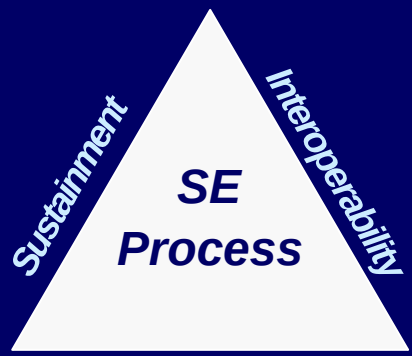
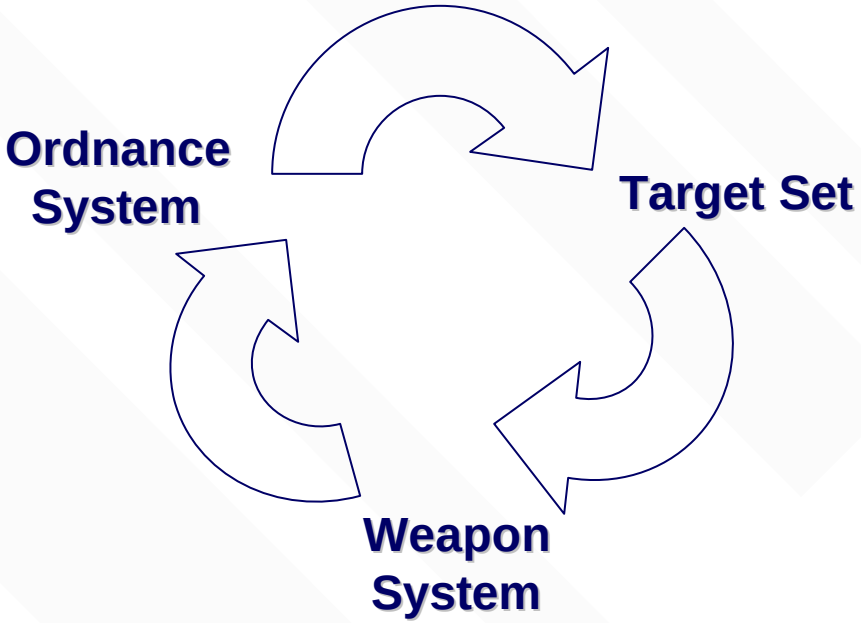
Certified
Naval Battle Groups



So, You Think It's Easy to Build a Warhead…
An Ordnance System Perspective



Karen Clotfelter, Donna Reedal, Leonard Wilson, and Walter Hoye

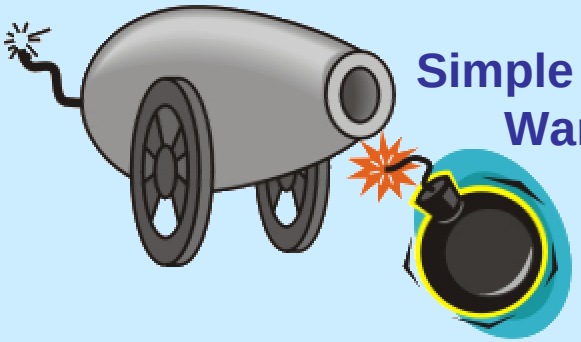
Naval Surface Warfare Center, Dahlgren, Virginia

NDIA System Engineering Conference Oct 21-24 2002

Agenda

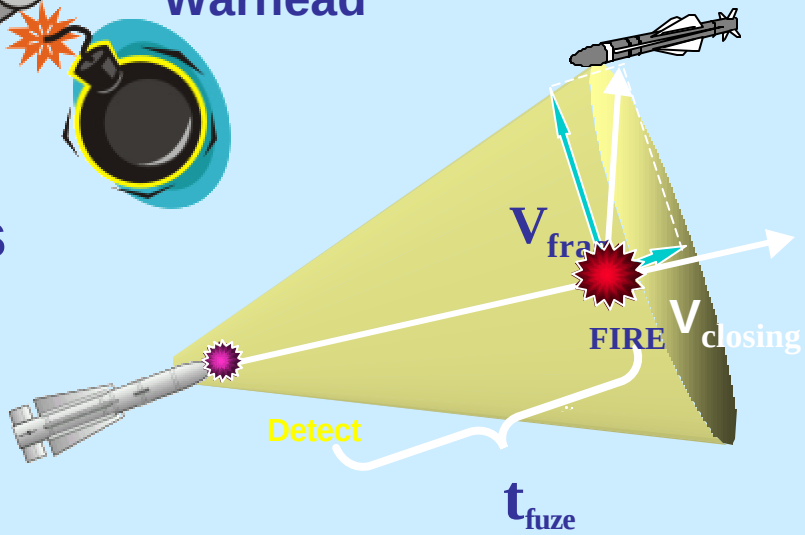
- What is a Warhead?
- What is the Challenge?
- Ordnance System Considerations
- System Effectiveness Implications
- Summary

