The IM Ship: Design Considerations to Mitigate Munition Hazards

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Presentation Outline

- Introduction
- System-of-systems approach
- The “IM Ship”
- High Risk Ship Hazards
- Examples of IM Mitigation techniques for an IM Ship
- M&S as a design tool
- M&S Examples for Shipboard Hazard Analysis
- Summary & Final Thoughts

Genesis of Insensitive Munitions

… from a Navy perspective,

Historically, IM events resulted in a new paradigm for the Navy. They changed the weapon development process and reinforced system safety emphasis. Several initiatives followed:

- **Make weapons safer with less sensitive energetic materials.**
- **Improve weapon logistic procedures for handling & stowage.**
- **Incorporate improvements to shipboard equipment to decrease hazard event vulnerability.**

Ship Survivability **during unplanned events such as accidents or hostile activity was the underlying objective the Navy's IM initiative.**

Afloat with No Operational Capability

USS Belknap Fire Damage

System-of-Systems Approach

IM Technology Integration —> the IM Ship

New insensitive energetic molocules

Explosive & propellant formulations

Warheads, Rocket Motors, Prop Charges,
Fuzes, Igniters, & initiation systems

Logistic containers (components & AUR)

Launchers & canisters

Weapon magazines
(shielding, thermal sensors, fire suppression)

Platform survivability

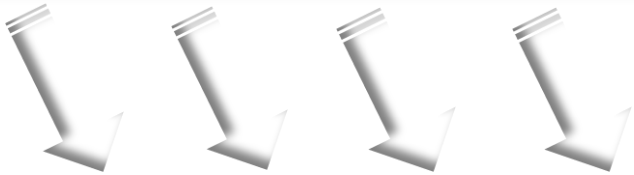
The *"IM Ship"*

What is an "IM Ship"

Navy vision for platform IM-ness:

Incorporate changes to ship systems & ship design philosophy to reduce risks and limit exposure to IM hazards & threats.

IM Ship = IM weapons + System Safety "best practices" + Improved hazard mitigation techniques



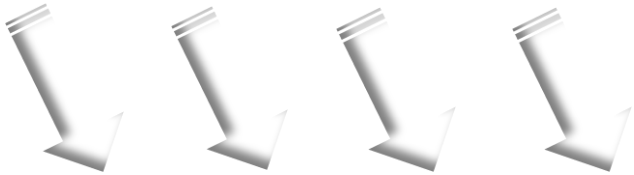
- **Sensors & sprinklers systems for thermal hazards**
- **Lightweight shielding materials for ballistic threats**
- **Improved logistic procedures for weapon placement and stowage**
- **Handling equipment and procedures to maximize safety**

System-level Integration of IM Technology —> the IM Ship

Improve Ship Survivability with an IM-focused Approach

High risk IM & System Safety hazards for ships:

- Thermal events: slow —> intermediate —> fast heating.
- High shock & ballistic events: bullets, fragments, SC jets
- Sympathetic reaction events (mass detonations)
- Combined hazard effects (cook-off response starts SR event)



Address areas of highest risk to personnel, weapon systems & platform:

- Minimize harmful effects of thermal events occurring as a result of accidents or hostile activity.
- Protect/shield weapons during logistic life-cycle, especially handling/transfer/stowage when deployed aboard ship.
- Mitigate chain reaction detonation (sympathetic reaction) events.

Current Design

- Limited monitoring of temperature changes in magazines.
- Localized sprinkler systems & firefighting equipment.
- Response time to thermal event (rapid heat build-up or fire) can vary
- If slow threat response occurs, then lives, weapon & ship at risk.
- Slower response times make fire fighting more difficult & hazardous.

Future Design

- Automated damage-control system combining sensors, cameras & automated firefighting capabilities.
- Ensures fastest possible response time to life & ship threatening events.
- Decreased collateral damage with lower risk to ship.
- Quicker automated response minimizes fire fighting hazards & risks.

