NAVSEA WARFARE CENTERS DAHLGREN

Weapon System Concepts for a Future Gunship

Michael Canaday

Next Generation Gunship (NGG) Analysis of Alternatives (AoA)

The Gunship IRD Requires a Transformational Capability

Target set:

- **Enemy troops in contact with friendlies**

Capabilities:

- **Situational Awareness**
- **Precise, responsive, focused weapons effects**
- **Persistence**
- **24-hour operations**
- **Survivability**

Supports two of OSD's operational goals:

"Denying sanctuary to enemies by providing persistent surveillance, tracking and rapid engagement with high-volume precision strike, … against critical mobile and fixed targets at various ranges in all weather and terrains."

"Protect and sustain US forces in distant anti-access and area-denial environments."

AoA PSAS Enabling Technologies

- Hovering UAVs
- Common Operating Picture and Control (COPaC)
- Very Small Missile (VSM)
  - Precise, Responsive, Focused-effects Weapon
  - Prosecute multiple, simultaneous targets throughout the hemisphere under the aircraft
  - 4 inch diameter, 57 inch long; 45 pounds
  - Performance: 15 miles maximum, in 65 seconds
  - Guidance: GPS/INS (in-flight updates) + Laser seeker (optional terminal guidance)
  - Warheads: Lethal and Non-lethal
  - Cost: Approximately $18,000 each

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Requirements

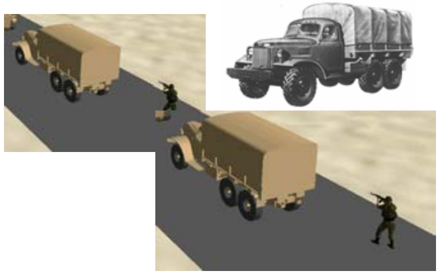
Requirements

- 10 to 15 nmi Range
- 360° Coverage
- Lethal
  - Enemy Personnel
  - Soft Skinned Moving and Stationary Vehicle
  - Armored Moving and Stationary Vehicle
  - Non-Hardened Structures
- Low Collateral Damage
  - Precise with Surgical Effects
- Deep Magazine = Light and Small
  - 45-50 pounds
  - 40-50 inches Long
- Affordable
  - Interservice Common Ammunition
  - Common System Components Across DoD/Commercial
- Selectable Effects
  - Modular Allowing for Guided Non-Lethal/Less than Lethal Munition Options
- Day/Night Capable
- Graceful Degradation
- Small Deployed Footprint
- Automated System

Light Armored Vehicle

Personnel

Buildings & Infrastructure



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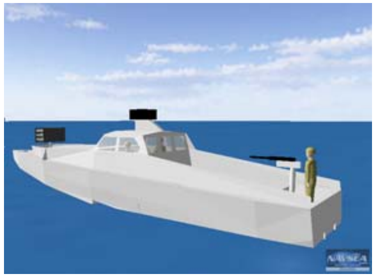

Boat

VSM Capabilities are Best Provided by a Weapon System

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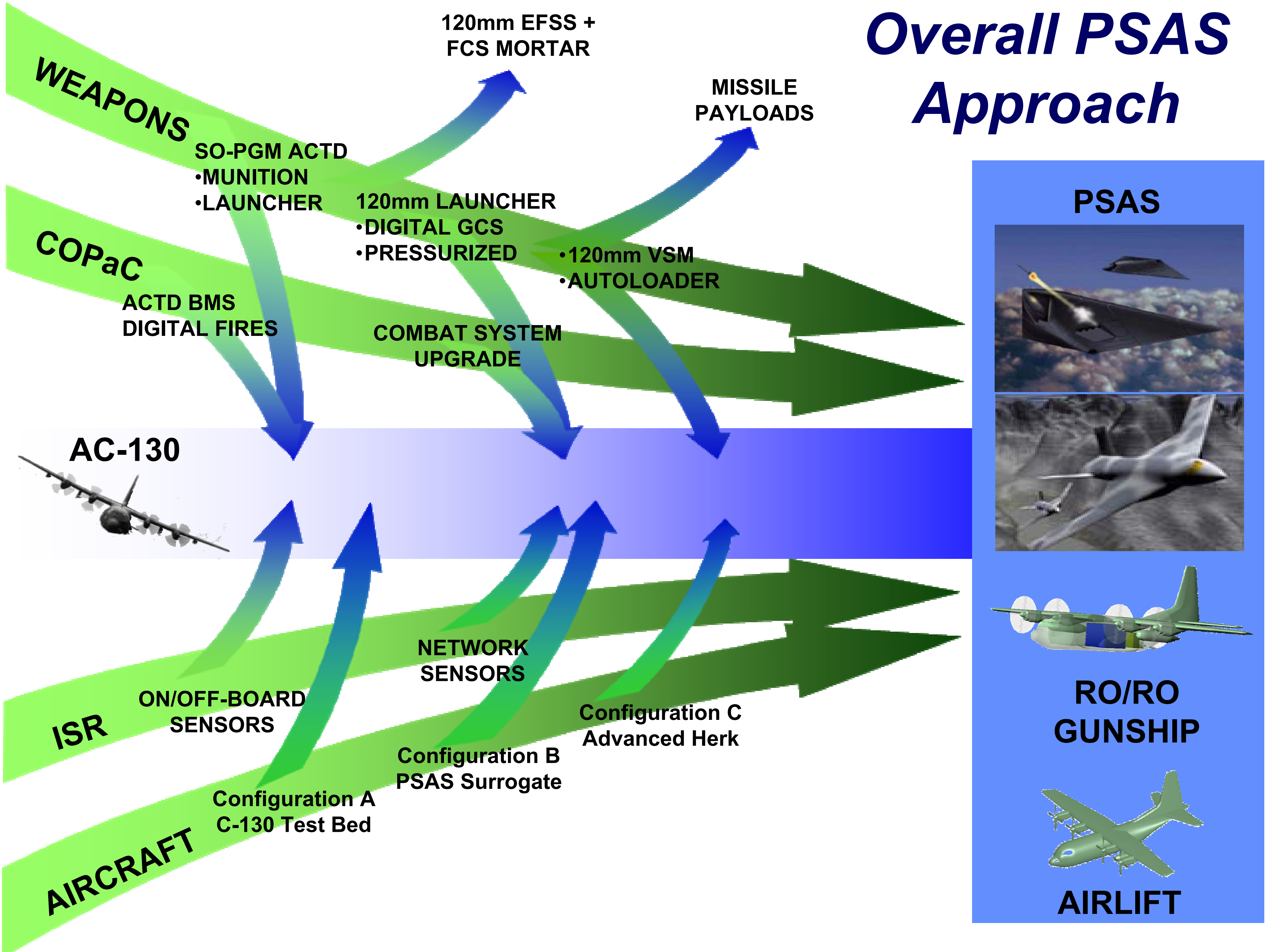
- **VSM Does Not Exist**
  - **The Capabilities of the VSM are Not Performed by Munitions that Fit the Size and Weight Requirements of the VSM**

Mr. Wynne’s Challenge

Demonstrate Capabilities That Can Be Spiraled Into The Current Fleet

Overall PSAS Approach



Munition / Launcher Size

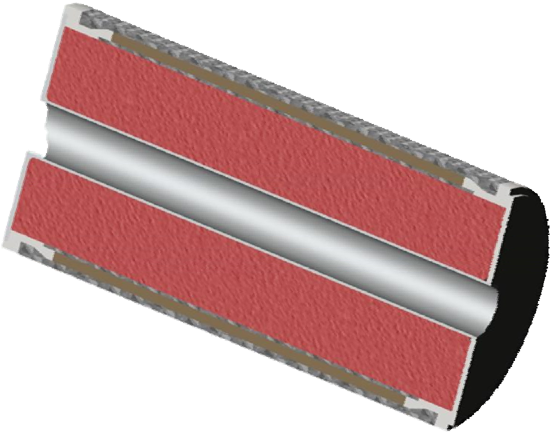
100mm < MUNITION DIAMETER <127mm

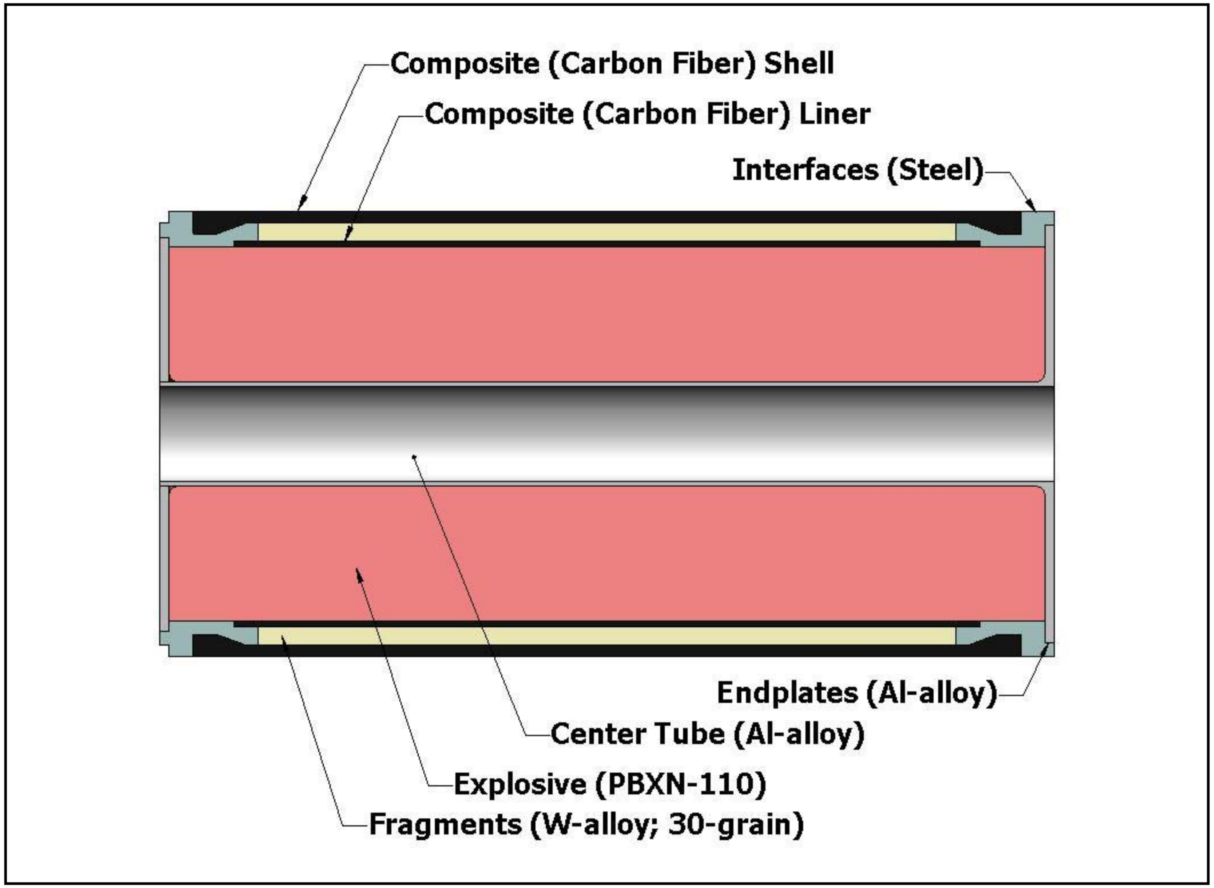
- Munition Volume Too Small for State of the Art Guidance & Propulsion Technology
- Lethal Payload Size Limited

- Munitions Too Heavy for one man lift
- Launch Loads Increase to Obtain Separation Velocities
- Lethality Overkill

120mm AND 105mm DIAMETER MUNITIONS ONLY COMMONLY USED SIZES IN THIS RANGE

Concept Warhead





120mm vs. 4 inch Diameter Warhead Effectiveness Summary

Munition		Accuracy CEP	HOB (ft)	Number of Shots to achieve Pk		
				Target 1	Target 2	Target 3
Baseline	**105mm (M1 MOD)**	**2 mils**	**0**	**5**	**10+**	**10+**
		2 mils	**14**	**3**	**10+**	**10+**
VSM	**Fast (120mm)**	**1.5 m**	**3**	**1**	**1**	**2**
		5.0 m	**4/5**	**1**	**1**	**3**
	Slow (120mm)	**1.5 m**	**3**	**1**	**1**	**1**
		5.0 m	**4**	**1**	**1**	**2**
	AoA VSM (4.0 in.)	**1.5 m**	**3**	**1**	**2**	**3**
		5.0 m	**4**	**1**	**2**	**7**

- **Effectiveness Studies Indicate that 120mm vs. 105mm/4 inch Diameter Warhead Designs Have Superior Performance Against Target Set**

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Launcher

- Gun
- Missile
- Dispenser
- Things to Consider:
  - PSAS Must Stay Within Geographic Location of High Priority Mission
    - Orbit is Not Necessary for Gun Fire Control - Allows for Short Range Use of Unguided Rounds
    - Less Expensive Munitions Can Be Used if Less Guidance Control Authority is Required (GPS Guided Artillery Rounds)
  - Gun Launch is a Well Proven Method of Deploying Munitions from Inside Aircraft
  - VSM-Like Munitions are Launched Out of Guns and Missile Launchers
  - Rocket Propelled Munitions Cannot Be Safely Ignited Inside of Aircraft
    - What if They Don't Leave?
  - Rocket Exhaust Plumes Burn Aluminum

movie

  - Fully Maneuvering Rocket Propelled Munitions are Expensive - Use Only When Needed
  - Unguided Munition are Cheap – Use IF You Can

