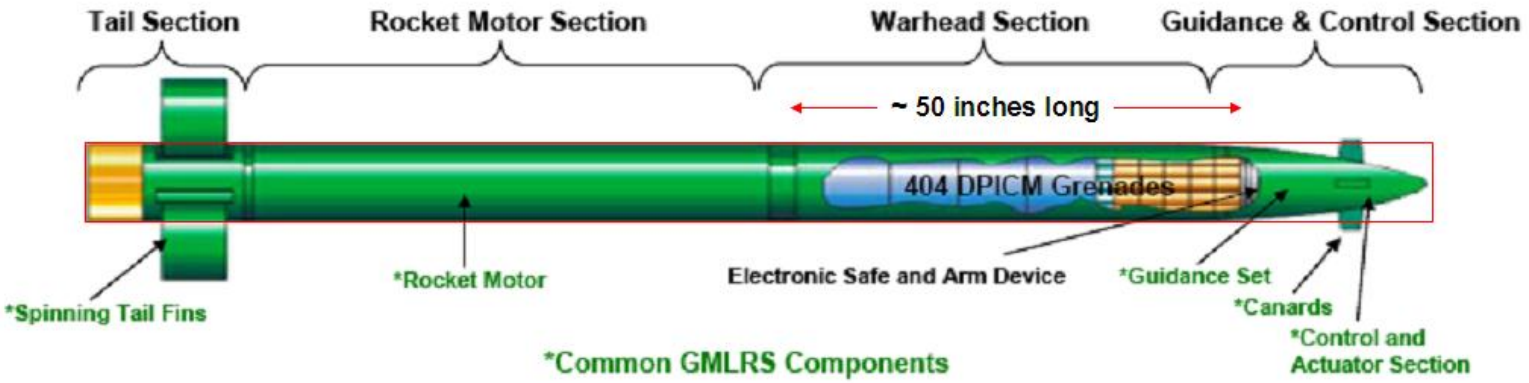
Fit 3 Submunitions
Within the 105 mm



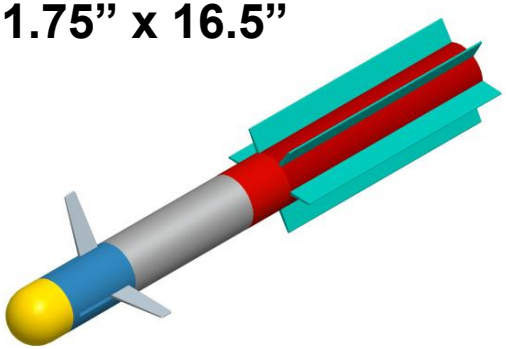
Fit 6 Submunitions
Within the 155 mm

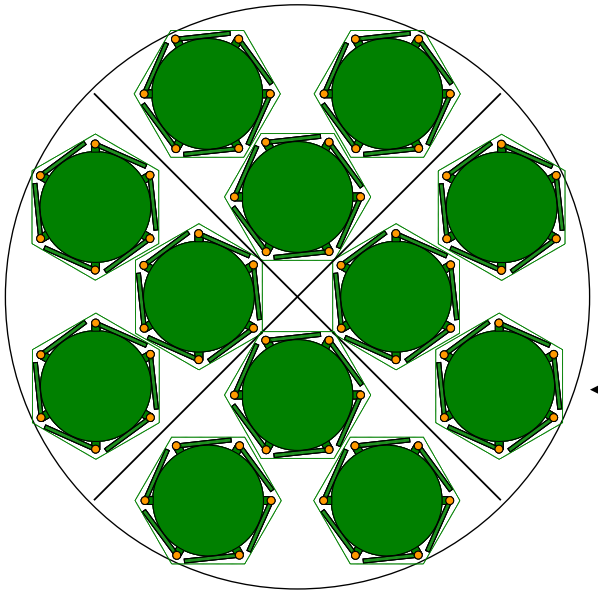
Folded Strakes and Pop-Out Canards

Preliminary Fitment Results for 1.75” NetSPEARS Submunition in GMLRS

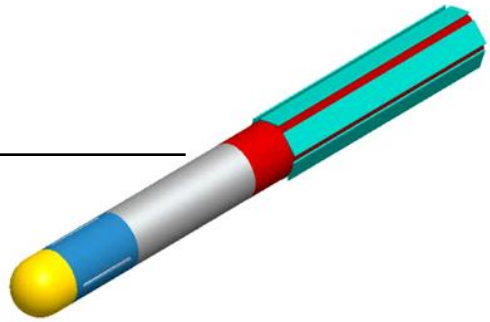


1.75” x 16.5”