Ballistic Hazard Mitigation

Current Design

- Missile launchers clustered together, in an in-board location, surrounded by ship structure (several bulkheads of varying sizes & spacing).
- Potential collateral damage can be extensive if a ballistic stimulus causes a chain reaction event.
- If a major chain reaction event occurs, then catastrophic outcome likely with loss of lives, weapons & ship.

Future Design

- A series of armored compartments for VLS located around the periphery of the ship.
- Makes launchers & missiles resistant to battle damage and safely isolating them from other weapon systems & ship's crew.
- Decreased collateral damage with lower risk to ship.

Ammunition Stowage & Handling

Current Design

- Major caliber gun ammo transferred (pier-to- ship) in open pallets & stored in open racks in below-deck magazine.
- Prop charges transferred & stored separately in a similar manner.
- Projectiles & Prop charges removed & paired manually during gun firing operations.

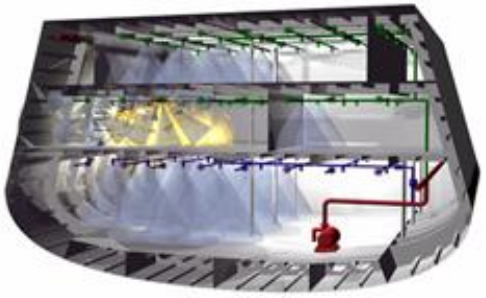
Future Design

- 155mm ammo components stored, transferred & deployed in heavily fortified pallets.
- Fully automated handling system in shipboard magazine.
- Decreased collateral damage with lower risk to ship.

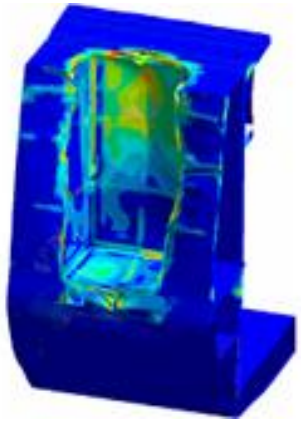
Examples of IM Ship Trends

IM Technology Integration —> the IM Ship

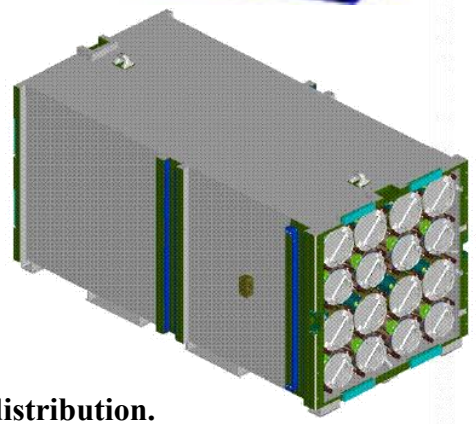
Raytheon's *Autonomic Fire Suppression System* (AFSS) designed for the Zumwalt Class Destroyer (DDG 1000)



The *Peripheral Vertical Launch System* (PVLS) designed by the Raytheon/BAE team for the Zumwalt Class Destroyer (DDG-1000)



BAE's *all-purpose ammo pallet* for 155mm projectiles and propelling charges designed to accommodate the Zumwalt Class Destroyer (DDG 1000)



IM Improvements — Beyond DDG-1000

IM Technology Integration —> the IM Ship

- **Thermal sensor linkage** (ship —> weapon communication)
  - Weapon sensors to magazine sensors ??
- **New lightweight armor** (ballistic & shock mitigating) for magazines and launchers.
  - Polyeurea + lightweight composites ??
- **Shipboard water barriers**
  - Fresh water stored in bulkhead compartments as magazine shielding ??