VSM must be developed in the context of an overall PSAS Combat System

105-mm GUN vs. 120-mm MORTAR

105-mm Howitzer

- Weight 100 rounds 4200 lbs
- Recoil Load: ~10,900 lbs
- Gun Recoiling Weight 1,465 lbs
- Muzzle Pressure: 3,560 psi
- Legacy System
- Little Guided Technology Ongoing
- Lethal Payload Size
- Current System Too Much Gun
- FCS 105mm Gun is Separate Loaded

120-mm Breech Loaded Mortar

- Weight 100 Rounds 3200 lbs
- Recoil Load: ~5,600 lbs
- Gun Weight 1,315 lbs
- Muzzle Pressure: 1,620 psi
- Leading FCS Fire Support Weapon
- Stryker Brigade Combat Team Fire Support Weapon
- A Lot of Guided Munition Development Work Ongoing
- Lethal Payload Size
- Low Gun Loads
- Lighter Ammunition

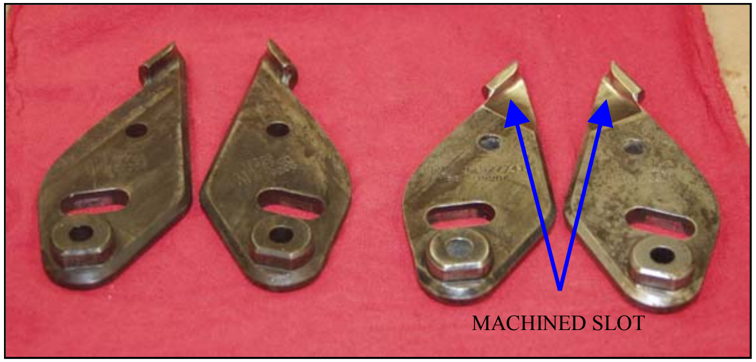
120mm DIAMETER MUNITION OFFERS BEST OPTIONS

M102 Howitzer 120mm Conversion Demo

- Fire Baseline 105mm M1 Howitzer Rounds and 120mm M931 Mortar Rounds from Modified M102 Howitzer
- Verify Functionality of 120mm Breech Loaded Mortar Concept, Establish Baseline Launcher for Unguided, Guided, and UAV Munitions
- Blast Overpressure Comparison
  - Reduce Blast Pressure on Aircraft Surfaces
- Recoil Force Comparison
  - Reduce Load on Aircraft
- 120mm Characterization
  - Range
  - Initial Flight Stability
  - Interior Ballistics

M102 Howitzer 120mm Conversion Demo

- **Bore Barrel ID to 4.732 inches (120.2mm)**
- **Breech Ring - Machine Larger Radius**
- **Breech Block - Machine Larger Radius**
- **Extractors - Machine Pockets To Fit 120mm Case**



M102 Howitzer 120mm Conversion Demo

- Flight Stability of Mortar Round is Satisfactory
- Further Testing Recommended in Simulated Crosswind

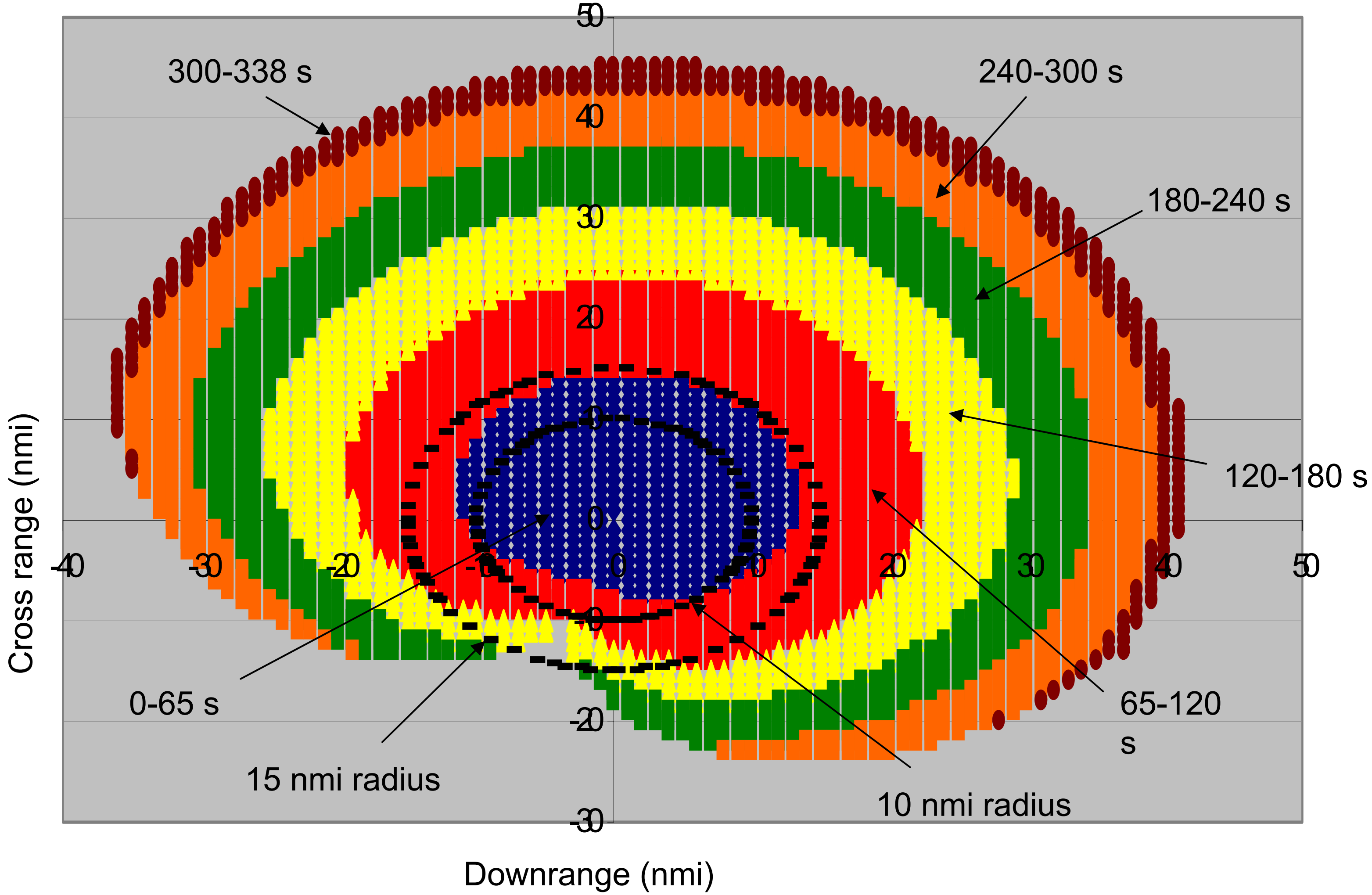
VSM Configuration Trade Studies
Range Studies

- Purpose: Investigate in Detail the Performance of the VSM with 1100 fps Initial Launch Velocity
- 1100 fps found to be best velocity for weight, length of munition
- Look at Range Achieved for Various Flight Times Using Three Launch Methods:
  - Side
  - Top
  - Forward
- Expand Study to Include Lighter Munition (15 pound Warhead vs. 20 Pound Warhead) Capable of Meeting 15 nmi/65 second Requirement
- Investigate Low Level CONOPS and Ground Launch Range of Munitions

VSM Configuration Trade Studies
Range Studies

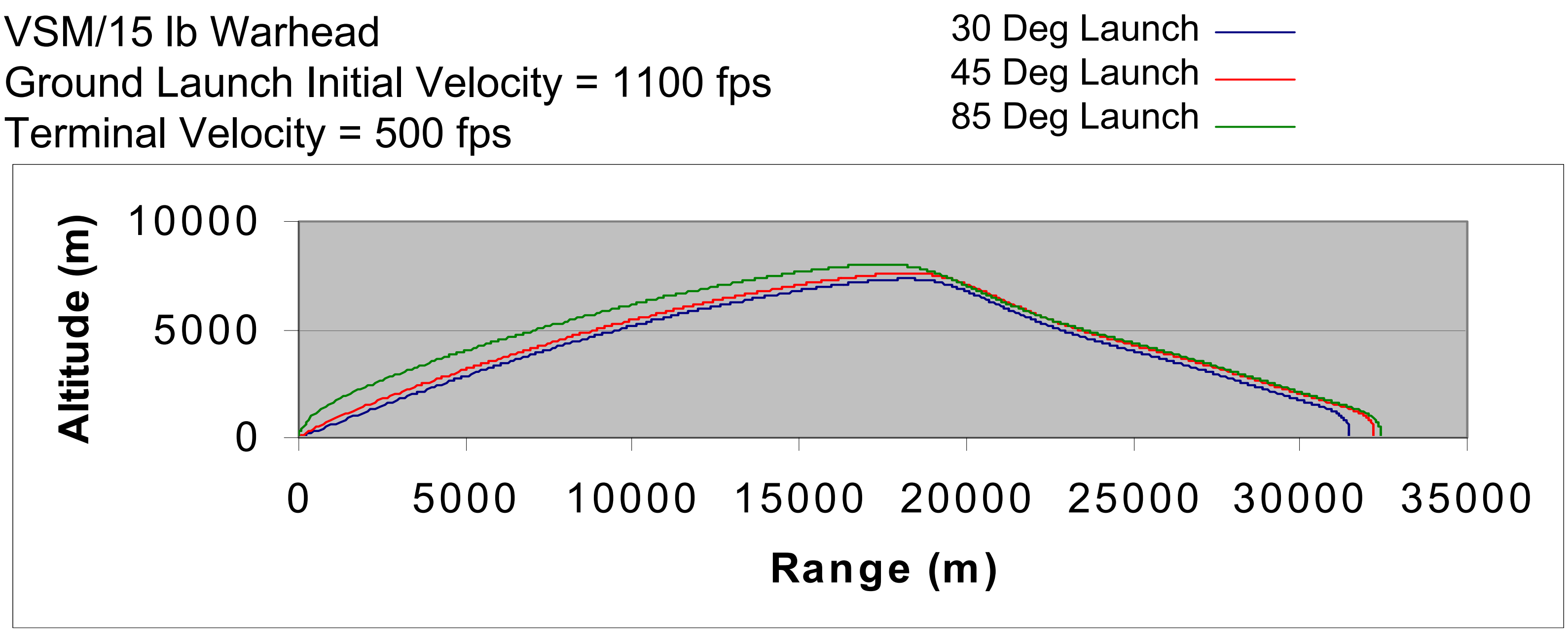
Configuration 2

Side Launched
Initial Velocity = 1100 fps
AOF = -90 deg

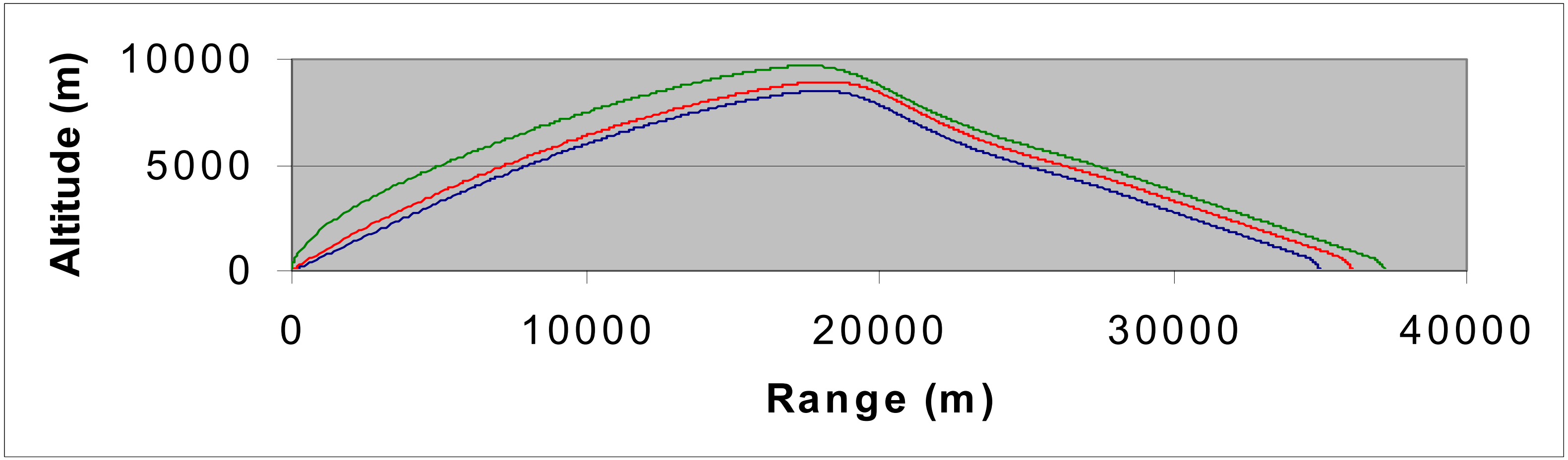


VSM Configuration Trade Studies
Range Studies

VSM/15 lb Warhead
Ground Launch Initial Velocity = 1100 fps
Terminal Velocity = 500 fps