We Have Come a Long Way with Ordnance



Simple Fuze and Warhead

1800's

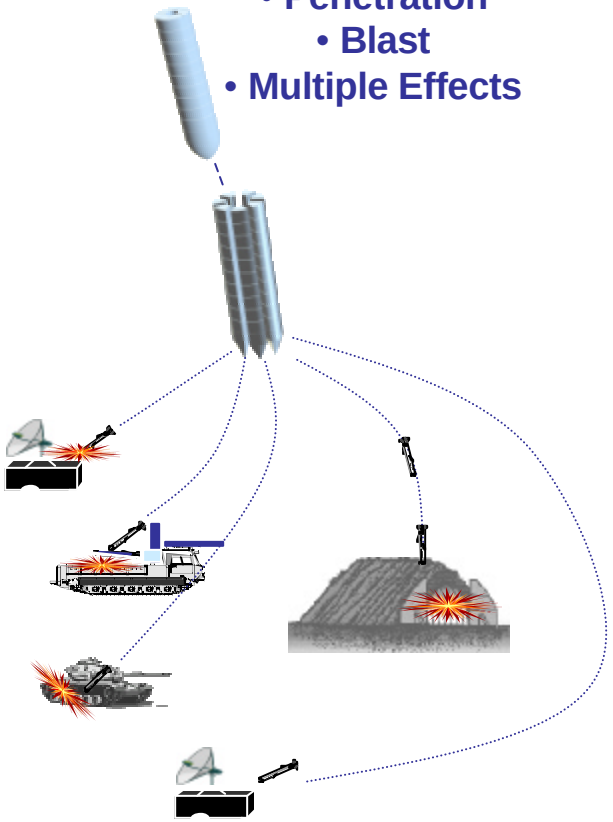


1990's

Precision Burst Point Control and Warhead Function

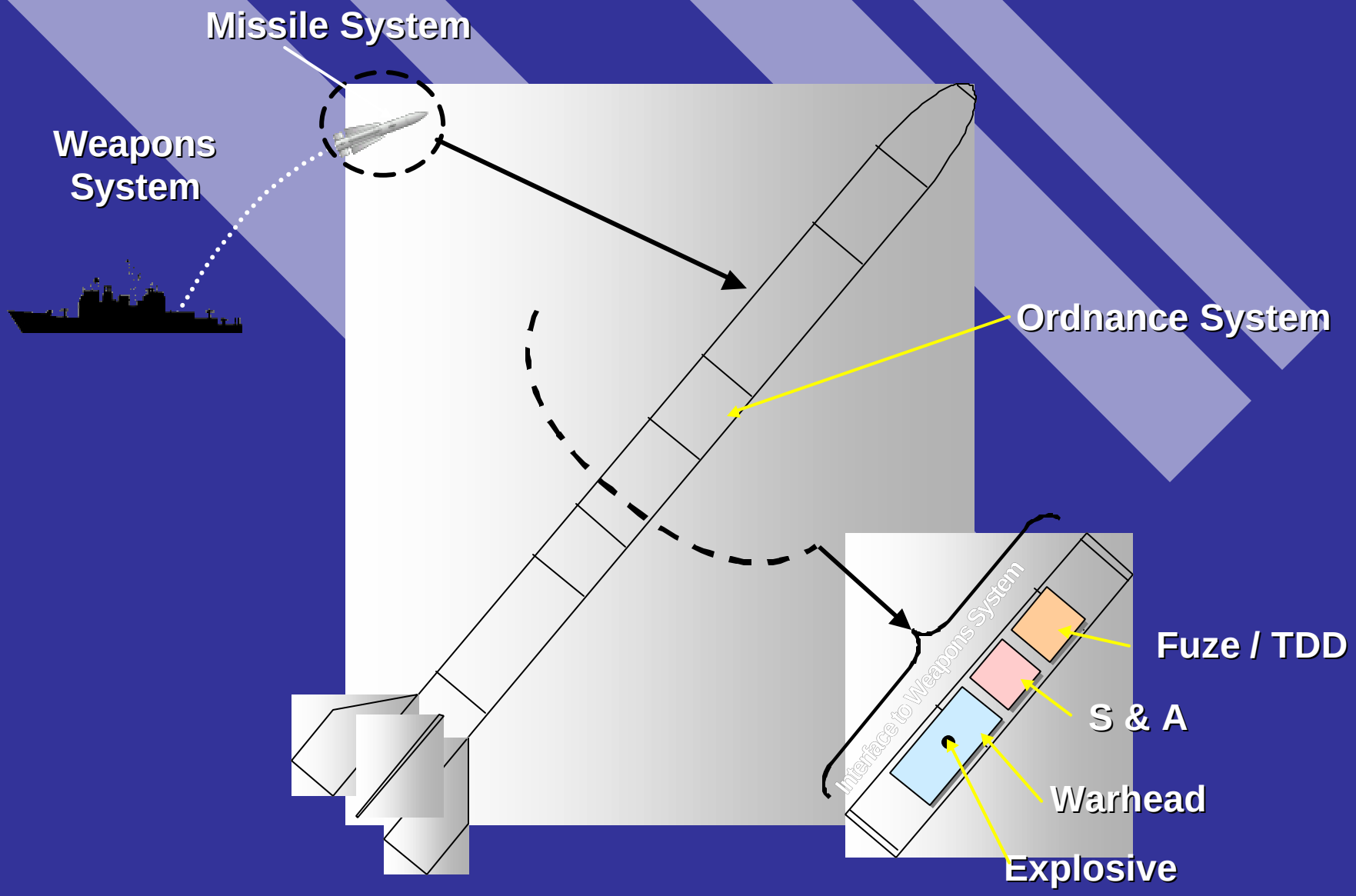
Adaptable Ordnance System

- Precision
- Penetration
- Blast
- Multiple Effects



2000's

What is an Ordnance System?

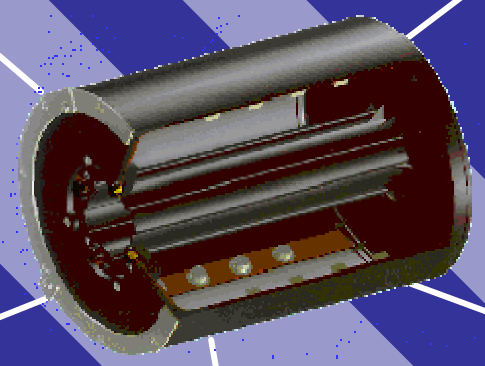


What is the Challenge with an Ordnance System?

- Effective and Timely Integration of a Weapon System and its Ordnance System to Achieve Required Lethality
- To Tailor Ordnance Systems to Provide Required Lethal Effects on the Target

Exploit Specific Target Vulnerabilities

Maximize Target Damage While Minimizing Collateral When Necessary

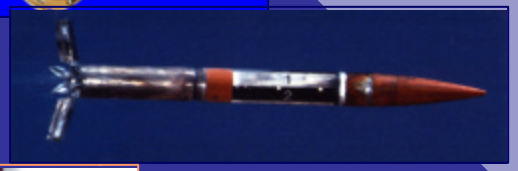


$ Cost Effective

Be Safe & Insensitive

Be Producible & Reliable

System Performance Considerations



Ordnance System

Lethal Mechanisms

- **Blast**
- **Fragmentation**

Interface with Weapon System

- **Structural**
- **Electrical**

Target Set

- **Geometry**
- **Construction Materials**
- **Critical Components**
- **Vulnerable Areas**
- **Kill Criteria**