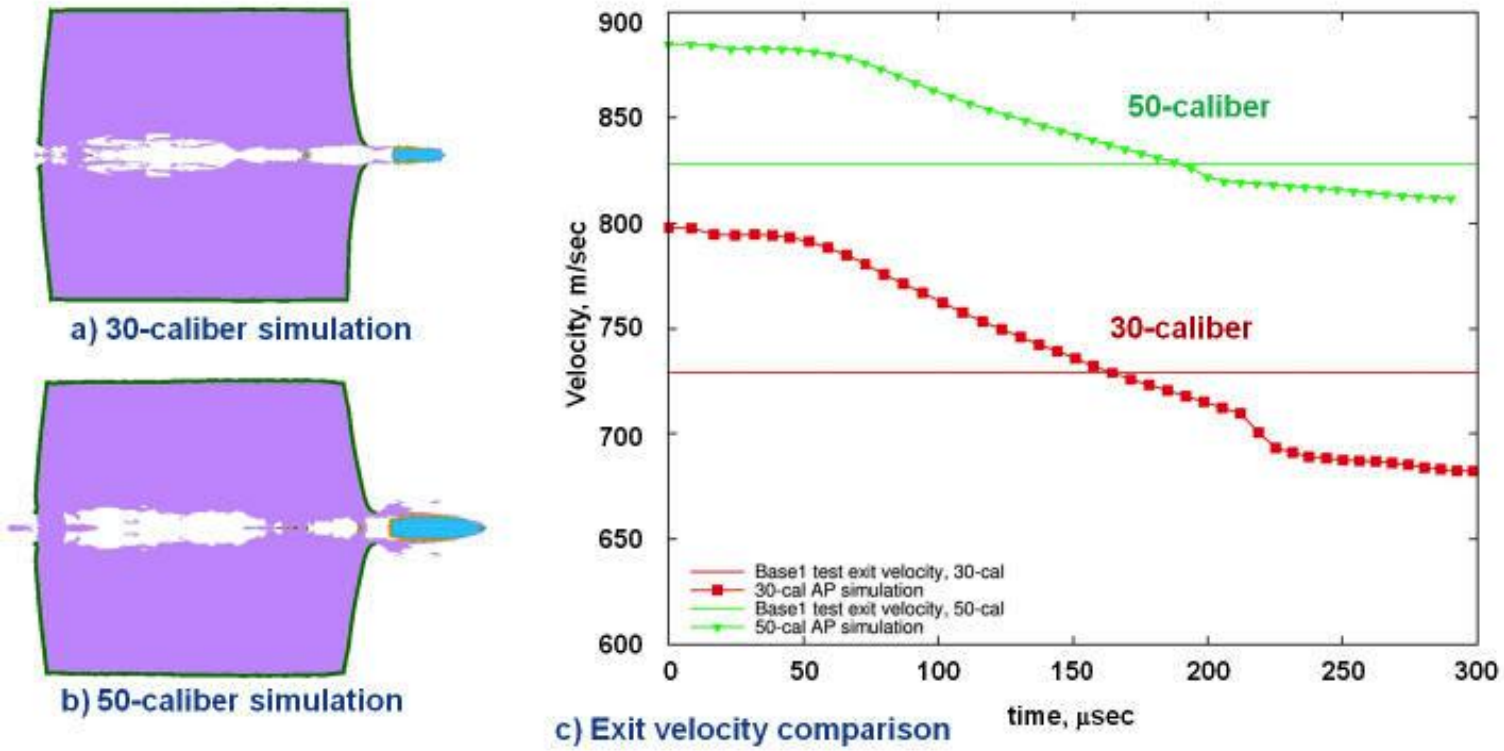
Future platforms & new ship classes must integrate the best available IM technology.

COMMUNICATION **among these communities is of paramount importance!**

Modeling & Simulation **can be an effective design tool when integrating IM technology during new ship development. A streamlined process could shorten development time, lower costs and improve system safety & platform IM-ness !**

Analysis of Ballistic Hazards (M&S tool application)