-90 Deg Angle of Fall

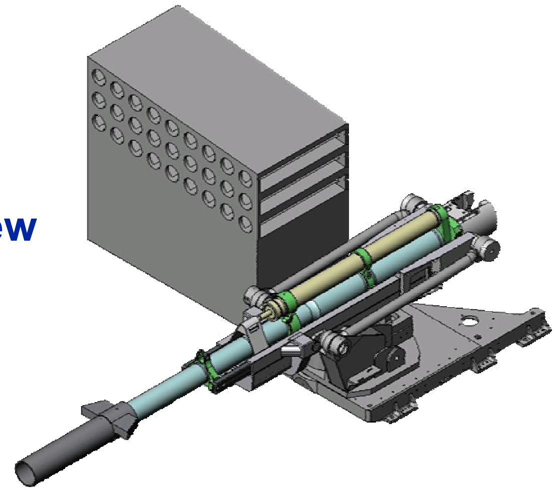


-70 Deg Angle of Fall

AC-130 Spiral Launcher Approach

120mm Breech Loaded Cannon Launching System

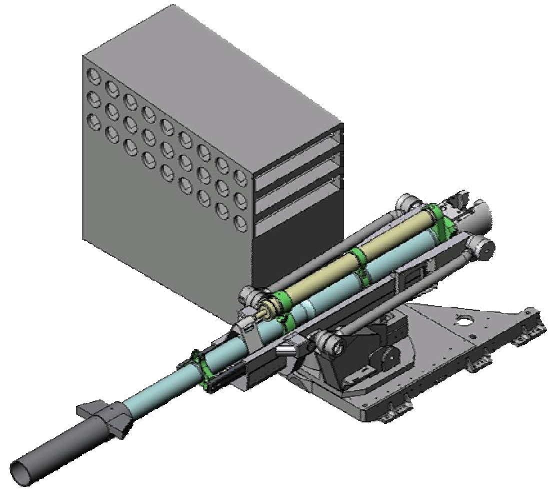
- 120mm Launcher/Munition interface
  - Lightweight Launcher and Ammunition
  - Lower Recoil Loads and Blast Overpressure
  - Safe Reliable Munition Separation
  - Multiple Service User Base
- Retains AC-130 Like Capabilities as Well as Embracing New Capabilities
  - Pylon Turn Not Necessary for Fire Control
  - CoPac Develops Instantaneously Computed Solution
- Multiuse
  - Conventional Unguided Ammunition
  - One or Two DOF Guidance as Well as Fully Maneuvering Munitions
  - Soft and Hard Launch of Munitions
- Automated Handling and Loading System
  - Tightly Integrated with CoPAC
  - Providing Health and Status of Ammunition and Launcher

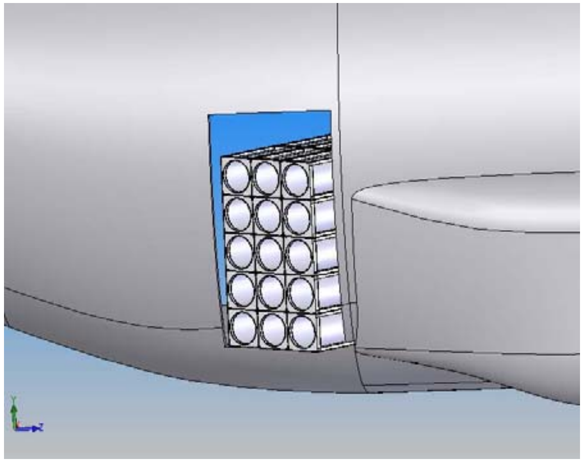


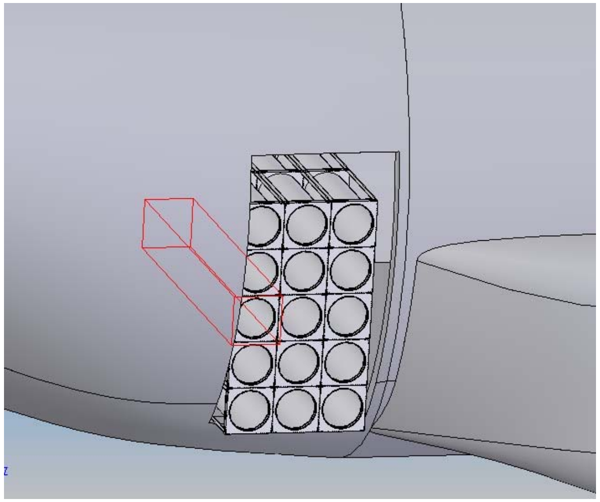
PSAS Launcher

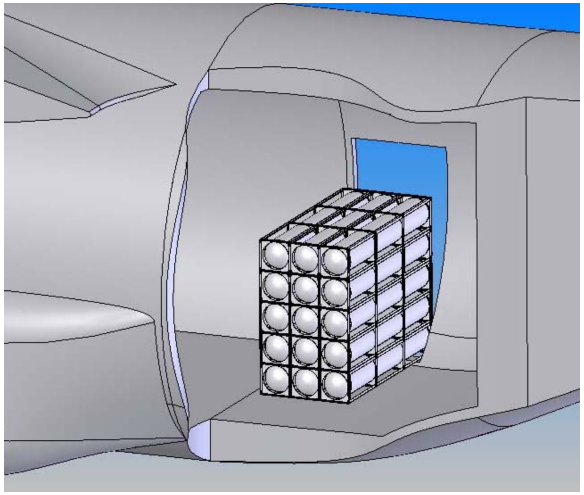
PSAS Launcher Concepts:

- **Must address LO Platform Requirements**
- **Autoloaded Trainable Gun Launcher**
- **Fixed Tube Bank Launcher**
- **VSM works in either type**









Munition Approach

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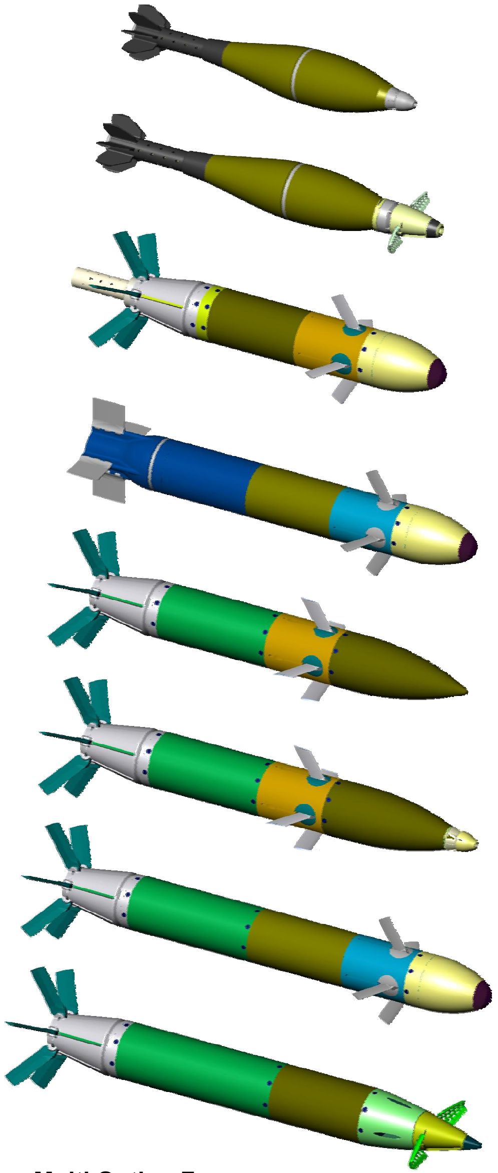
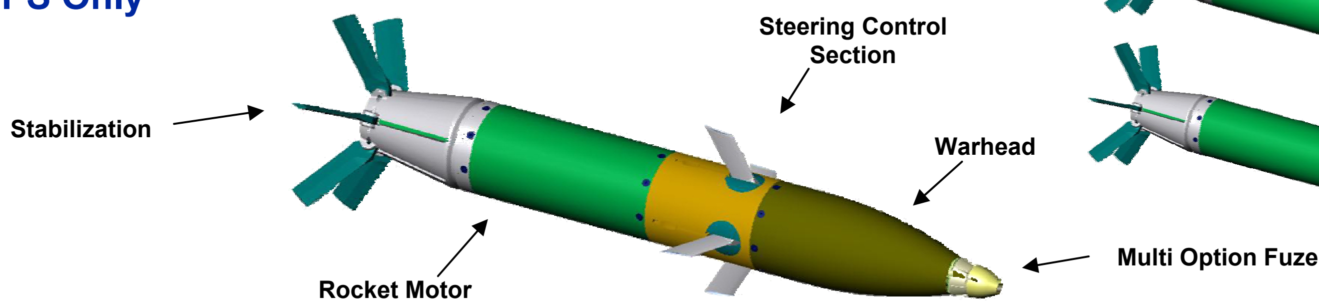
- **Modular Open System Design**
- **Member of a family of munitions**
- **Lightweight**
- **Multiple Warhead Types**
  - **Blast Frag Penetrator**
  - **EFP**
  - **Combination Blast/Frag-EFP**
  - **High Pressure Low Blast Radius Warhead**
  - **Less-than-Lethal**
- **Remote Data Control Interface**
- **GPS/INS Guidance**
- **Terminal Guidance Technologies Available**
  - **Semi Active Laser Seeker**
  - **GPS Only**

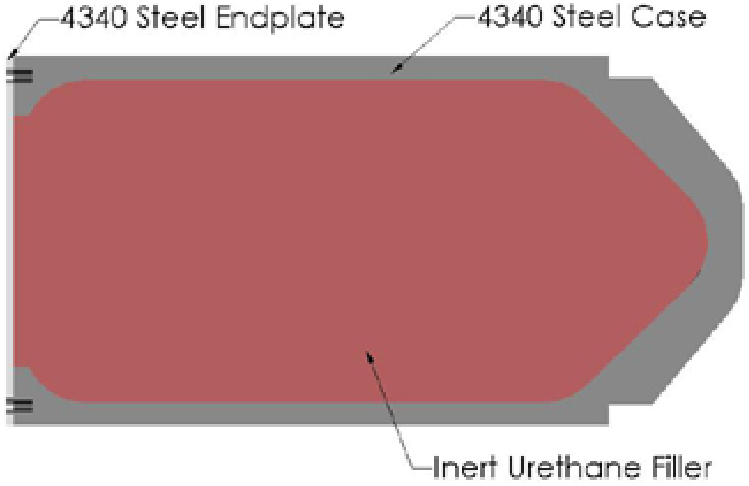




Modular Munition Design and Standard Interfaces Allows Affordability

120mm Warhead Penetration Demo

- 5 Shot Series from Airgun
- VSM Warhead Design
  - Inert
  - 4340 Steel Case
  - 20 pound
  - 120mm diameter
- 900 fps Impact Velocity
- Targets:
  - 10.5 5000 psi Reinforced Concrete; Normal Impact
  - 7 inch 5000 psi Reinforced Concrete; 30° Obliquity
  - .5 inch RHA; Normal Impact
  - .5 inch RHA; 30° Obliquity
  - 1 inch RHA; Normal Impact

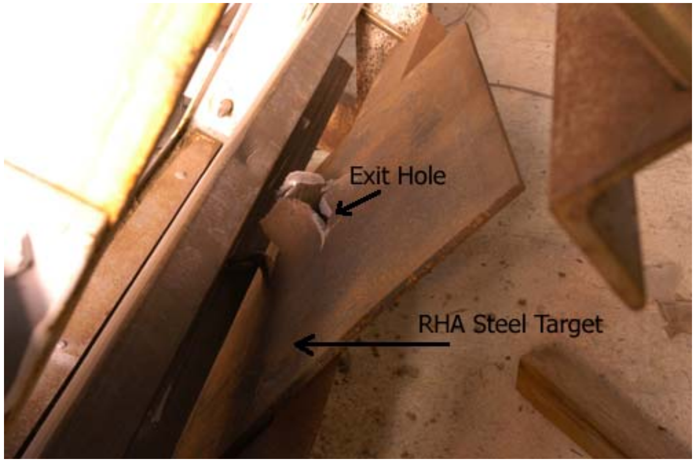


120mm Warhead Penetration Demo

Target Material	Target Thickness, in.	Obliquity, degrees	Impact Vel, ft/s	Complete Perforation	Exit Vel, ft/s	Projectile Assembly Weight, lb
RHA Steel	1	0	892	No	n/a	22.30
RHA Steel	0.5	0	888	Yes	556	21.80
RHA Steel	0.5	30	896	Yes	655	22.01