Weapon System

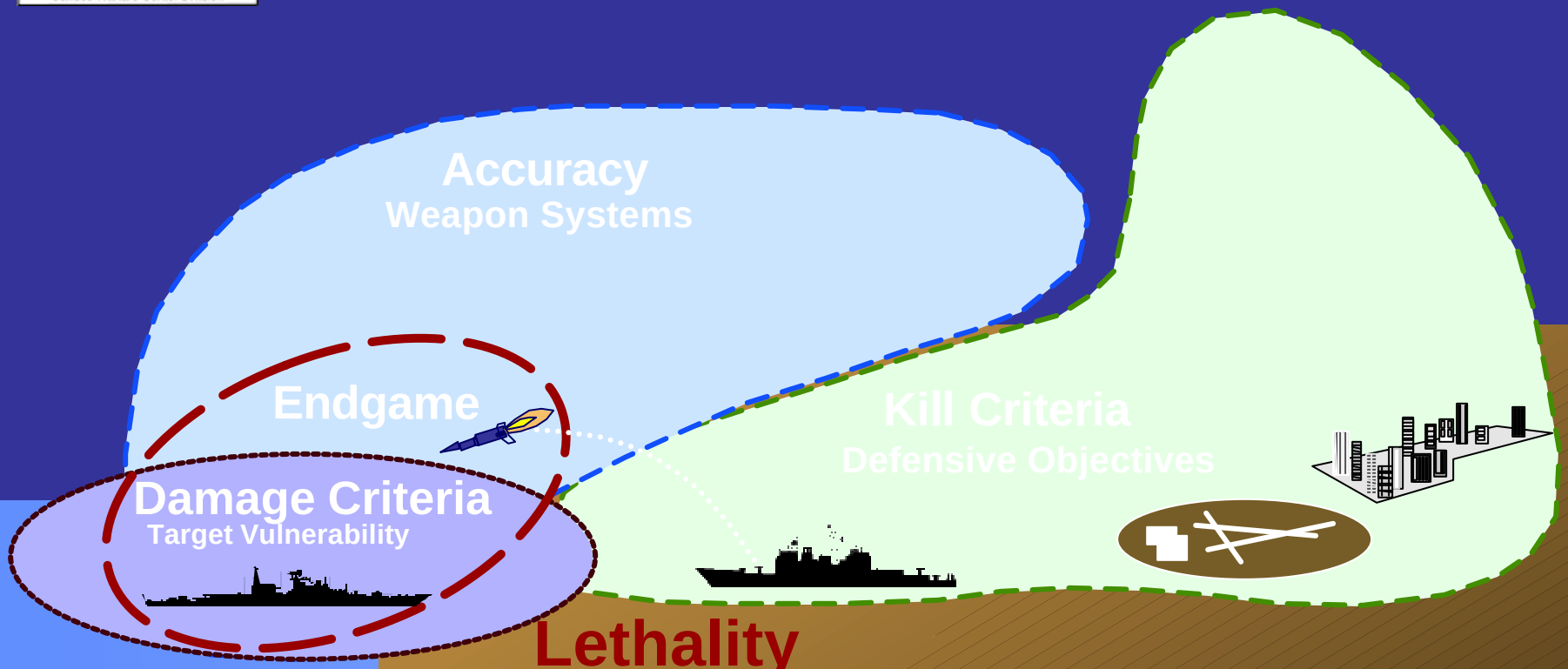
Functions

- **System Control**
- **Target Acquisition**
- **Guidance Accuracy**
- **Terminal Conditions**

Interface with Ordnance

- **Structural**
- **Electrical**

System Effectiveness

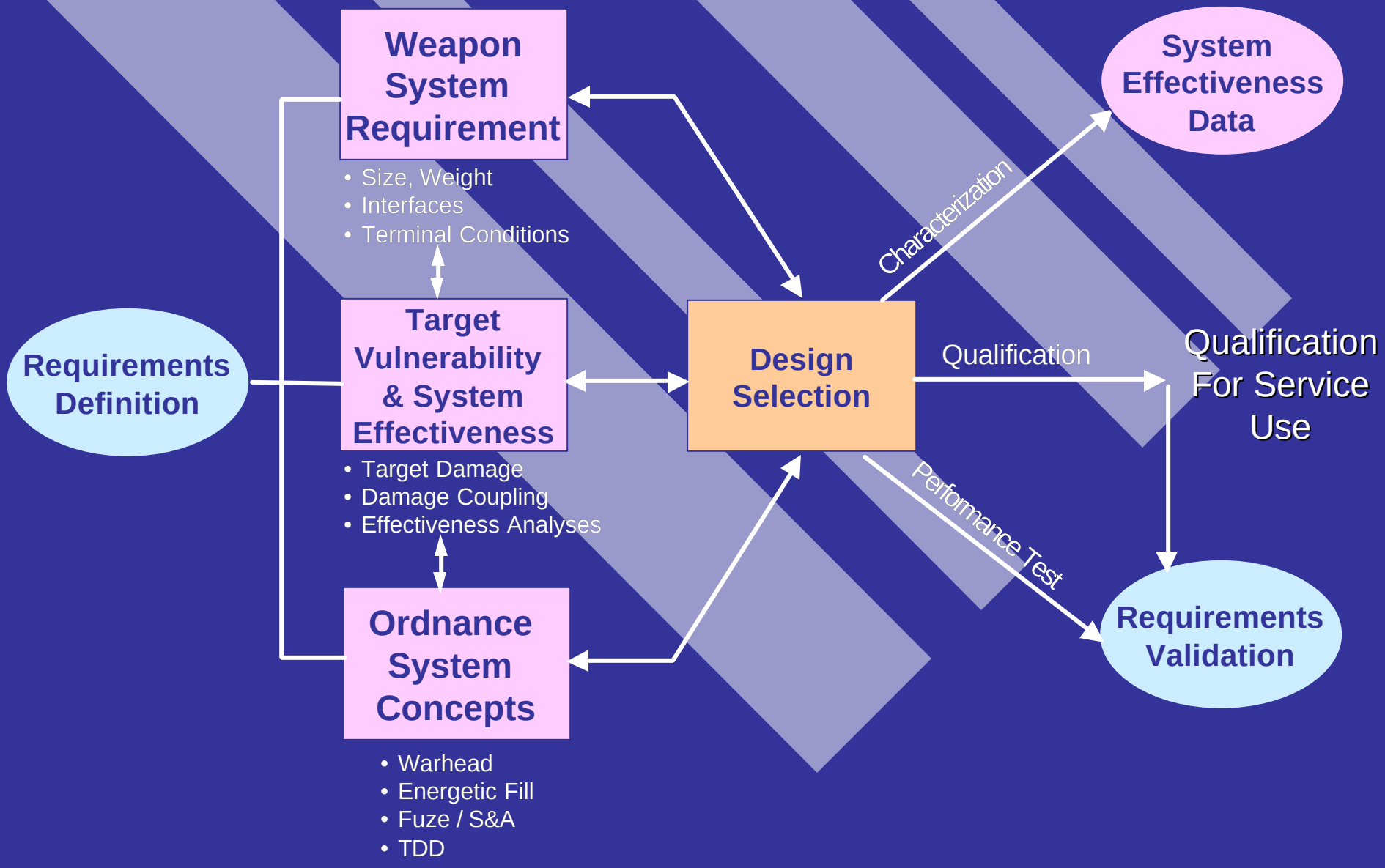


Lethality

P_h	x	$P_{d/h}$	x	$P_{k/d}$	=	P_k
Accuracy		Damage Criteria		Kill Criteria		Effectiveness
• Seeker Type • Fuze Sophistication		• Kill Mechanisms • Target Construction • Target Responses		• Defensive Objectives • Engagement Proximity		• System Analysis • Evaluation & Comparison

Ability to Develop Measures of Effectiveness (MOE) and Evaluate Weapon System Performance at the Platform and Force Level

Typical Ordnance System Engineering Process



Ordnance System Design Parameters

- **Warhead Type**
  - Blast / Fragmenting
  - Penetrator
  - Shaped Charge
  - Explosive Formed Penetrator
  - Combined Effects
  - Adaptable
- **Fragment Control**
  - Size
  - Velocity
  - Distribution (Spatial & Mass)
  - Initiation Method
- **Burst Point Control**
  - Fuzing / Target Detection Device
    - Proximity
    - Penetrating
  - Safe & Arm
- **Weapon System Terminal Conditions**
  - Angles / Orientation
  - Velocity
  - Accuracy
- **Energy Coupling into Target**
  - Maximize Transfer of Lethal Energy
- **Insensitive Munitions / Safety**
  - Case Materials
  - Explosives
  - Geometry
  - Storage Configuration