GMLRS Cross Sectional View of Warhead Area Showing Fitment of 1.75” Submunition with Surfaces Folded



36 Army NetSPEARS in GMLRS Based on Fitment of 3 Weapon Bays (12 each)

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NetSpears Weapon System Performance Prediction Studies

Mission Utility Study for Helo Launched NetSPEARS

- Evaluation of both helicopter-launched and truck-launched (JSOW) NetSPEARS munitions in the Small Boat Suppressor Mission Level Model scenario to provide a rough idea of the military effectiveness of the submunition
  - JSOW version deployed from F/A-18s
  - Helo-launched version carried in a 19-round rocket launcher, two or three NetSPEARS munitions per rocket tube

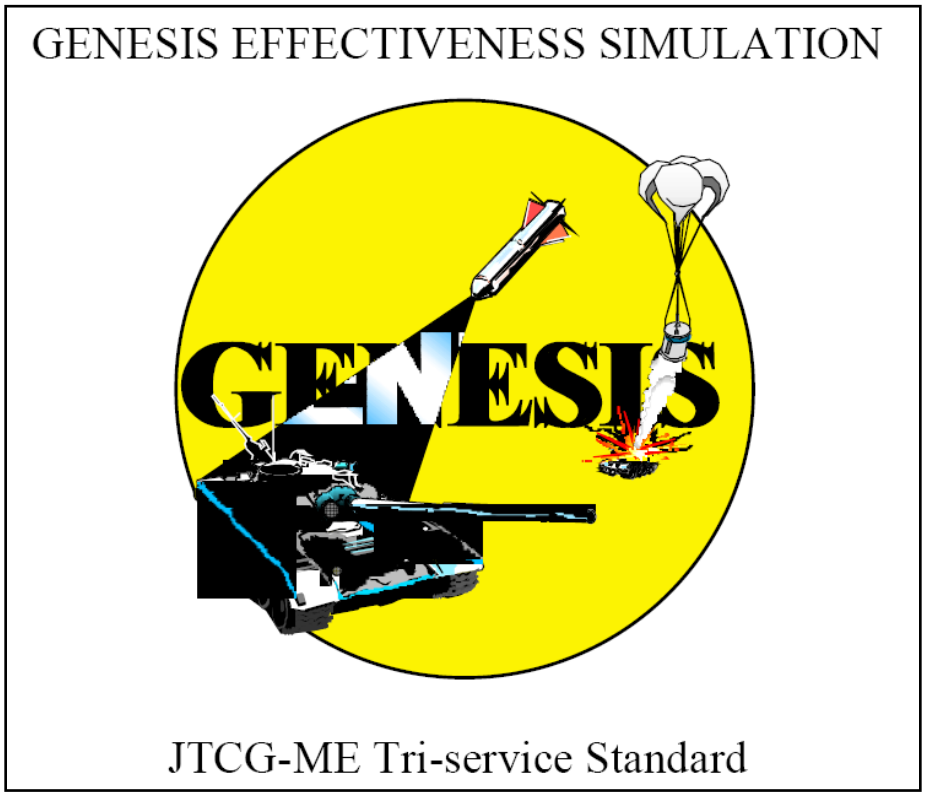
- The effort was to evaluate the lethality of the NetSPEARS submunition concept against small boat targets. This required a two-step process. The first was to generate small boat damage for single submunition encounters. Next, when these values were completed they were used as input to a SUPRESSOR many-on-many simulation.

- This study leveraged previous, similar work for an AOA study of small guided warheads. Because of this, the target models, effectiveness methodology, lethality input scripts, and parametric analysis schemes were available, in place, and tested.