Penetration Hole in 0.5-in. RHA Steel

Bulge in 1-in. RHA Steel Plate, Exit View



Target Damage, Shot PGM-S03 .5" RHA 30° Obliquity

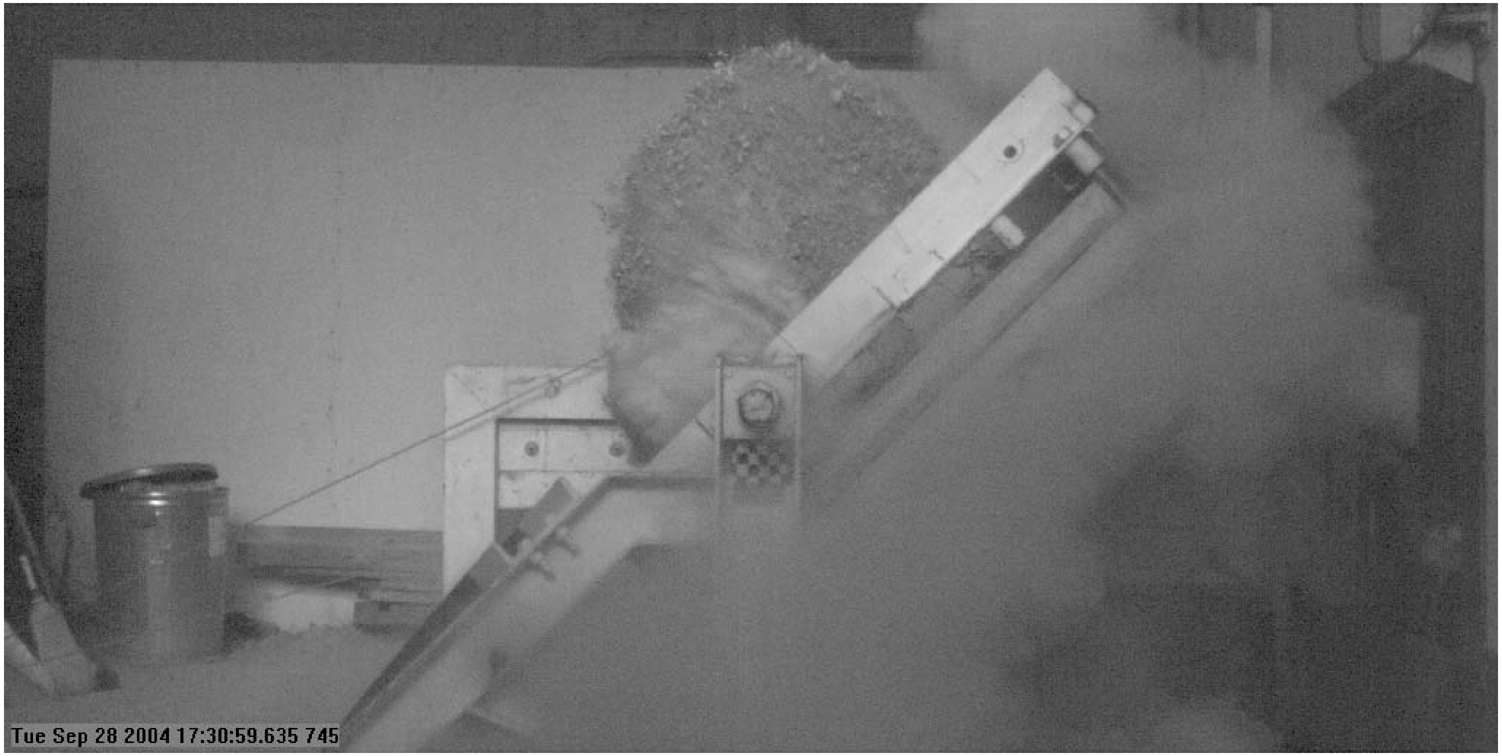
120mm Warhead Penetration Demo

Target Material	Target Thickness, in.	Obliquity, degrees	Impact Vel, ft/s	Complete Perforation	Exit Vel, ft/s	Projectile Assembly Weight, lb
Concrete	10.5	0	910	Yes	194	22.54
Concrete	7	45	914	Yes	242	22.27

Entrance Hole, Test PGM-C01
10.5" 5K RC

Exit Hole, Test PGM-C02
7" 5K RC 30° obliquity

120mm Warhead Penetration Demo



7 inches 5000 psi Reinforced Concrete
45° Obliquity

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Summary

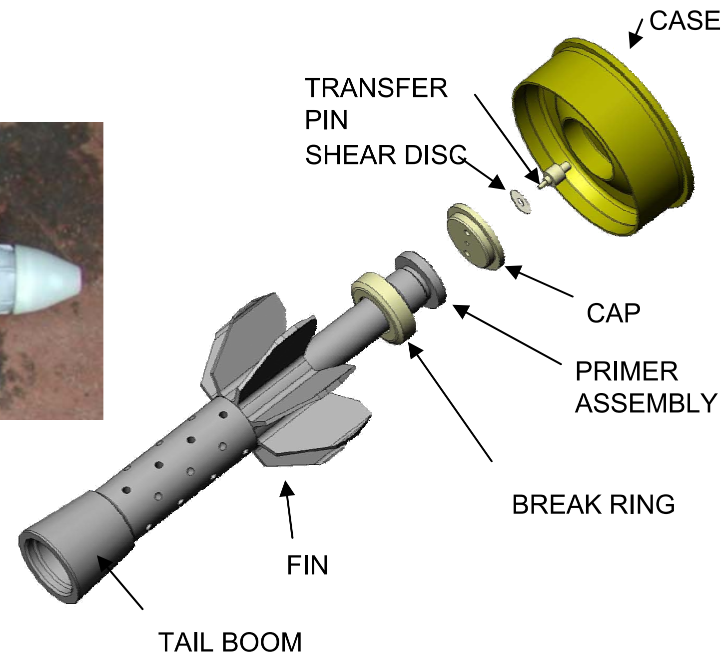
Very Small Munition:

- **120mm Diameter**
- **Launchers:**
  - **side firing gun capable of firing standard 120mm mortar ammunition**
  - **PSAS Concept Launcher**
- **Provides 360° Coverage from either AC-130 or PSAS**
- **A Viable Spiral for AC-130**
- **Meets PSAS Roadmap Objectives**

BACKUPS

M102 Howitzer 120mm Conversion Demo

- **Standard M931 TP Cartridge**

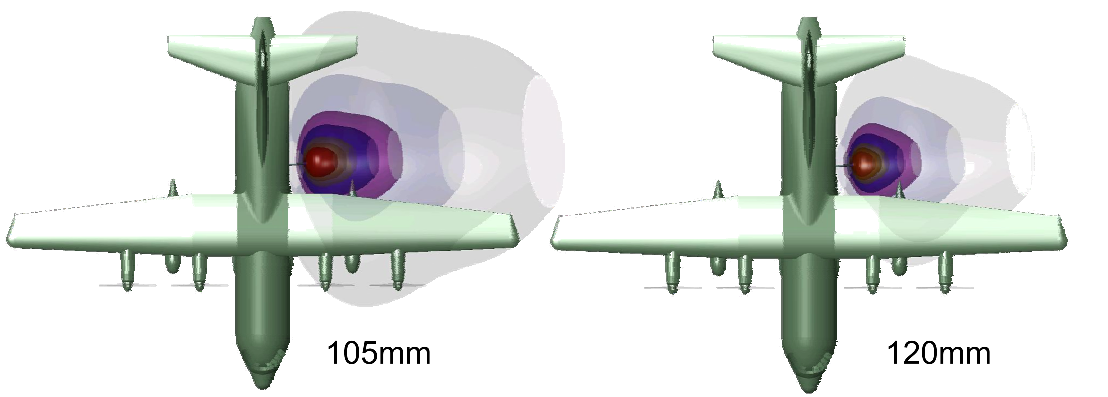


- **M931 After Conversion**
- **Conversion Applicable to All M930 Series Ammunition**

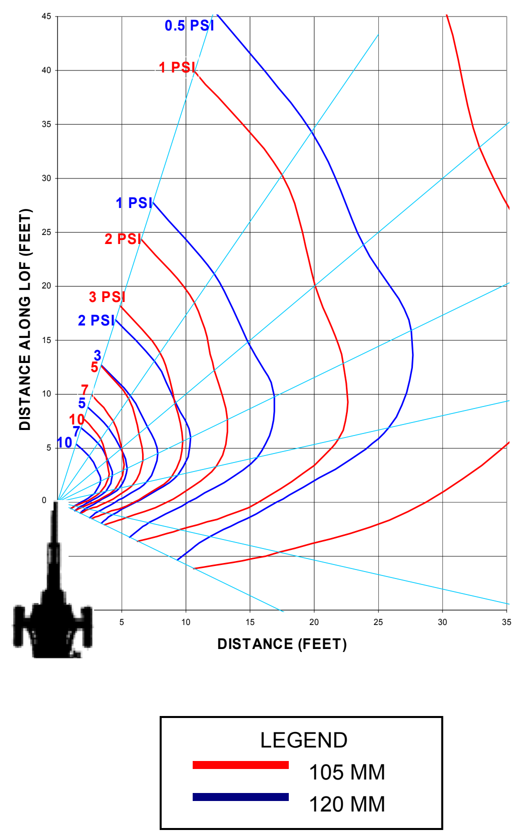
M102 Howitzer 120mm Conversion Demo

- **Blast Overpressure of 120mm was Approximately 35% Lower than 105mm**
- **120mm Mortar Rounds Shot at Highest Charge**
  - **Further Reduction in Blast Possible from Lower Propellant Charge Configuration**

Overlay of 3D Blast Pressure Curves on C-130

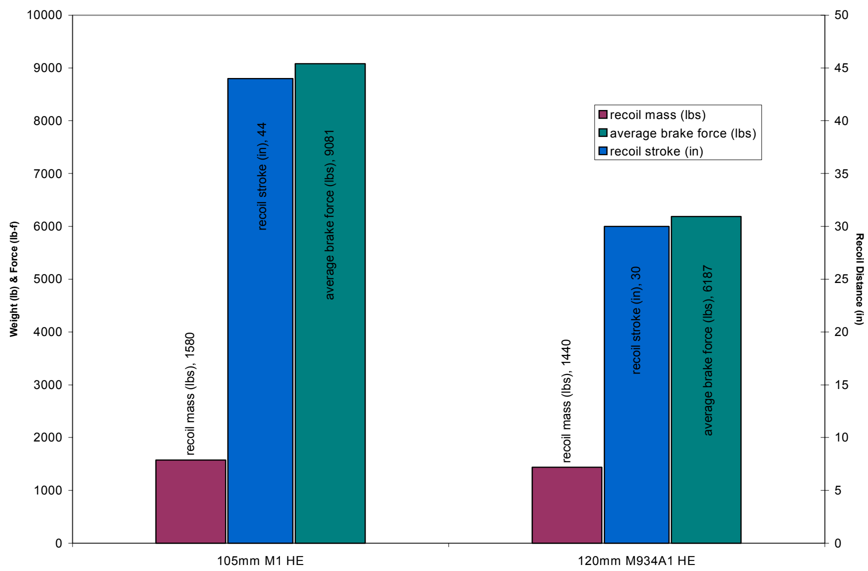


Blast Pressure Curves



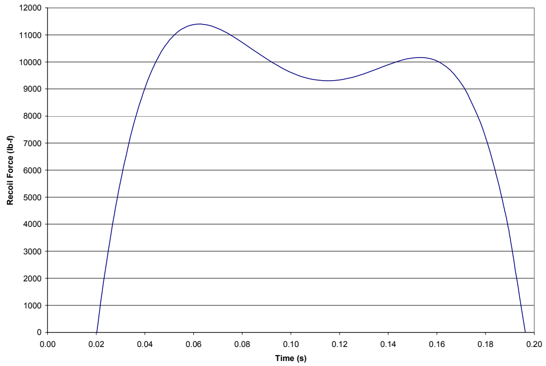
M102 Howitzer 120mm Conversion Demo

- Recoil Force of 120mm was Approximately 30% Lower than 105mm
- Recoil Mechanism Can be Optimized for 120mm Gun
  - Further Reduction in Recoil Force
  - Lighter Weight Gun Components
- Lower Charge Propellant Should Reduce Recoil Loads

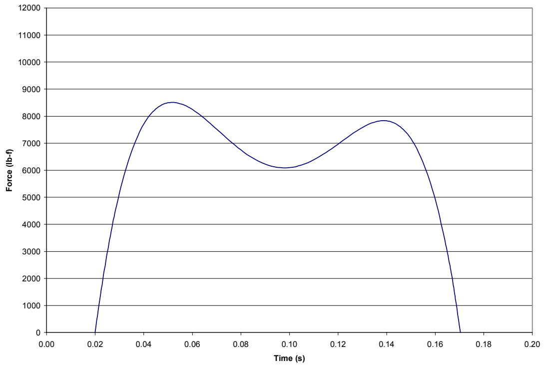


105mm 120mm

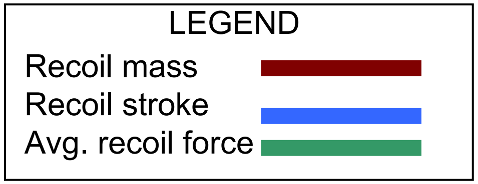
Recoil force curves from high speed video derivation, force vs. time