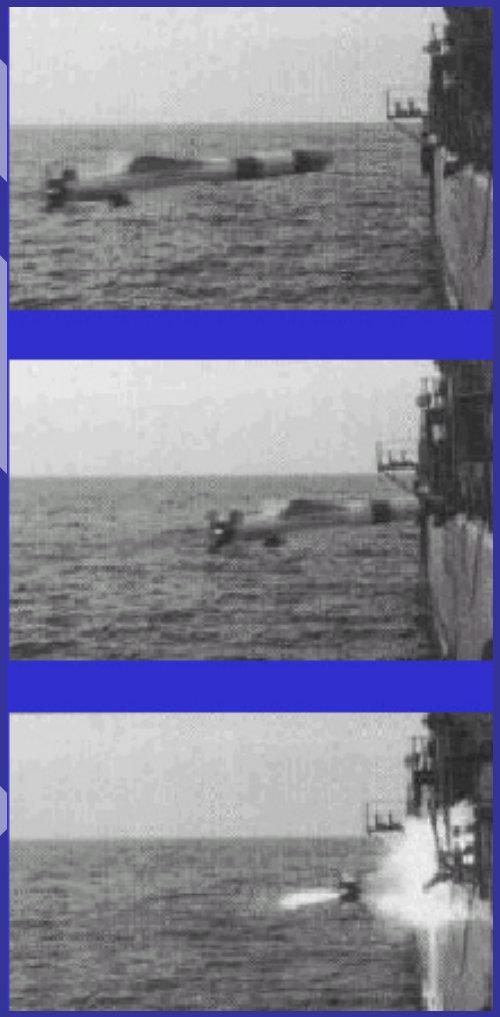
- **Explosive Characteristics**
  - Blast
  - Metal Accelerator
  - Survivable
- **Material Characteristics**
  - Strength / Ductility
  - Brittleness
  - Thermal
  - Incendiary

Available Parameters Allow Flexibility And Adaptability in Ordnance System Design and Upgrade

Example: Warhead Type

- Blast-fragmenting Warhead
  - Controlled Fragmentation
    - » Mass
    - » Velocity
    - » Distribution
    - » Fuzing for Burst Control Point
- Penetrating Warhead
  - Penetration Integrity of Warhead Case
  - Explosive Blast
  - Explosive Survivability
  - Fuzing for Burst Point Control
- Shaped Charge
- Explosively Formed Penetrator
- Combined Effects Warhead
  - All of the Above – Choose Optimized Design to Meet Mission Requirements
- Adaptable
  - Selectable Output