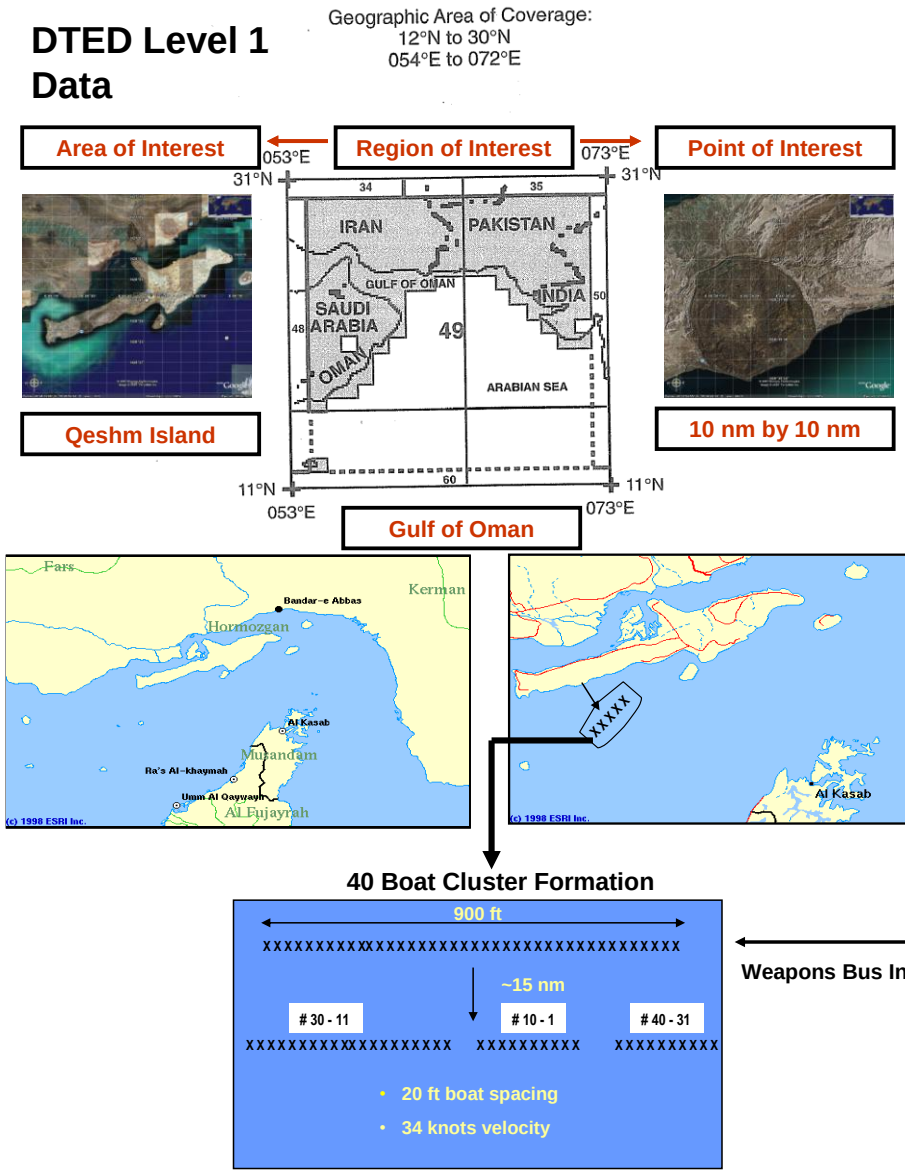
- The kill criterion used: Mission Kill

Performance Model Description

- **The GENEric Smart Indirect Fire Simulation (GENESIS) is used to perform effectiveness evaluations based on user defined engineering parameters and system performance data.**
  - **Monte Carlo Based US Army/Air Force Performance Model for Dumb & Smart Submunitions**
  - **Many-on-Many**
  - **Indirect fire**
  - **End game (effects of targeting and delivery errors modeled)**
  - **Effectiveness model (1 volley of smart munitions vs. target arrays**