105mm

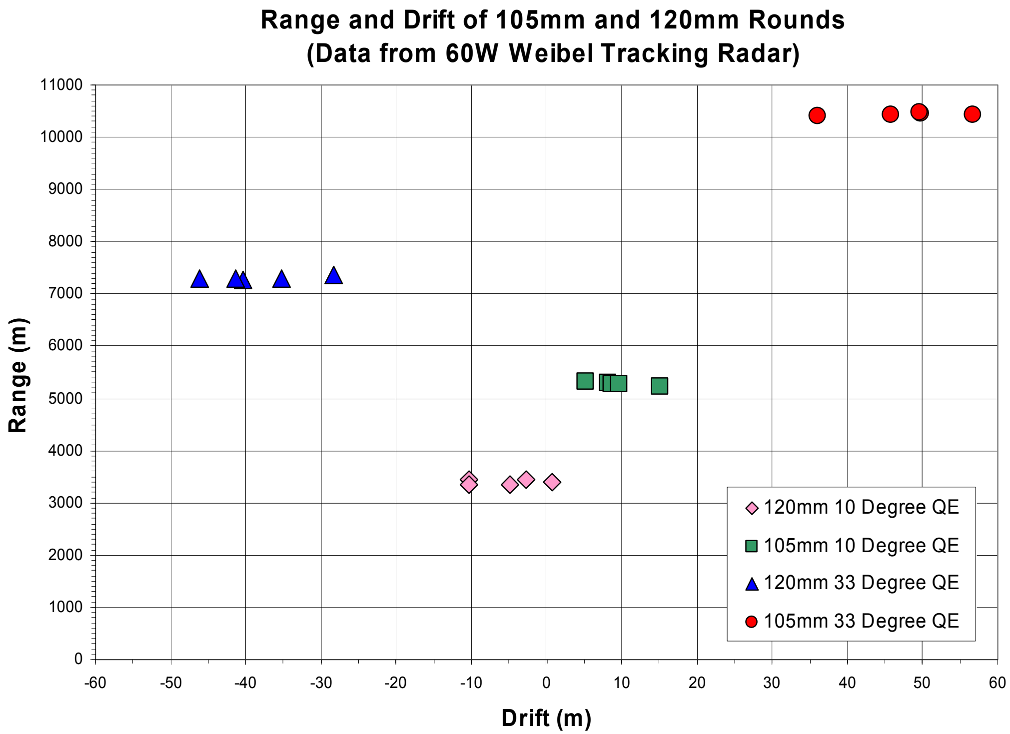


120mm



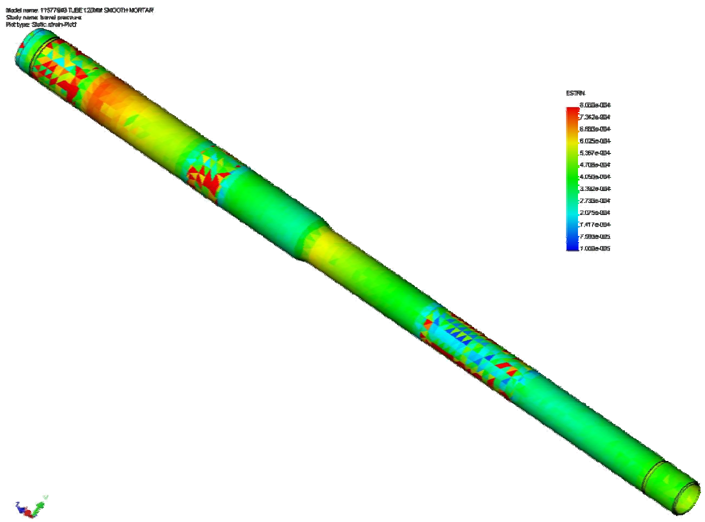
M102 Howitzer 120mm Conversion Demo

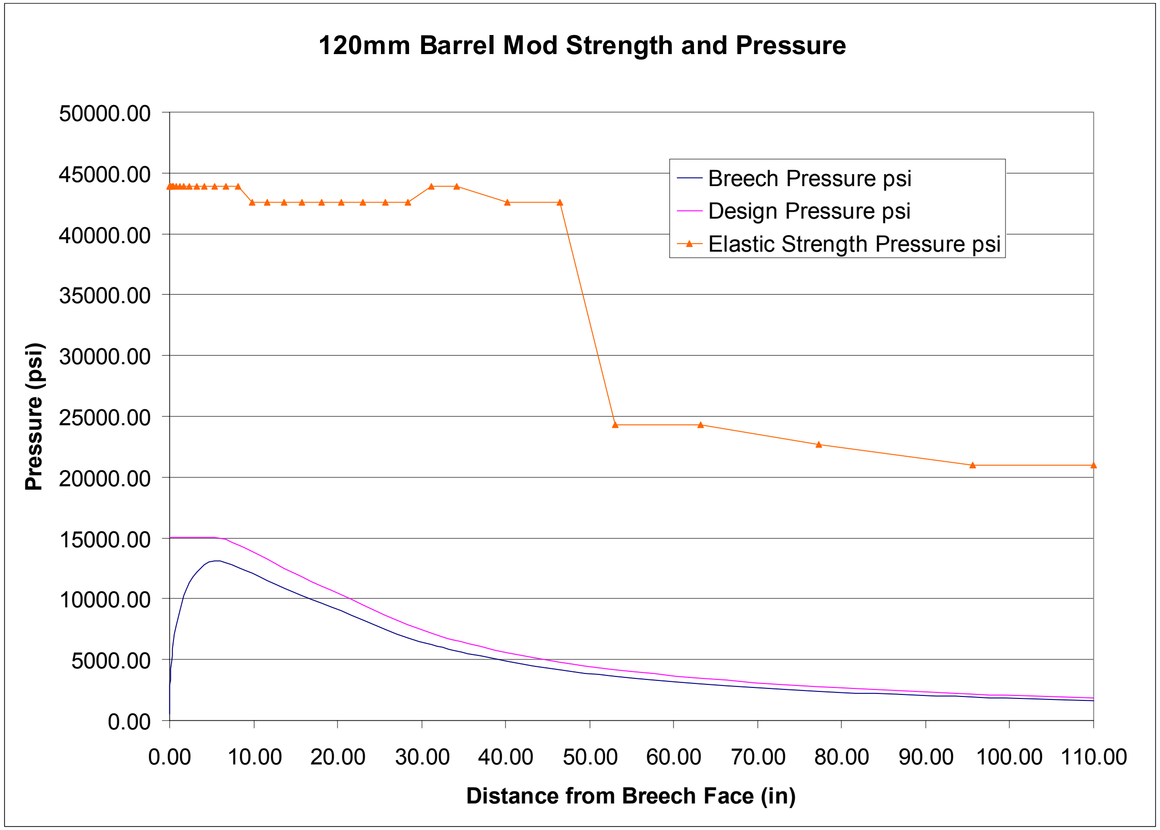
- **120mm Muzzle Velocity -> 1218 ft/s**
  - **Maximum Muzzle Velocity from M120 Mortar -> 1040 ft/s**
- **120mm Range: 10° QE -> 3400 m Average; 33° QE -> 7300 m Average**
  - **Maximum Predicted Range for 120mm -> 8100 m**
  - **Maximum Range from M120 Mortar ->7270 m**



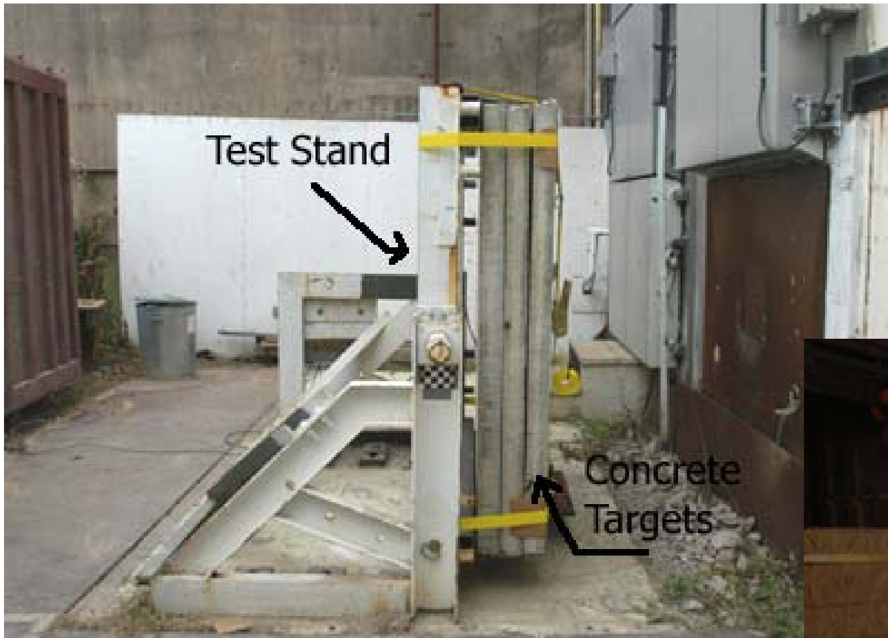
M102 Howitzer 120mm Conversion Demo

- **Design Pressure of Gun System Below Elastic Strength Pressure**
  - **Optimize Gun Dimensions to Reduce Weight and Footprint**
  - **Optimize Recoil Mechanism to Reduce Recoil Load**