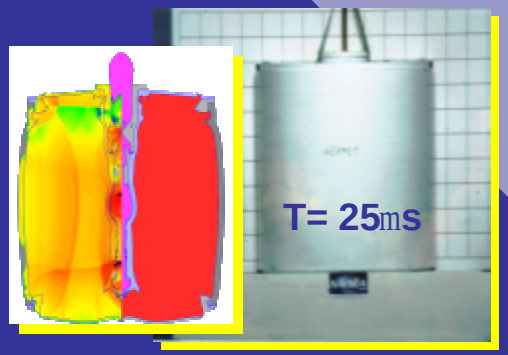
Surface Effects Warhead

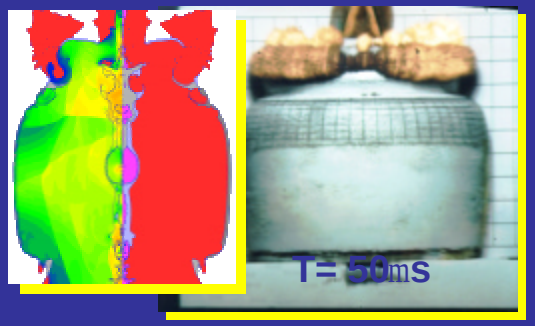


Penetrating Warhead

Basic Warhead Type Selected to Optimize System Lethality Requirements

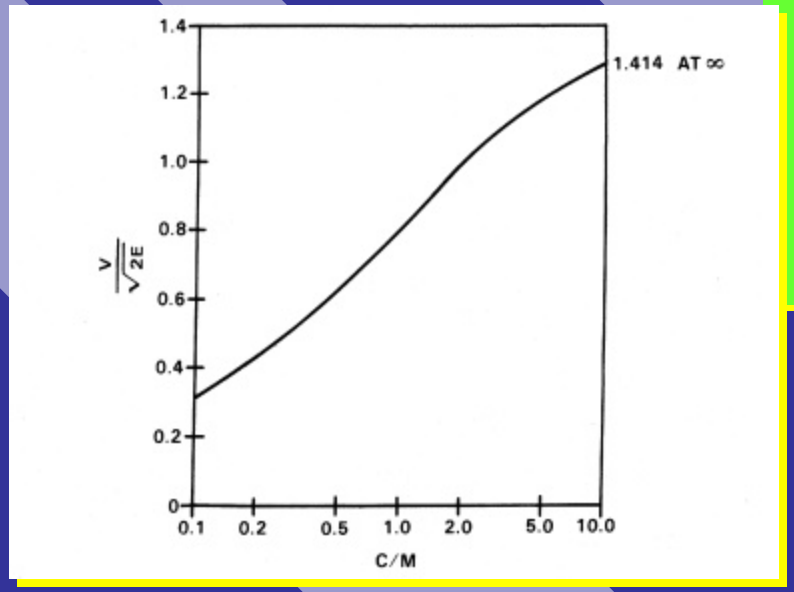
Example: Fragment Control



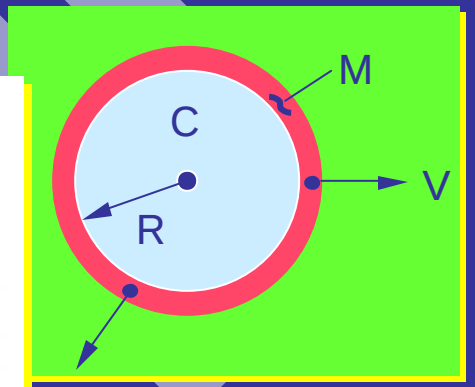


Case Expansion

Predict Fragment Initial Velocity and Mass Distribution



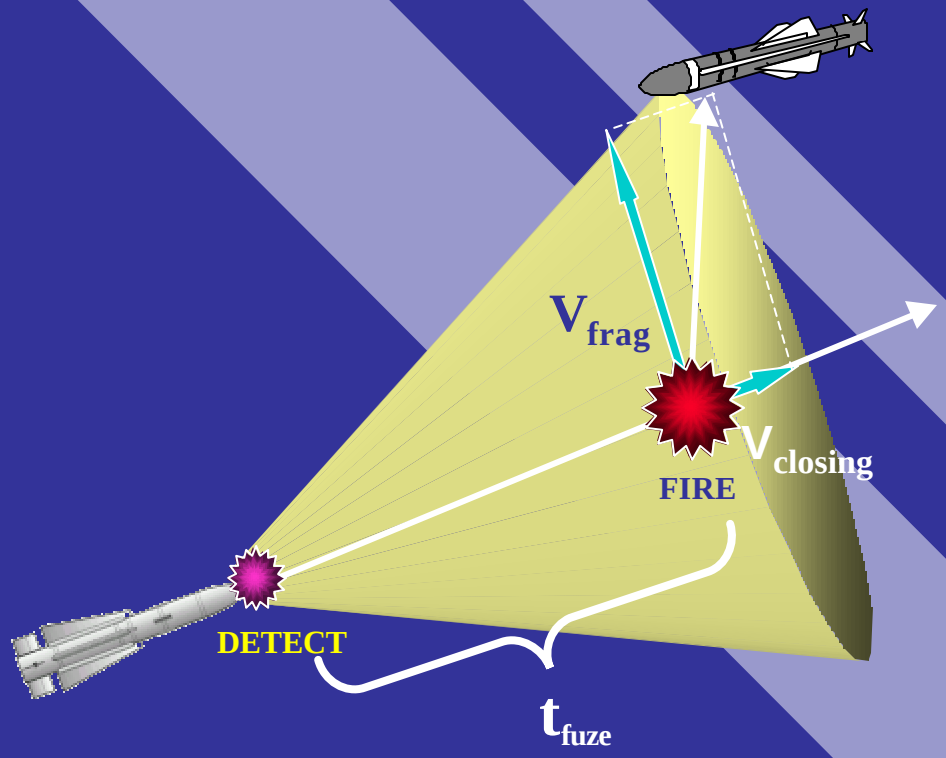
Normalized Case Velocity for Cylinder as a Function of C/M

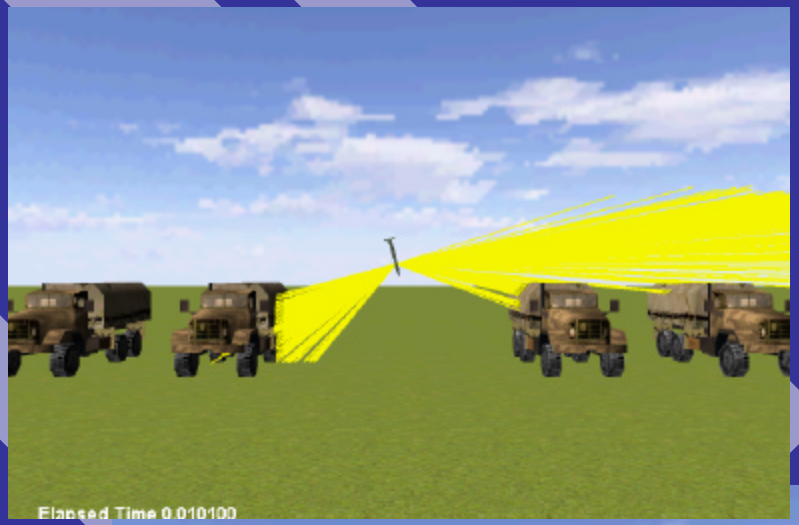


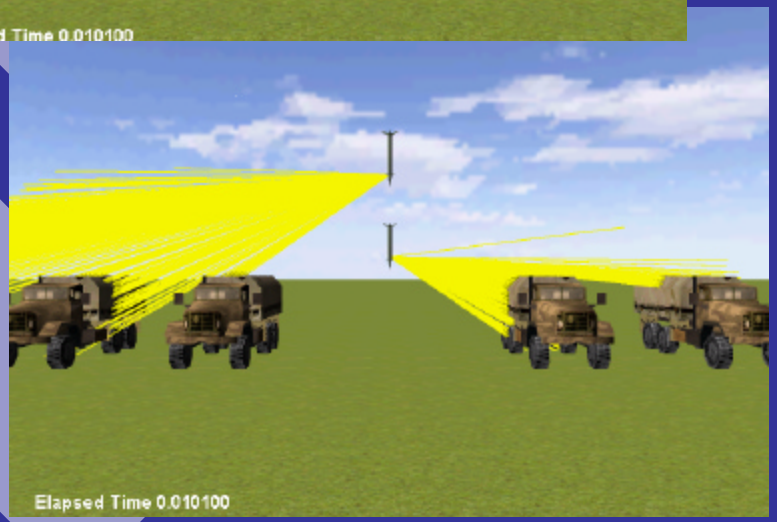
Gurney Initial Case Velocity

Hydrodynamic Codes Provide Excellent Tool to Model Explosive Events and Reduce Test Costs