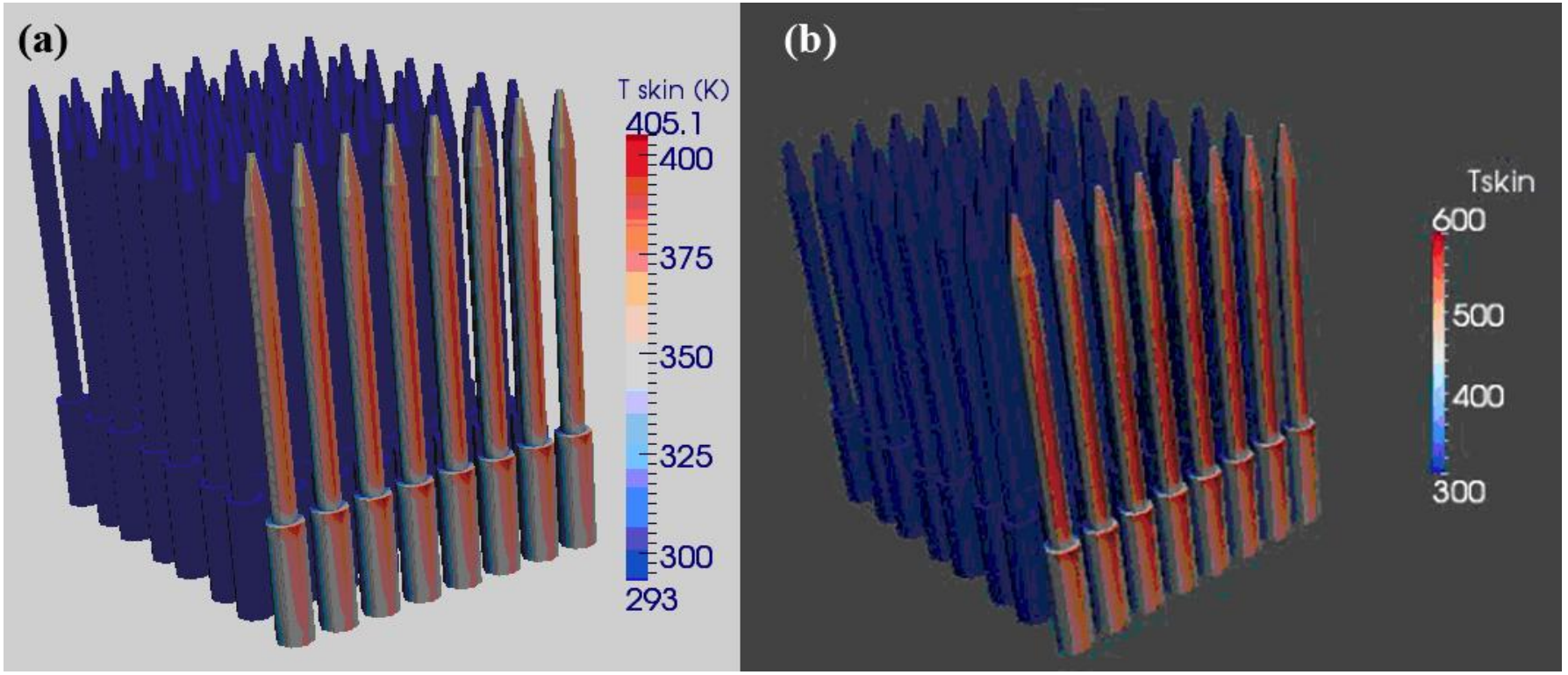
How —> Use M&S tools to evaluate/screen materials for ballistic protection (magazine bulkheads, weapon shields, ammo dunnage, etc.)



Pumice Penetration Simulation for (a) .30-caliber, (b) .50-caliber Projectile, and (c) Simulation Predicted Exit Velocity Comparisons with Test Data

Analysis of Thermal Events (M&S tool application)