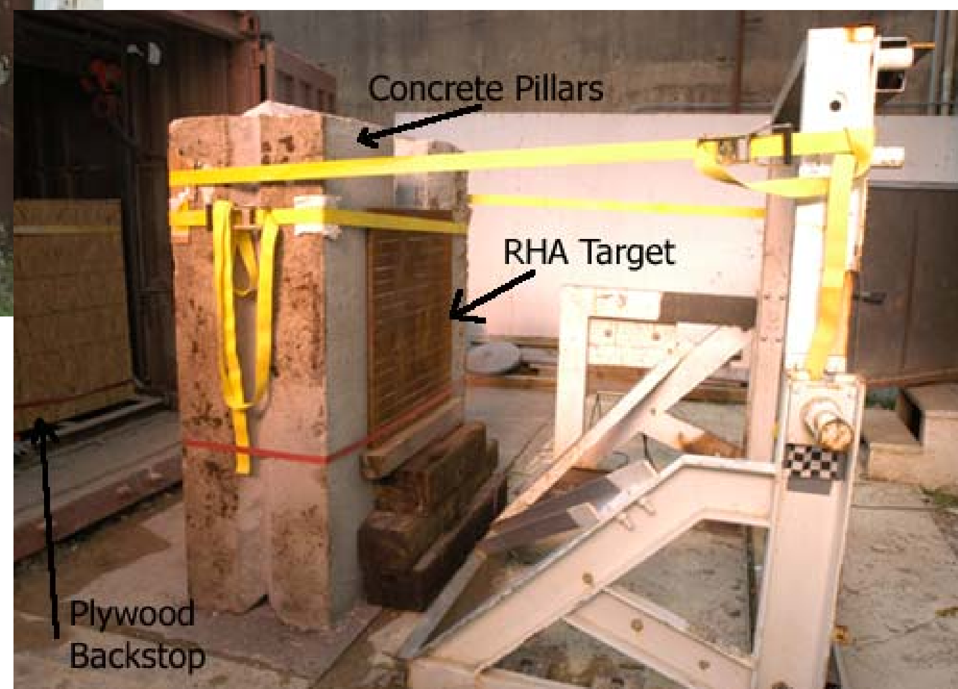




120mm Warhead Penetration Demo

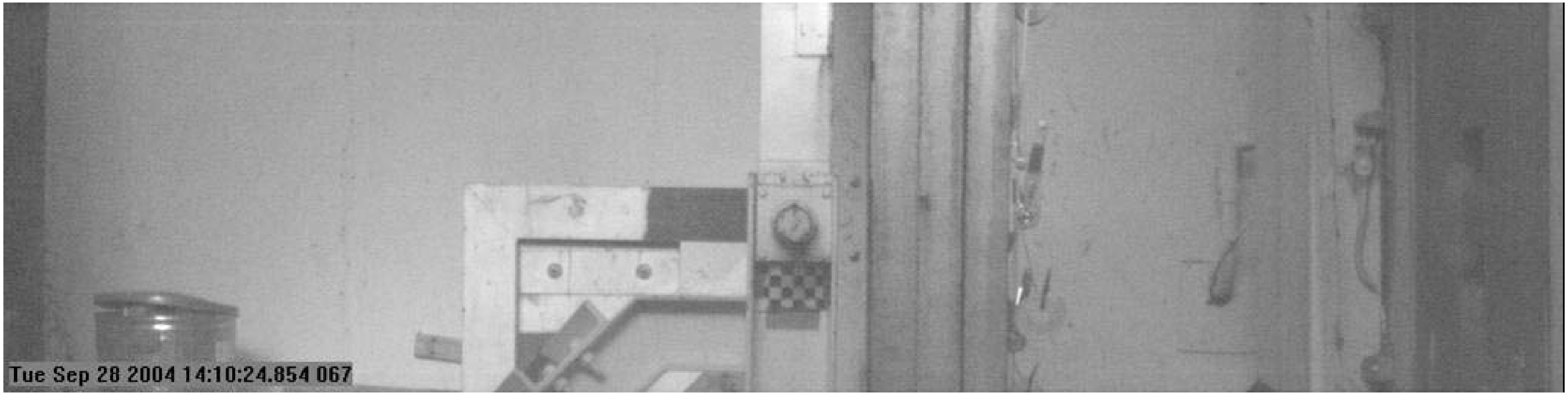


Concrete Target and Oblique RHA Test Setup



Normal Impact RHA Steel Target Setup

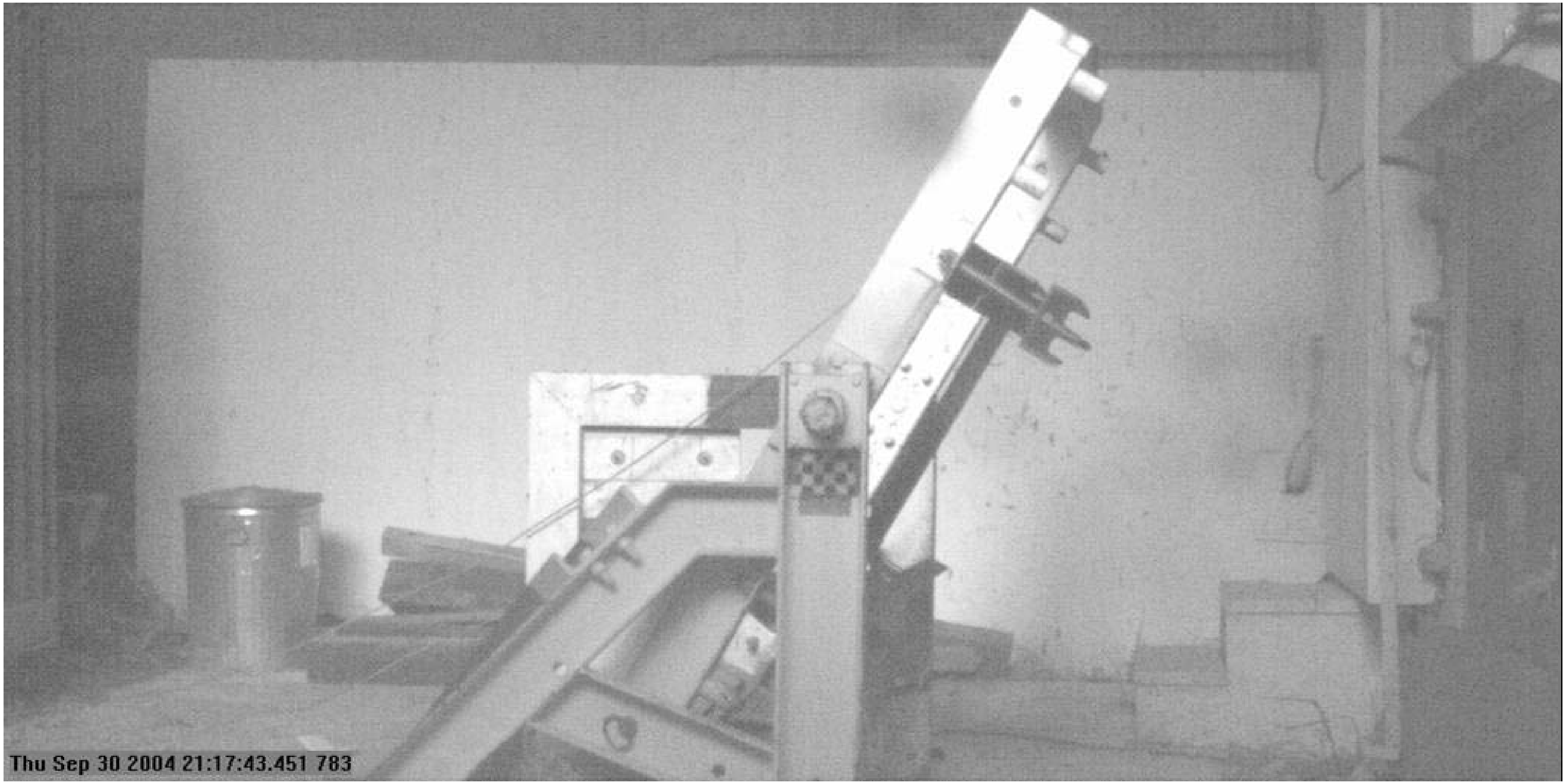
120mm Warhead Penetration Demo



10.5 inches 5000 psi Reinforced Concrete

0° Obliquity

120mm Warhead Penetration Demo



.5 inches RHA
30° Obliquity

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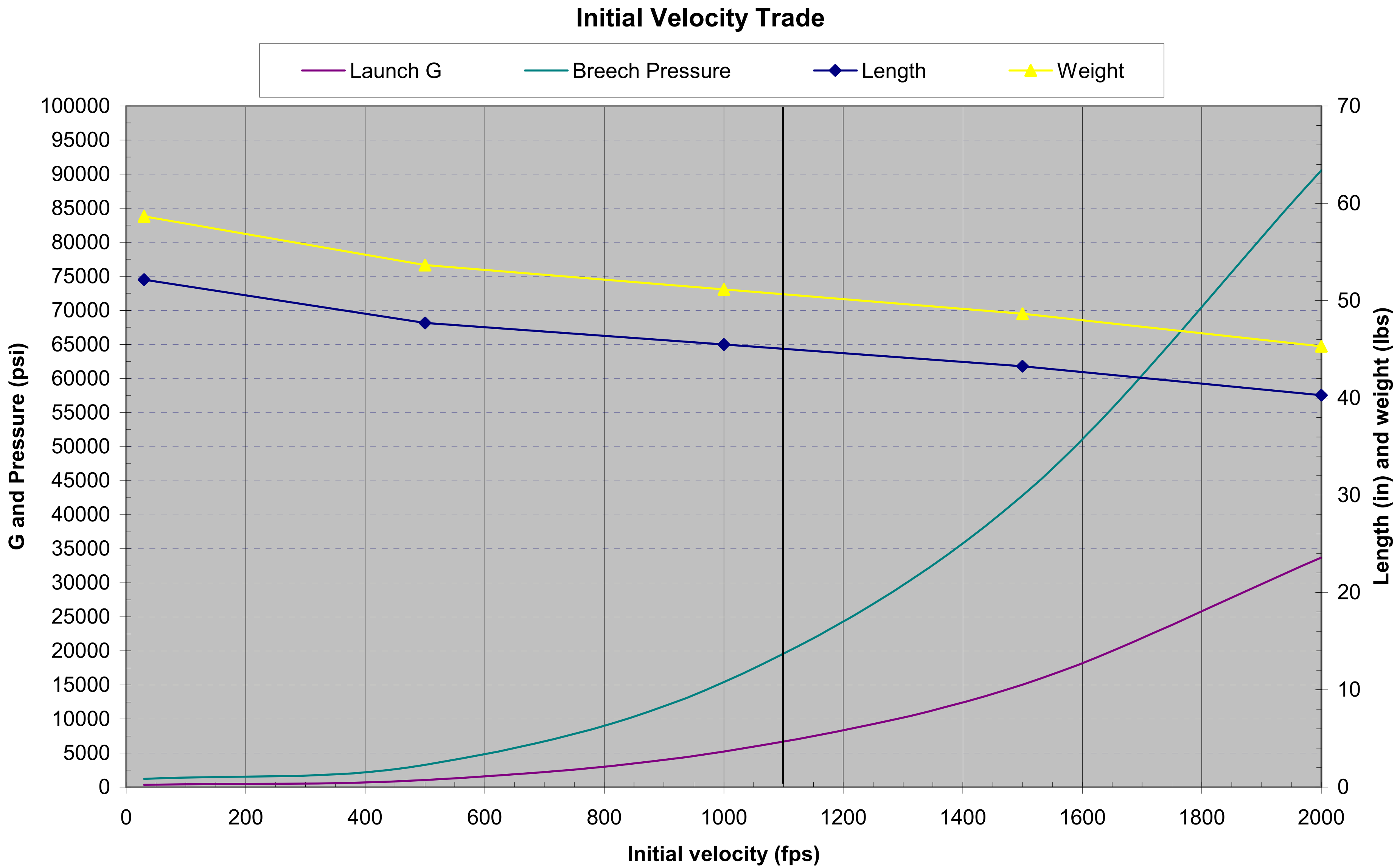
VSM Configuration Trade Studies
Initial Velocity

- **Purpose: Investigate Length and Weight Payoff of Utilizing Higher Gun Launch Initial Velocity vs. Carrying More Rocket Propellant in Munition.**
- **Fixed Performance: Munition to Achieve 15 nmi in 65 seconds**
- **Allow Necessary Weight and Length to Vary Given Different Initial Velocities**
- **Considerations:**
  - **G Load on Munition**
  - **Recoil Loads**
  - **Chamber Pressure**
  - **Munition Length**
  - **Munition Weight**

VSM Configuration Trade Studies
Initial Velocity



VSM Configuration Trade Studies Initial Velocity

- Higher Initial Velocity Allows Munition to Loose Weight and Length for Same Given Range Performance
- Limiting Factors
  - Chamber Pressure
  - G Loads on Munition – 7500 G is not Difficult for Mortar Ammunition Components
- 1100 fps Yields Acceptable Levels for All These Parameters:
  - 51-pound Munition
  - 45 inches Long
  - 21,000-psi Chamber Pressure
  - 7200 G
- Lower Mortar Propellant Increments will Permit Lower G Launch, and Munition Weight and Length Benefits will be Achieved, Needs Further Investigation

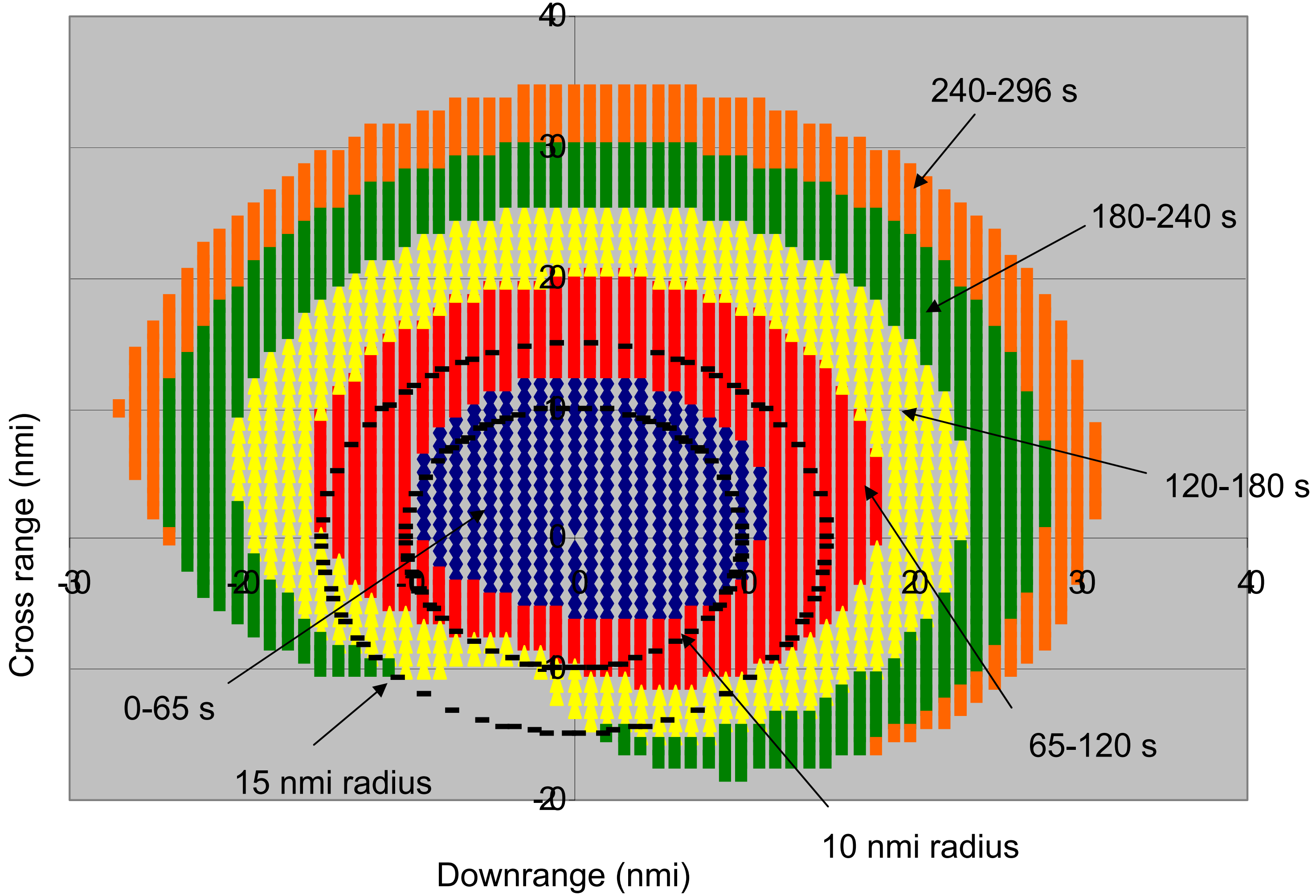
VSM Configuration Trade Studies
Range Studies

- Side Launching Munitions Offers Some Performance Advantages Over Top and Forward Launch
- Top Launch has Best Extended Range Advantage, but has Some Difficulty Getting Under AC
- New Control Algorithms Being Examined for Better Offside Performance from Side Launched Munitions
- Low Altitude CONOPS are Feasible with this Munition
- VSM would have Tremendous Application as a Ground Combat Fire Support Munition
- The Range and Response Time Requirements must be Examined in the Context of the Overall PSAS Combat System