Example: Burst Point Control and End Game Optimization

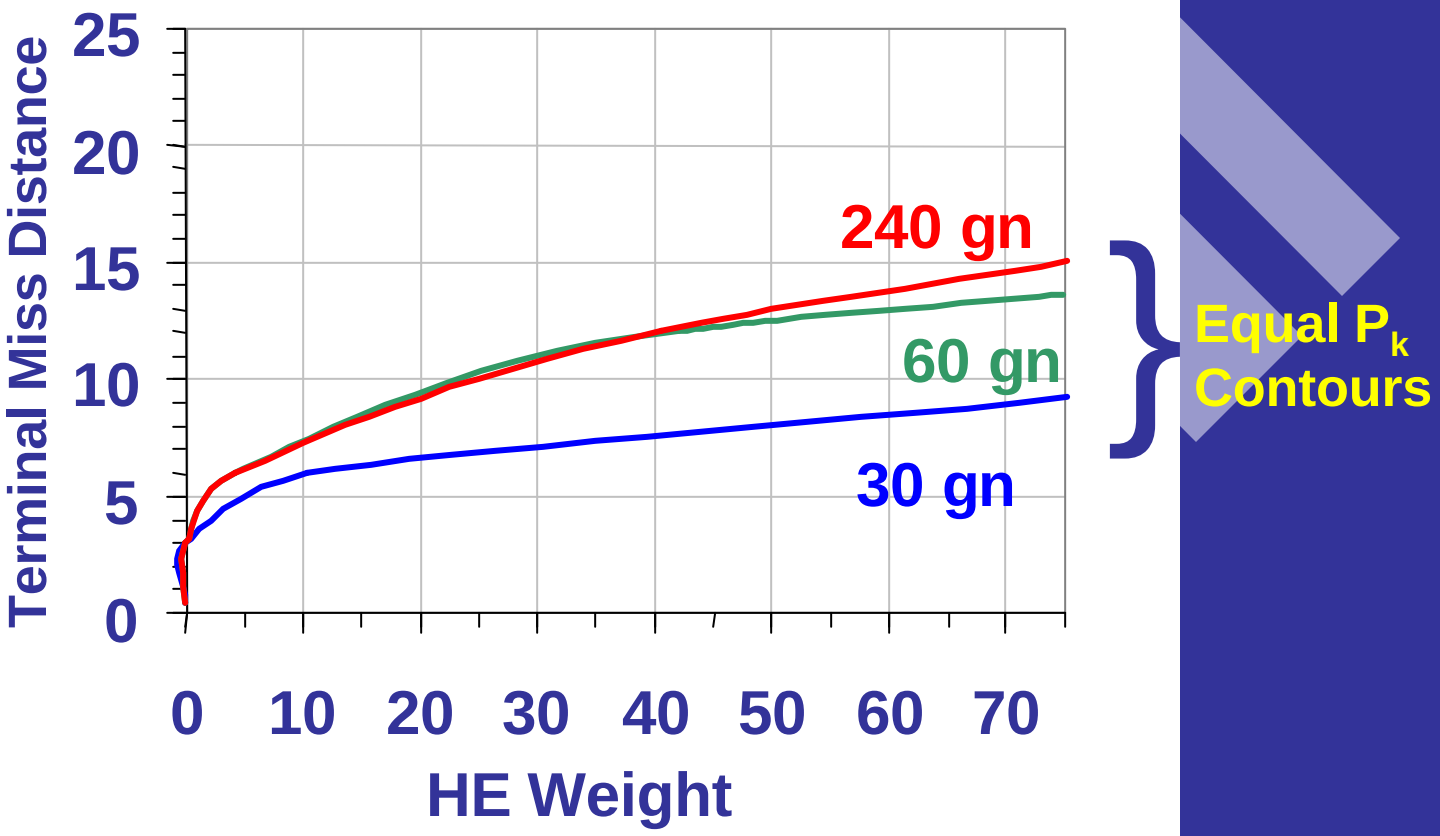






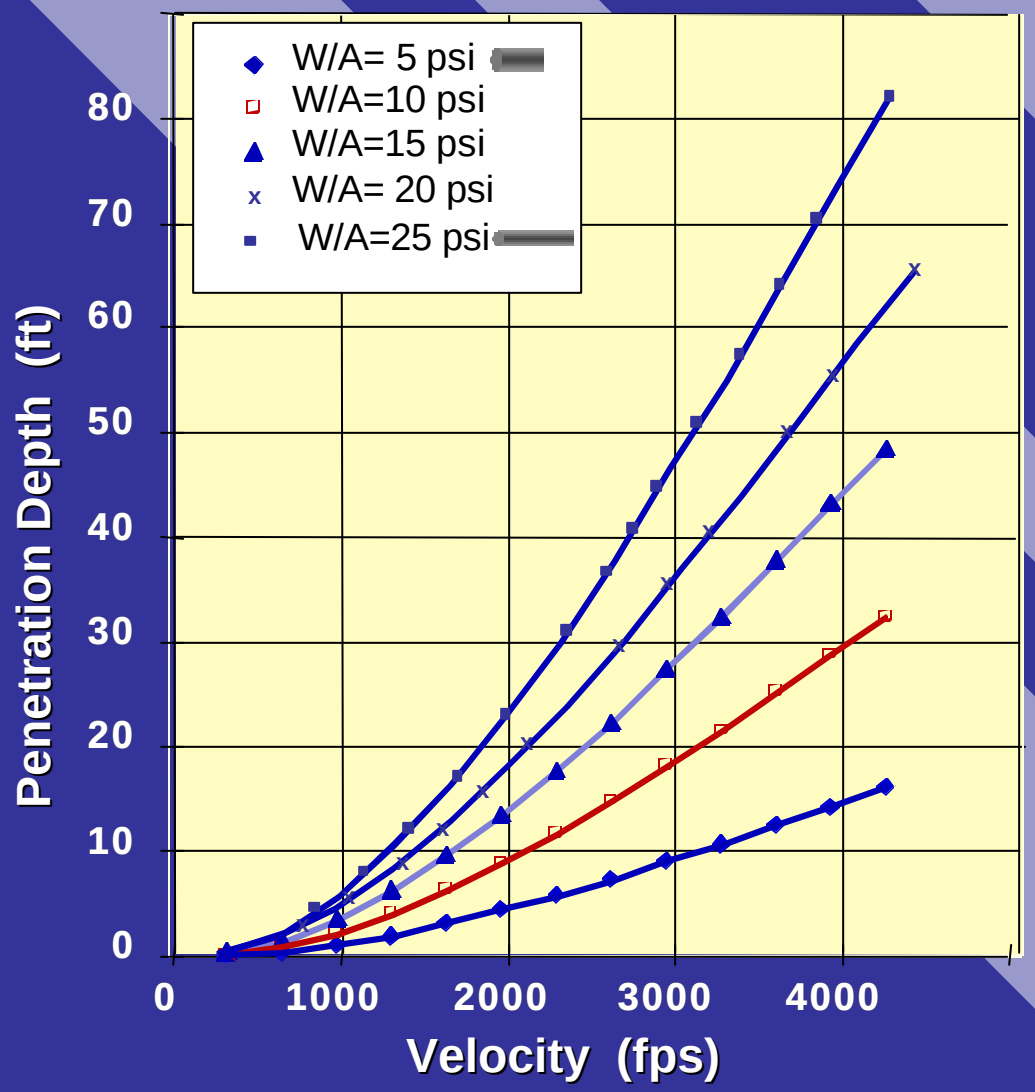
Optimal Burst Point Selection and End Game are Key to Depositing Lethal Effects on Target

Example: Fragment Control & Terminal Conditions



Multiple System Parameters Affect Kill Level (P_K)

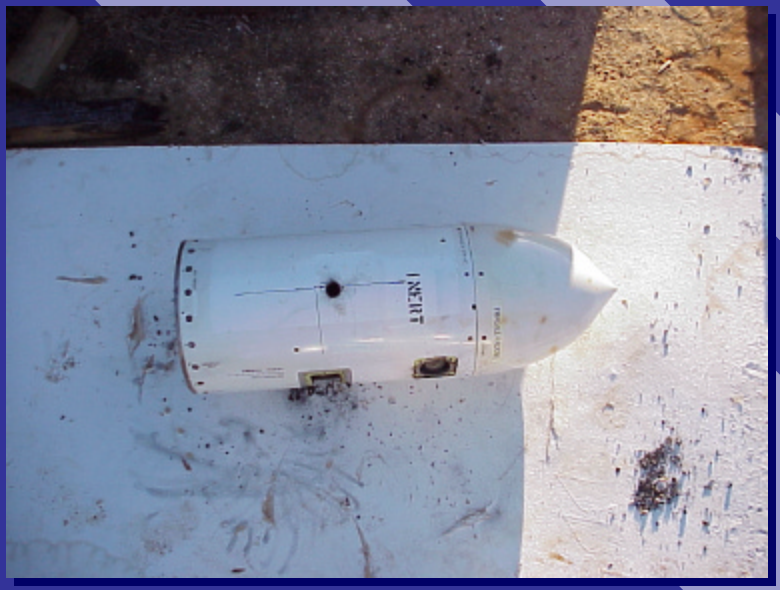
Example: Terminal Conditions and Material Characteristics