***How* —> Use M&S tools for detailed analysis for complex thermal events occurring in a missile launcher.**

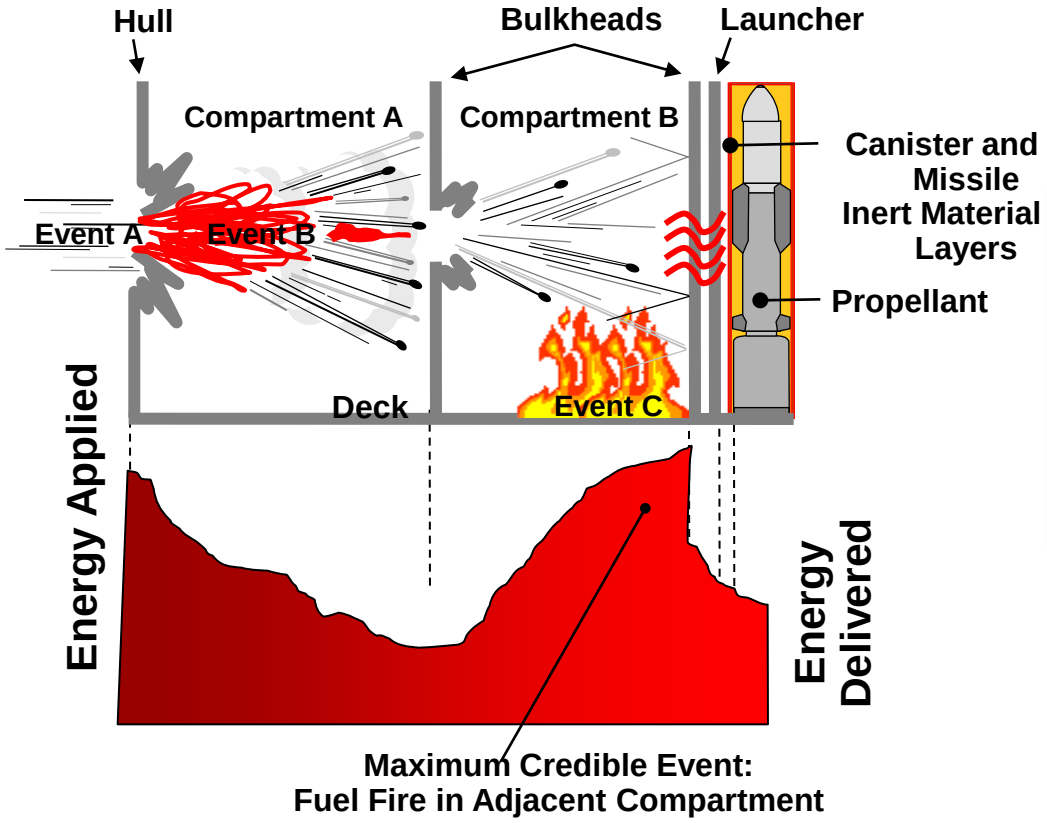


Predicted Missile Surface Temperatures after 1 hour in Thermal Environment Resulting From Fire in Adjacent Compartment.

Analysis of Combined Ballistic/Thermal Events (M&S tool application)

Scenario: Fragments or SCJ penetrate hull & weapons. Fires start & create risk for violent reactions to spread with potential for SR event.

Physics-based tools can simulate complex hazard events & evaluate risks to ship



Assess Ship Design Safety Margins

Summary

- **We're heading in the right direction. Diverse groups (IM, weapon developers, logisticians, ship designers) are working together to integrate technology.**
- **Platform survivability will improve. The System-of-systems approach is working for the Navy.**
- **IM is a system-level process requiring a holistic solution for each ship class.**
- **Apply lessons learned, especially to logistic procedures for weapon stowage & handling throughout weapon life cycles.**
- **Do more mixed-store analyses for SR and/or thermal events in magazines and launchers.**
- **System-of-systems approach applies to all services, all types of weapon platforms, including aircraft & land vehicles.**

The IM Ship — the wrong approach to Insensitive Munitions

Recipe for IM (circa 1628 AD)

- **Build ship in haste to meet demands of the King.**
- **Add more firepower than any ship of her era, 64 cannons in all.**
- **Mount cannons on 1st deck and high on 2nd deck**
- **Add length to accommodate additional armament at the King's behest.**
- **Beam dimension, why worry! Ballast below, no worries!**
- **Set sail on maiden voyage, catch wind to fill the sails!**
- **Heel to port, take in seawater in lower gun ports & keep filling for gradual descent.**
- **Guns & gunpowder safely submerged at 105 feet at harbor's bottom.**
- **All munitions are now INSENSITIVE.**
- **No future naval battles to survive but inglorious history endures!**