VSM Configuration Trade Studies
Range Studies

Configuration 1

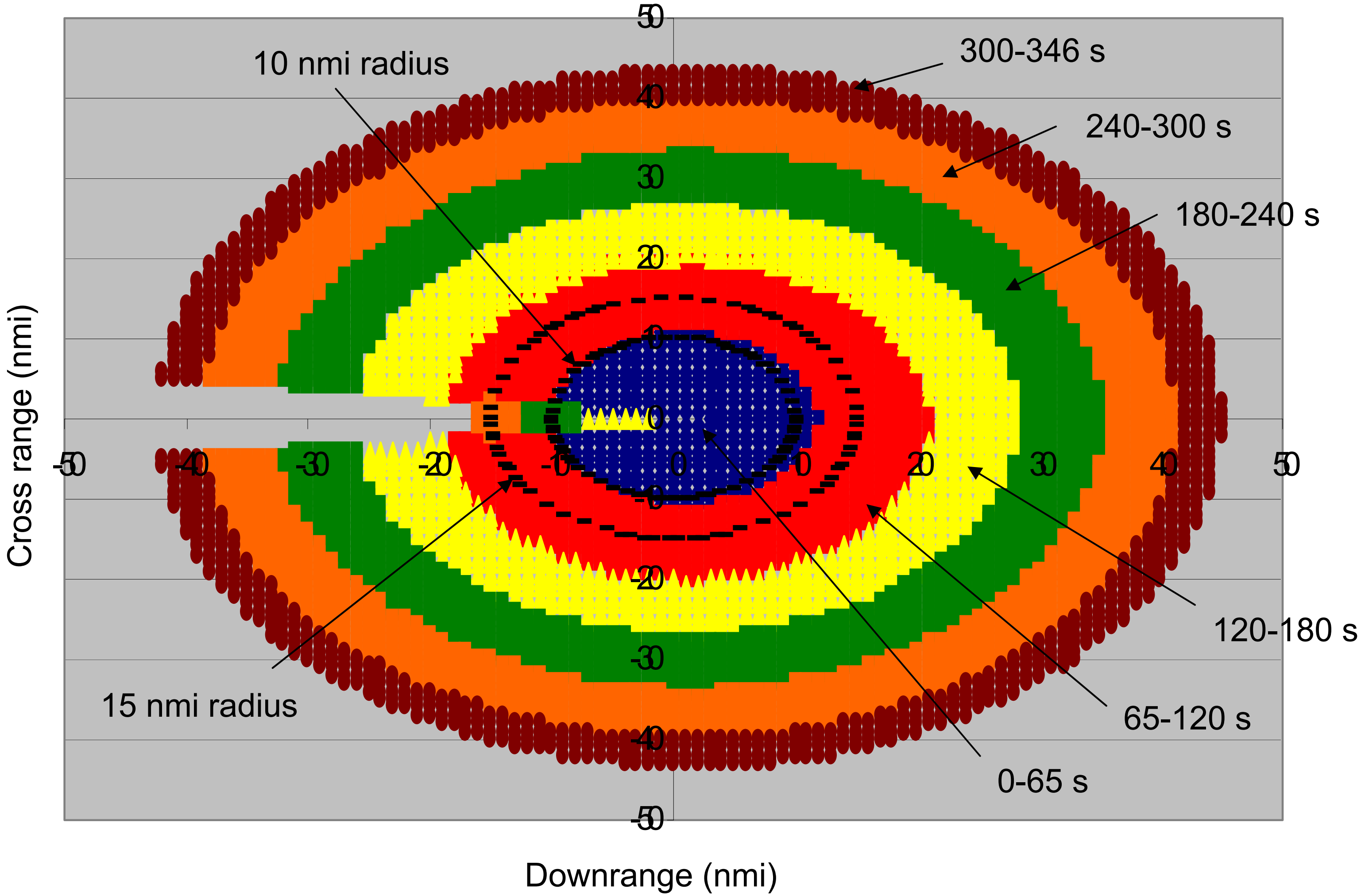
Side Launched
Initial Velocity = 1100 fps
AOF = -90 deg



VSM Configuration Trade Studies
Range Studies

Configuration 1

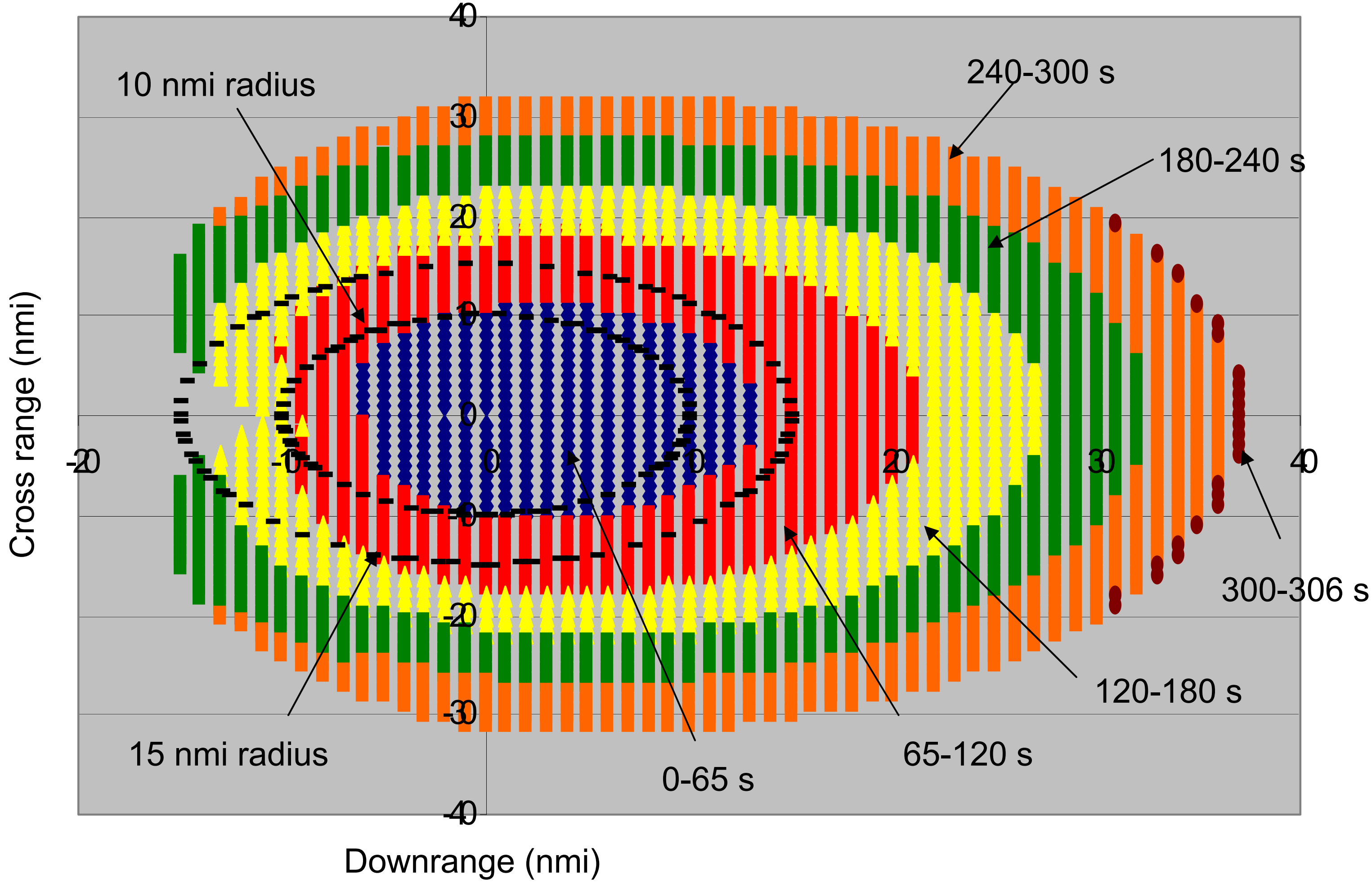
Top Launched
Initial Velocity = 1100 fps
AOF = -90 deg



VSM Configuration Trade Studies
Range Studies

Configuration 1

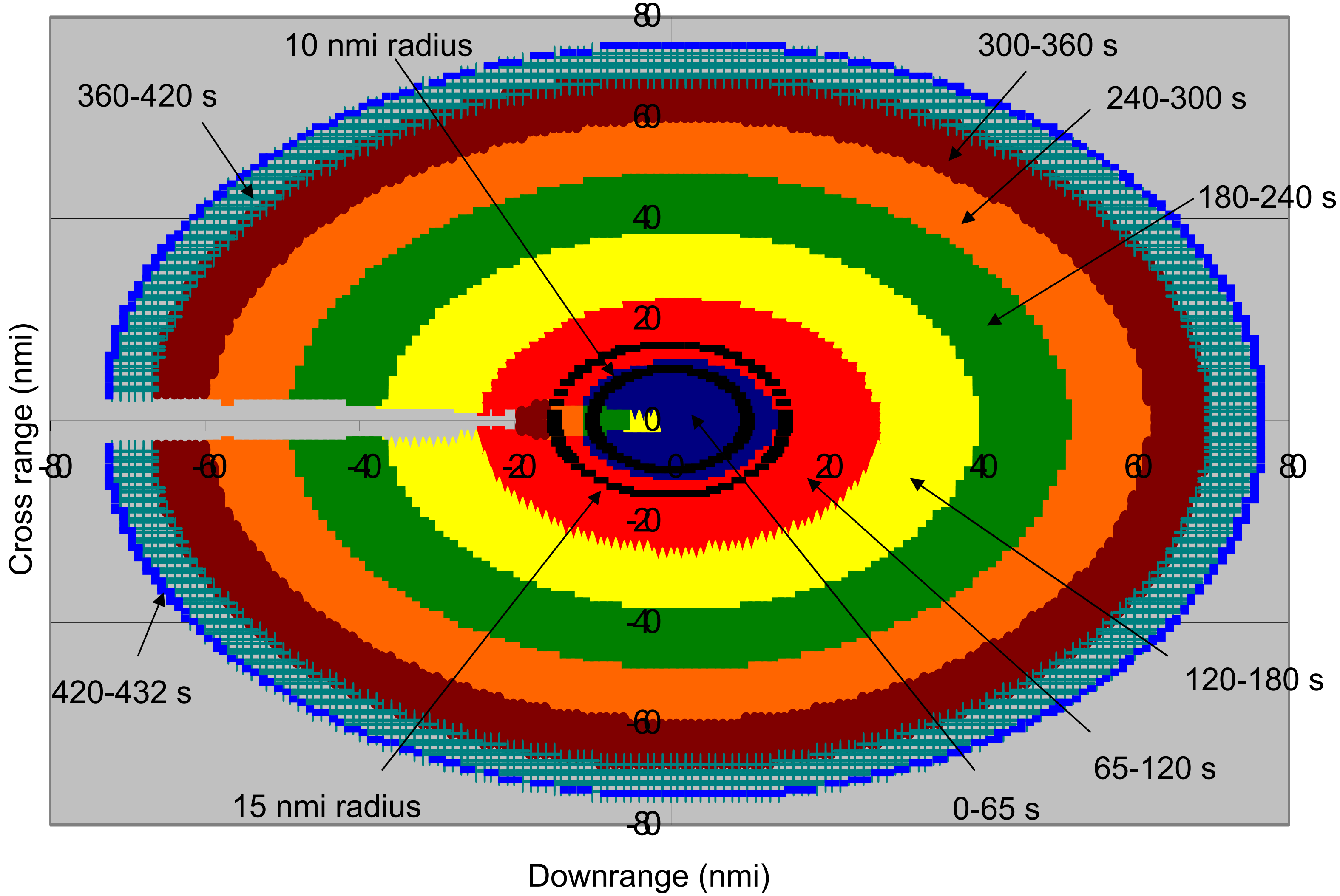
Forward Launched
Initial Velocity = 1100 fps
AOF = -90 deg