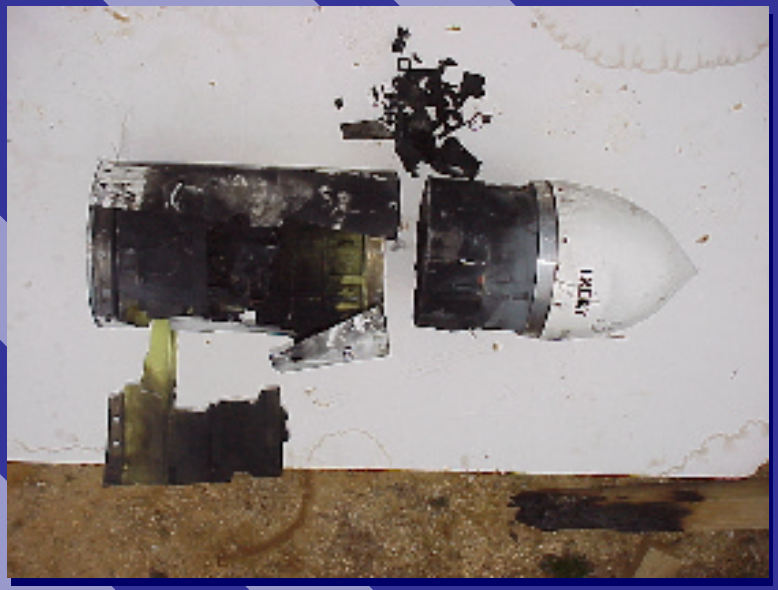
- **Penetration Greatly Affected by**
  - Terminal Velocity and Geometry
  - Warhead Weight / Presented Area (W /A)
  - Target Composition
- **Warhead Material Selection Critical for Performance**
  - High Strength
  - Low Erosion
- **Fuzing Critical for Optimal Burst Point**
  - High G Load Survivablity
  - Time or Cavity Counting
- **Energetic Fill and Fragmentation Maximize Target Damage**
  - Blast Effects
  - Fragmentation Damage

Penetration Significantly Affected by Terminal Conditions and System Design

Example: Optimization of Energy Coupling



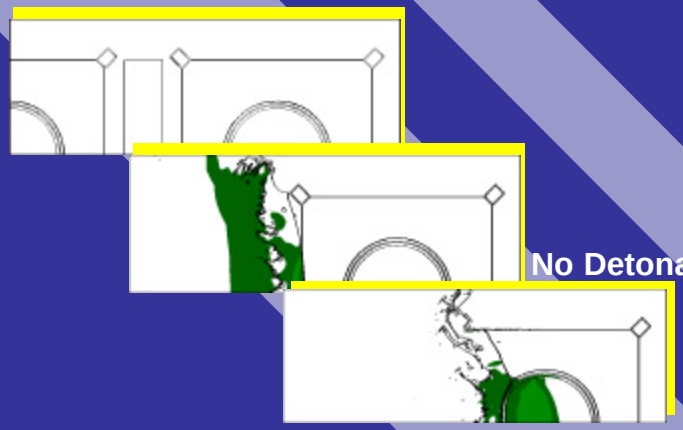
Minimal Energy Coupling



High Energy Coupling

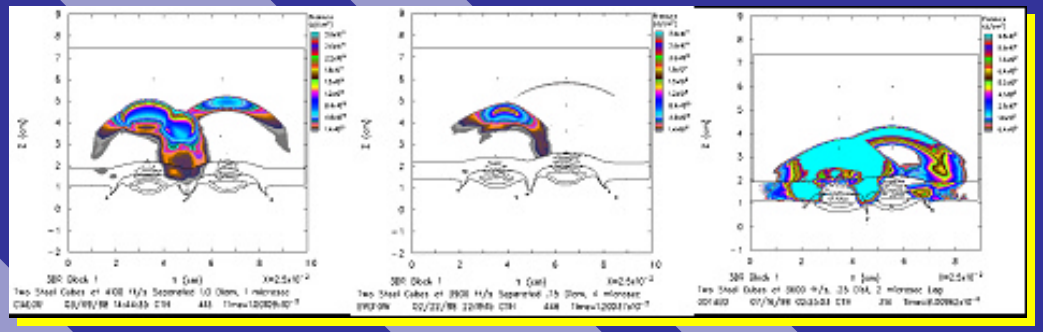
Energy Coupling – Vastly Different Damage Levels

Example: Insensitive Munitions (IM)

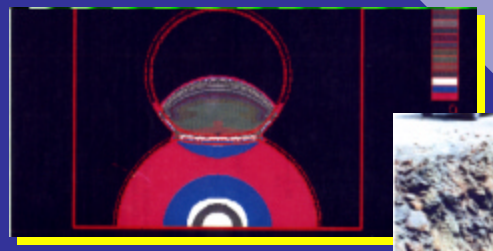


No Detonation

Sympathetic Detonation Modeling



Fragment Impact



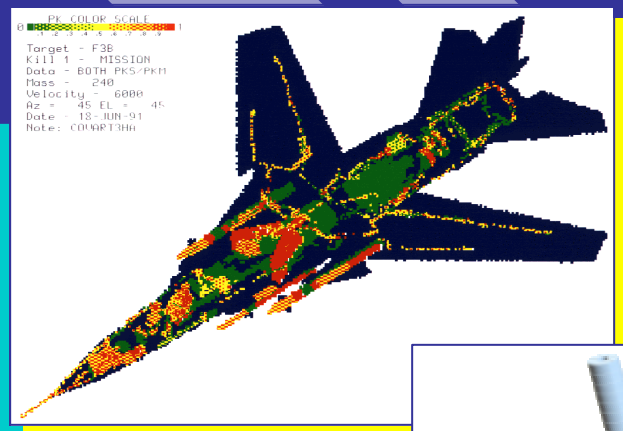
- Acceptor Detonated
- No Large Debris Found

Select

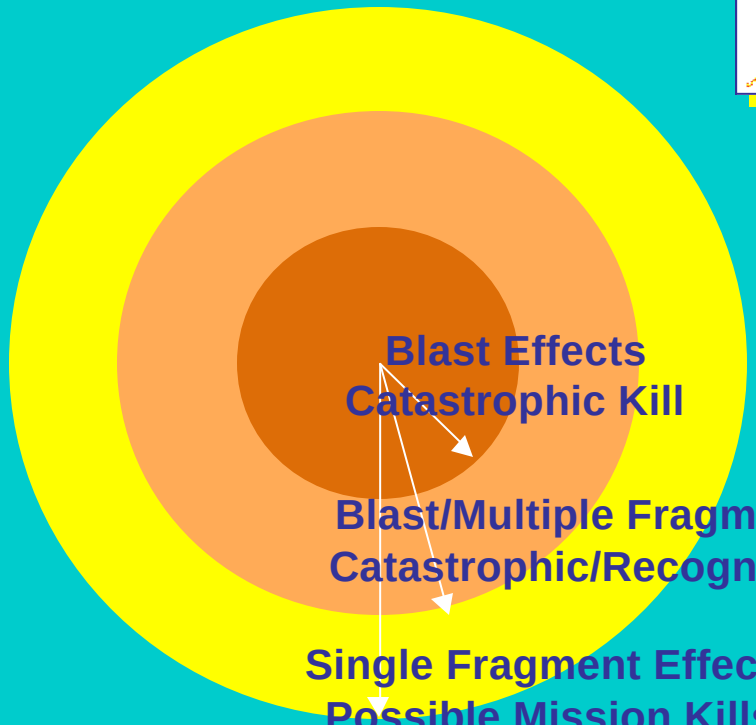
- Case Material
- Explosive
- Geometry
- Storage Configuration