Scenario and Approach for Navy System Performance Evaluation Trade

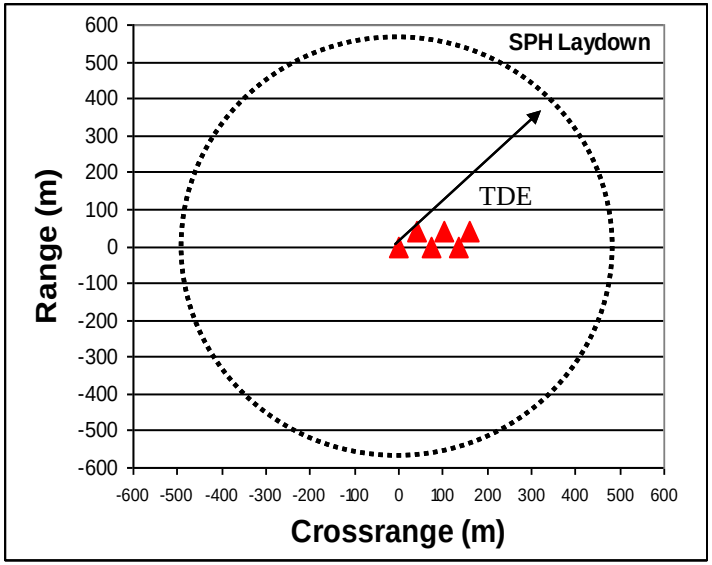


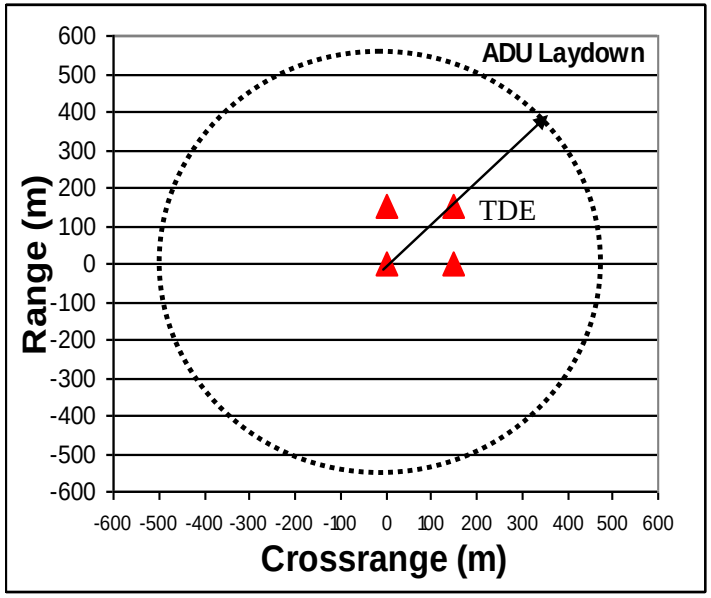
- **Dumb Submunitions Tactics, Techniques and Procedures**
  - 4 Cruise Missile Target the Cluster
  - 166 BLU-97 CEBs per Bus
  - Payload Dispenses ~ 1000 ft Altitude
  - Single Dispense Location per Weapon
  - 1 Pass Only Over Target Area

- **Smart Submunitions Tactics, Techniques and Procedures**
  - 1 Cruise Missile Targets the Cluster
  - 88 NetSPEARS Submunitions on the Bus
  - Payload Dispenses ~ 1000 ft Altitude
  - Evaluate Single & Multiple Dispenses from Weapon
  - 1 Pass Only Over Target Area

Army Systems Performance Evaluation Run Matrix

- **Targets**
  - Self-Propelled Howitzer Battery (SPH)
  - Air Defense Unit (ADU)
- **Rounds Fired**
  - Artillery w/NetSPEARS: 6, 12, 18
  - Artillery w/DPICM: 18, 36, 54
  - MLRS: 6, 12 (All Cases)
  - ATACMS: 1, 2 (All Cases)





Weapon & Payload
105mm (Unguided & Precision) a) 42 DPICM b) 3 SmartCATS (1.75”)
155mm (Unguided & Precision) a) 72 DPICM b) 6 SmartCATS (1.75”)
MLRS (Unguided) a) 404 DPICM b) 10 SmartCATS (2.75”) c)200 lb Unitary
GMLRS (Guided) a) 72 DPICM b) 10 SmartCATS (2.75”)
ATACMS Blk 1A a) 300 APAM b) 26 SmartCATS (2.75”)

NetSPEARS System Attributes

- A smart submunition containing sensors and power can be programmed to detonate under virtually all conditions thus leaving ***no UXO*** on the battlefield
- A warhead design that will assure at least a mission or functional kill and will meet IM requirements.
- Loaded with a qualified Insensitive High Explosive, the small SmartCATS warhead in its life-cycle (containerized) configuration will meet most IM requirements (FI, BI, SCO, FCO), and, with appropriate packaging, will pass SD
- Low cost by the heavy use of COTS components

NAVAIR

Raytheon
Missile Systems

Summary

- **NetSPEARS Weapon System Benefits**:
  - Submunitions will attempt to engage the entire incoming small boat raid simultaneously rather than targeting just one boat at a time.
  - The submunitions themselves are smart, meaning they have their onboard sensors to acquire and track targets and determine their own altitude and GPS coordinates. ***The delivery vehicle is free to move on after the dispense***.
  - The target-weapon pairing algorithm is optimized so that the appropriate number of submunitions can be allocated to each target of interest in order to maximize lethality

NetSPEARS Weapon System Employs a New Paradigm:

"The Submunitions Pair-Up with Targets as They Drop & Talk"

Can Provide a Low-Cost Solution for Neutralizing Large Coordinated Raids of Fast Moving Asymmetric Surface Targets