VSM Configuration Trade Studies
Range Studies

Top Launched
Initial Velocity = 1100 fps
AOF = -90 deg

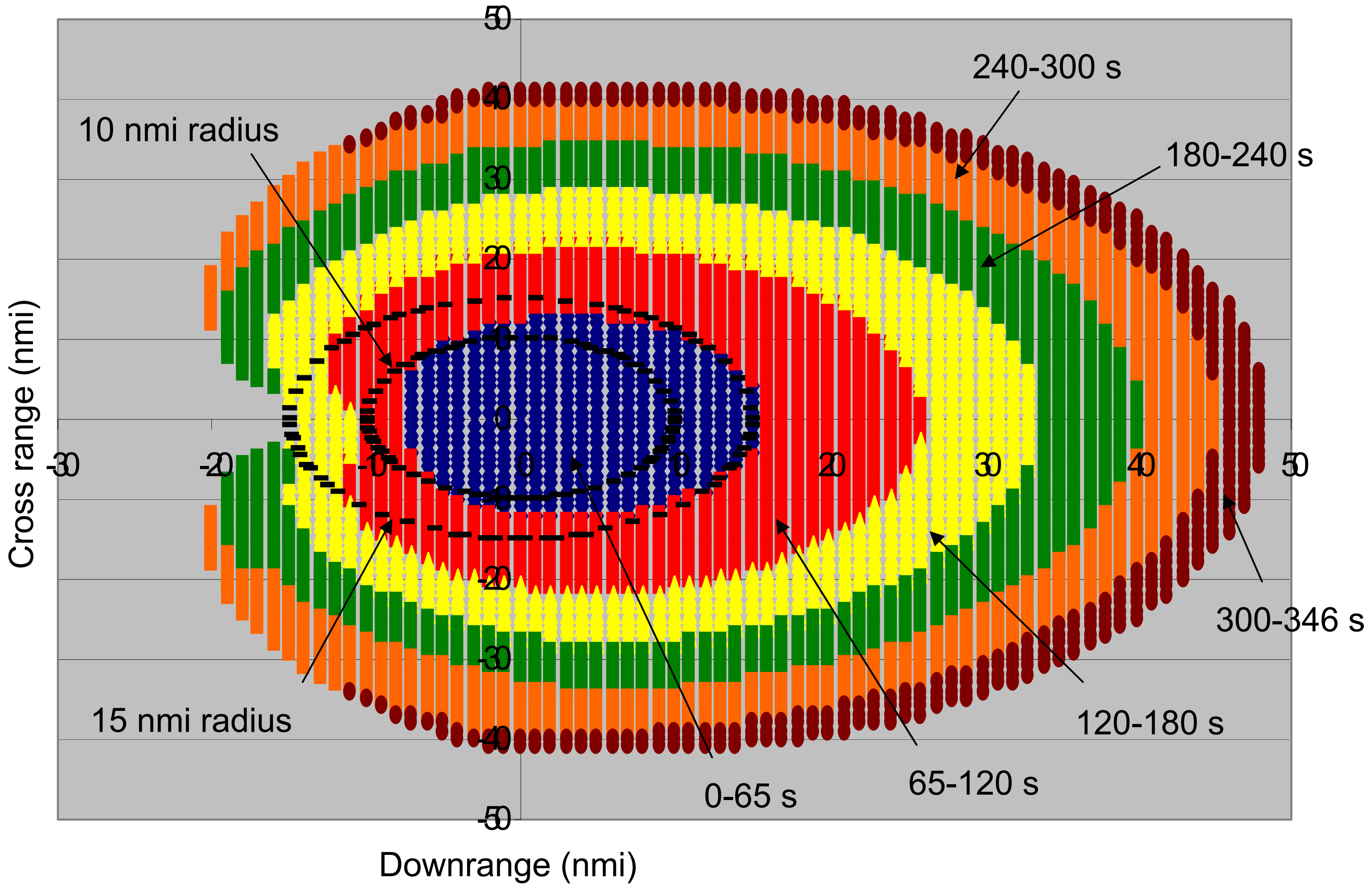
Configuration 2



VSM Configuration Trade Studies
Range Studies

Configuration 2

Forward Launched
Initial Velocity = 1100 fps
AOF = -90 deg

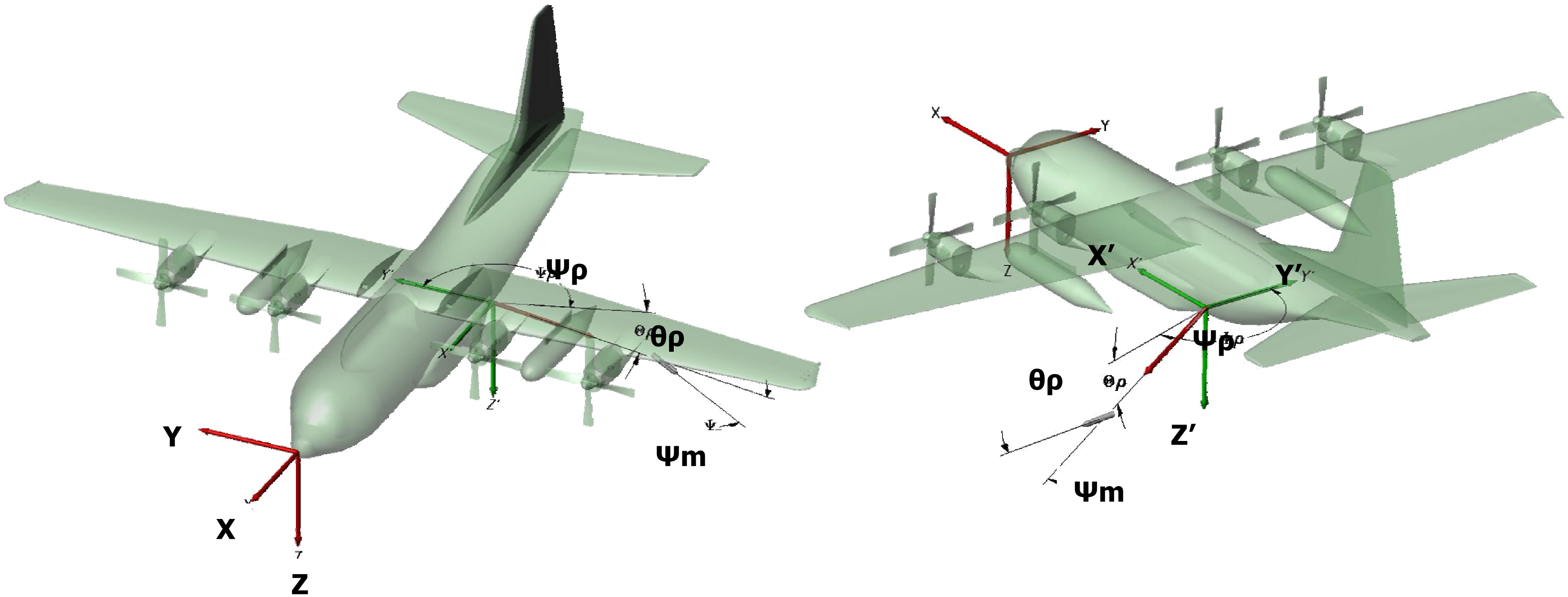


NAVSEA WARFARE CENTERS DAHLGREN

VSM Configuration Trade Studies
Munition / Aircraft Separation Study

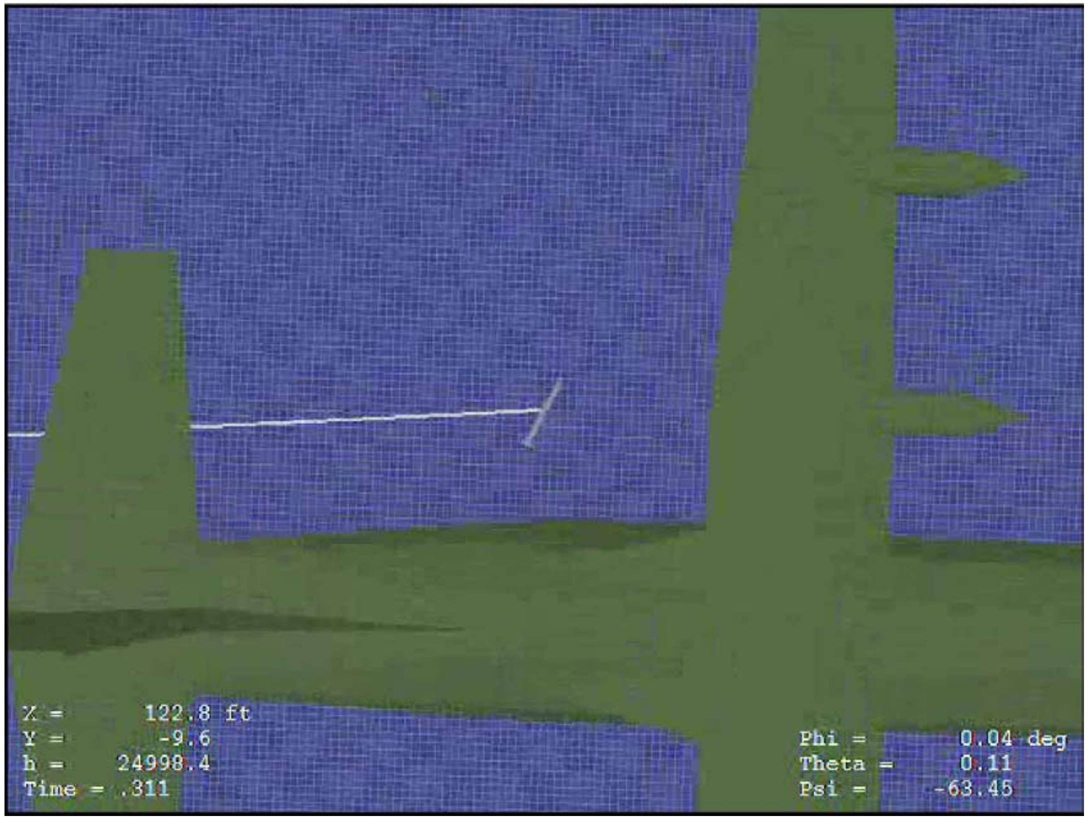
- **Purpose of Study: Develop a Simulation that will Allow Modeling of Munition Flyout from AC**
- **Six Degree of Freedom (6-DOF) Simulation**
- **Ejection Speed (Study Variable)**
- **Parameters:**
  - **C-130 Slip Stream and Prop Wash is Modeled**
  - **Munition is Unguided Through Separation**
  - **Munition Initial Conditions Based Upon:**
  - **Aircraft Velocity (240 kts)**
  - **Launcher Position Relative to Aircraft (X', Y', Z')**
  - **Two Launcher Angles Relative to Aircraft: Azimuth Ψp, Elevation θp**
  - **One Munition Angle Relative to Launcher: Azimuth Ψm**

VSM Configuration Trade Studies Munition / Aircraft Separation Study



Global (Aircraft): X, Y, Z
Local (Launcher): X′, Y′, Z′
Launcher Azimuth: Ψρ
Launcher Elevation: θρ
Munition Azimuth: Ψm

VSM Configuration Trade Studies
Munition / Aircraft Separation Study



- Initial Velocity: 100 fps
- Initial Velocity: 250 fps.
- Initial Velocity: 30 fps Good Trajectory
- Initial Velocity: 30 fps Bad trajectory

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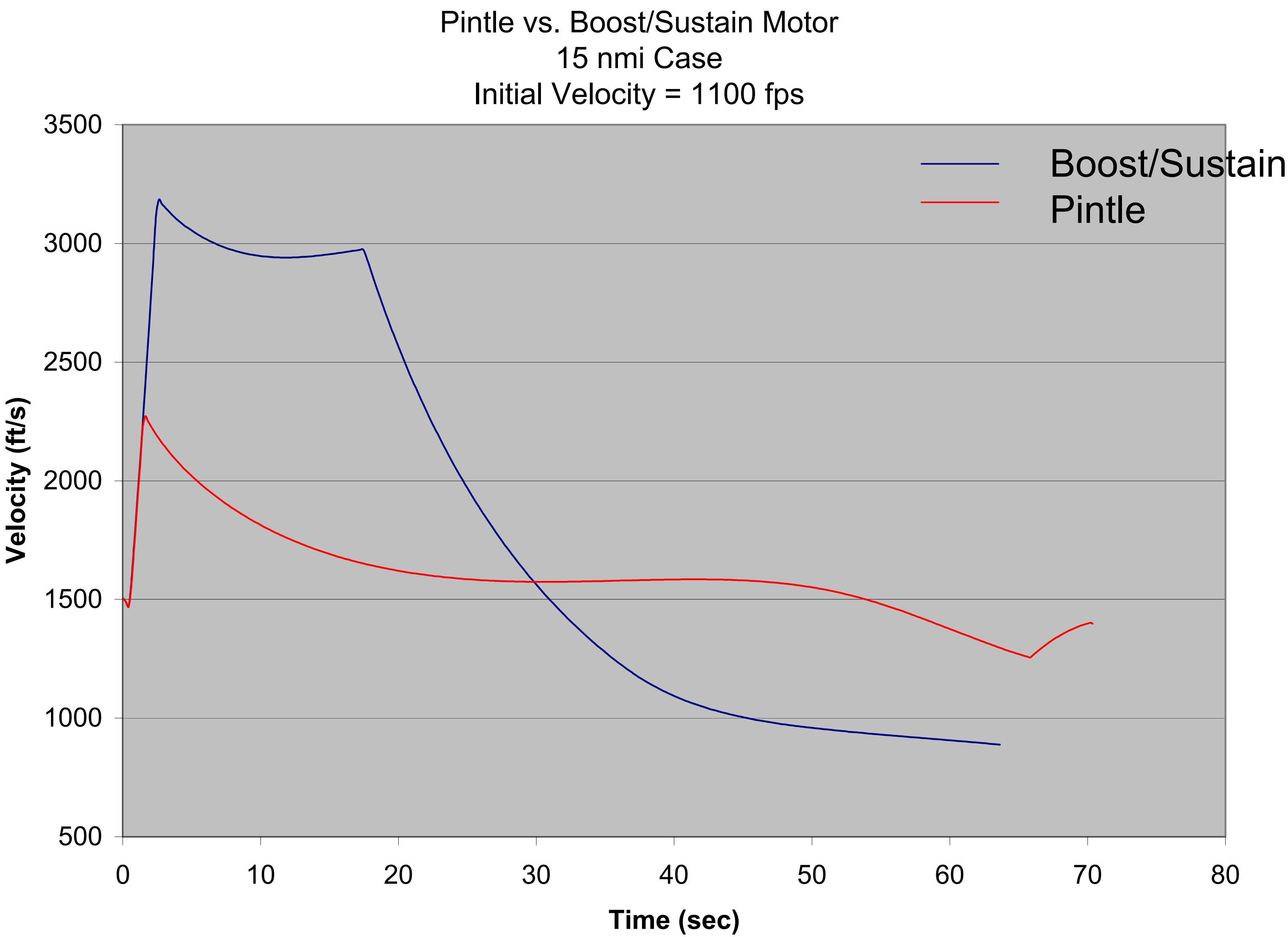
VSM Configuration Trade Studies
Munition / Aircraft Separation Study

- **Initial Studies of Munitions Indicates that Lower Launch Velocities (200-500) will not have Difficulty Separating from AC**
- **Oscillation of Munition During Low Velocity Launch May be an Issue for Guidance System**
- **Further Development of Simulation Warranted Using AFSOC Owned AC-130 Flow Field Model Developed by Auburn University**
- **Results Should be Verified in Actual Flow Field**

VSM Configuration Trade Studies
Motor Configuration

- Study of Pintle Motor Configuration Examined to Investigate Potential of this Type of Motor
- Possible Pintle Motor Trade-offs:
  - Fly During "Cruise" with Low Mass Flow Rate Allowing for Possible Higher Terminal Velocities
    - This Allows for More Propellant to be Left to Throttle Up With
  - Fly During "Cruise" with High Mass Flow Rate Allowing for Possible Shorter Time-of-Flights
    - This Leaves Little Propellant for Throttling Up, but can Possibly Give Better Time-of-Flights than a Boost/Sustain Motor
- This is only a rough cut! This pintle motor design will need some optimization to determine what the best burn conditions are for the specified mission (i.e. higher terminal velocities and shorter time-of-flights may be possible to achieve).

VSM Configuration Trade Studies
Motor Configuration



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VSM Configuration Trade Studies
Motor Configuration

- Rough Cut Analysis Indicates that the Configuration is Promising
- May Need to Be Soft Launched
- Less Mature Technology
- This Pintle Motor Design will Need Some Optimization to Determine What the Best Burn Conditions are for the Specified Mission
- With this Technology it may be Possible to Achieve:
  - Higher Terminal Velocities
  - Shorter Time-of-Flights