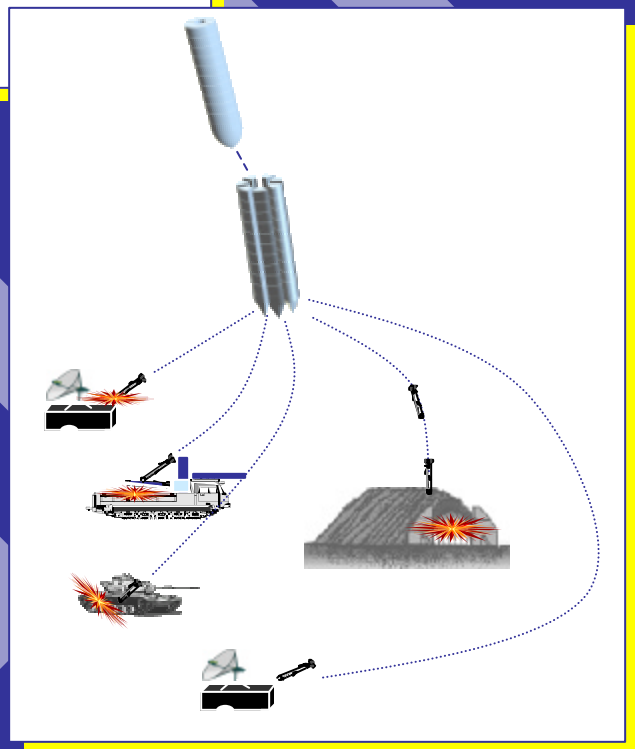
Munitions are Designed to be Insensitive for Safety

Example: Effectiveness Implications



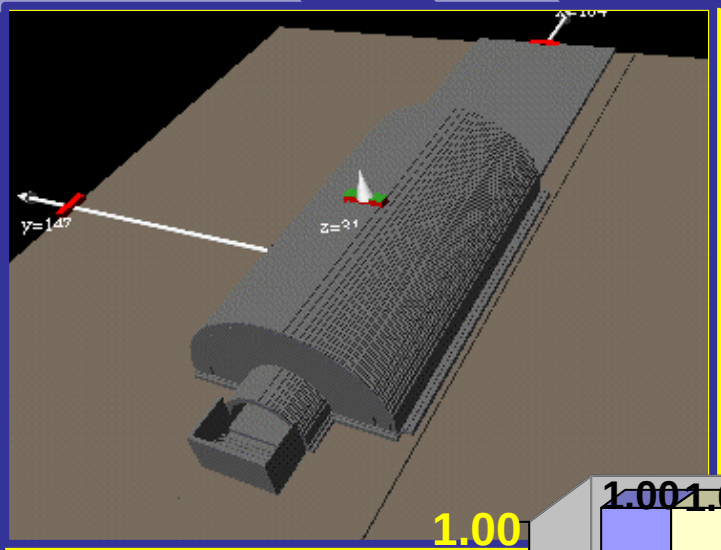
Lethal Radii

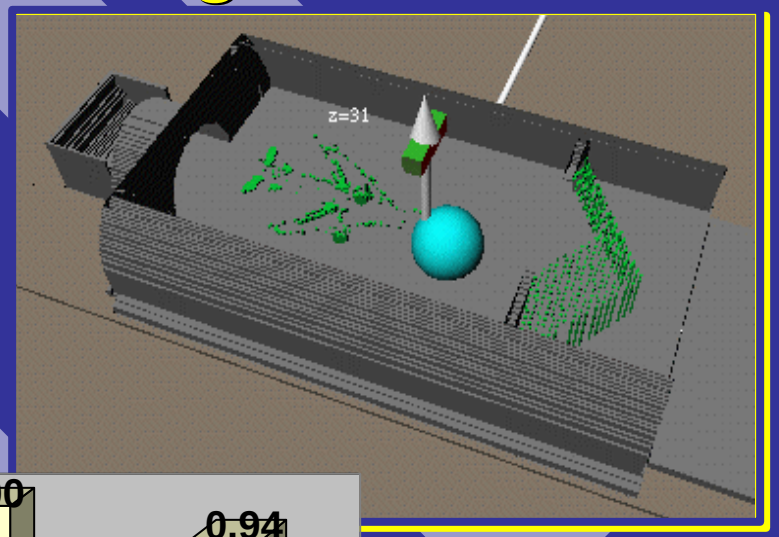


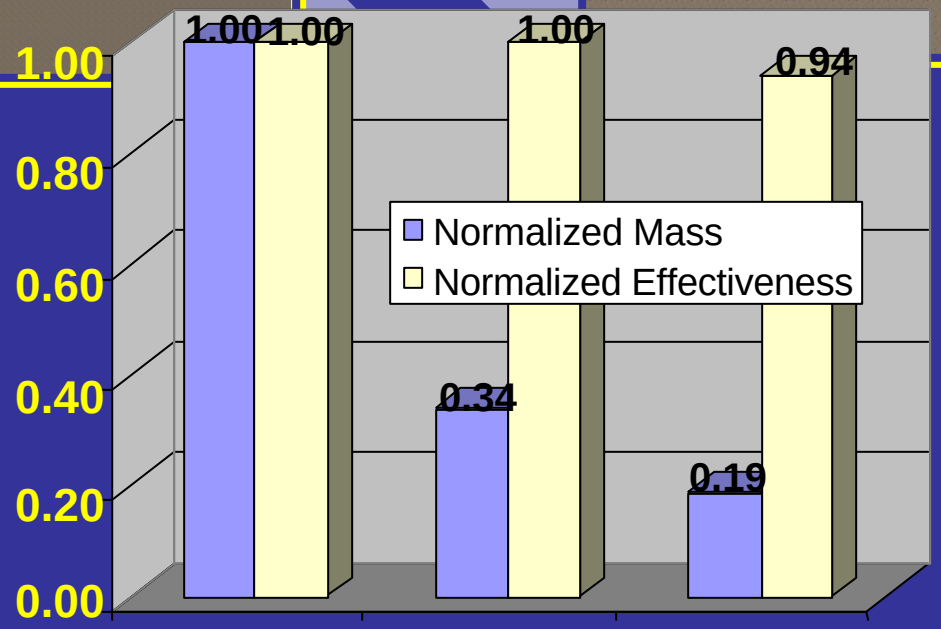


Kill Maximized by Using Multiple Damage Mechanisms

Example: Effectiveness Against Bunkered Target







Each Target is Unique-Design Must be Appropriate for Multiple Targets

Summary

Ordnance Design Requires System Engineering

- Integration of the Ordnance and Weapon System to Maximize System Effectiveness
- Optimal Combination of Ordnance System Components for Target Set
- Adaptability of Ordnance System Components for Individual Targets
- Efficiency in Testing
- Flexibility for Evolving Weapons Systems and Threats