TES Technical Enabling Services

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Threat Hazard Assessment Methodology and Explosives Effect Mitigation for 4.5 Inch Mk 8 Medium Range Naval Fire Support HE Ammunition.

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Presentation Aims

Overview of:

Platform & Ordnance Munitions Explosives (OME) Integration

Threat Hazard Assessment Methodology to derive Platform & OME Protection Strategies

Consequence Analysis methods to determine tolerable events in Naval Platforms

OME Characterisation

4.5 Inch Mk8 HE Ammunition

Examples of Platform & OME Protection Strategies

Example of Mitigation Control Measures

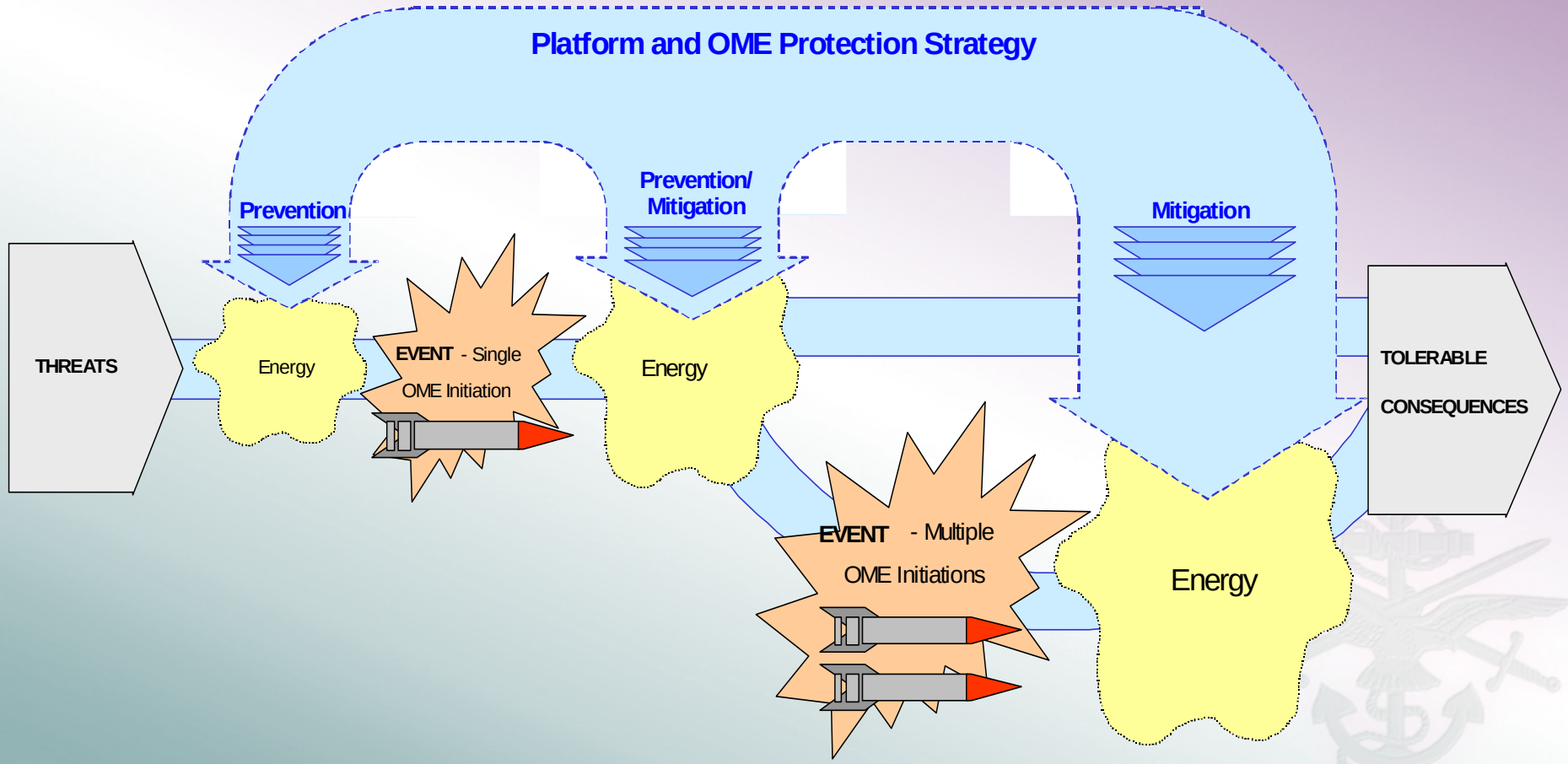
4.5 Inch Anti-Fratricide Assembly

Platform & OME Integration

- Aim is to Prevent Initiation and Reduce Consequences to ensure Safety and maintain the Capability of Naval Platforms.

- Def Stan 00-101 - Design methodology is based on Threat Hazard Assessment to integrate munitions into Naval Platforms.
  - –includes Generic Naval Environment comparing base lined Platform environment and threats to munition response from STANAG tests.
  - –Assesses IM response and consequence in Naval Environment.
  - –Includes Cost Benefit Analysis and enables ALARP judgements.

Threat Hazard Assessment Methodology



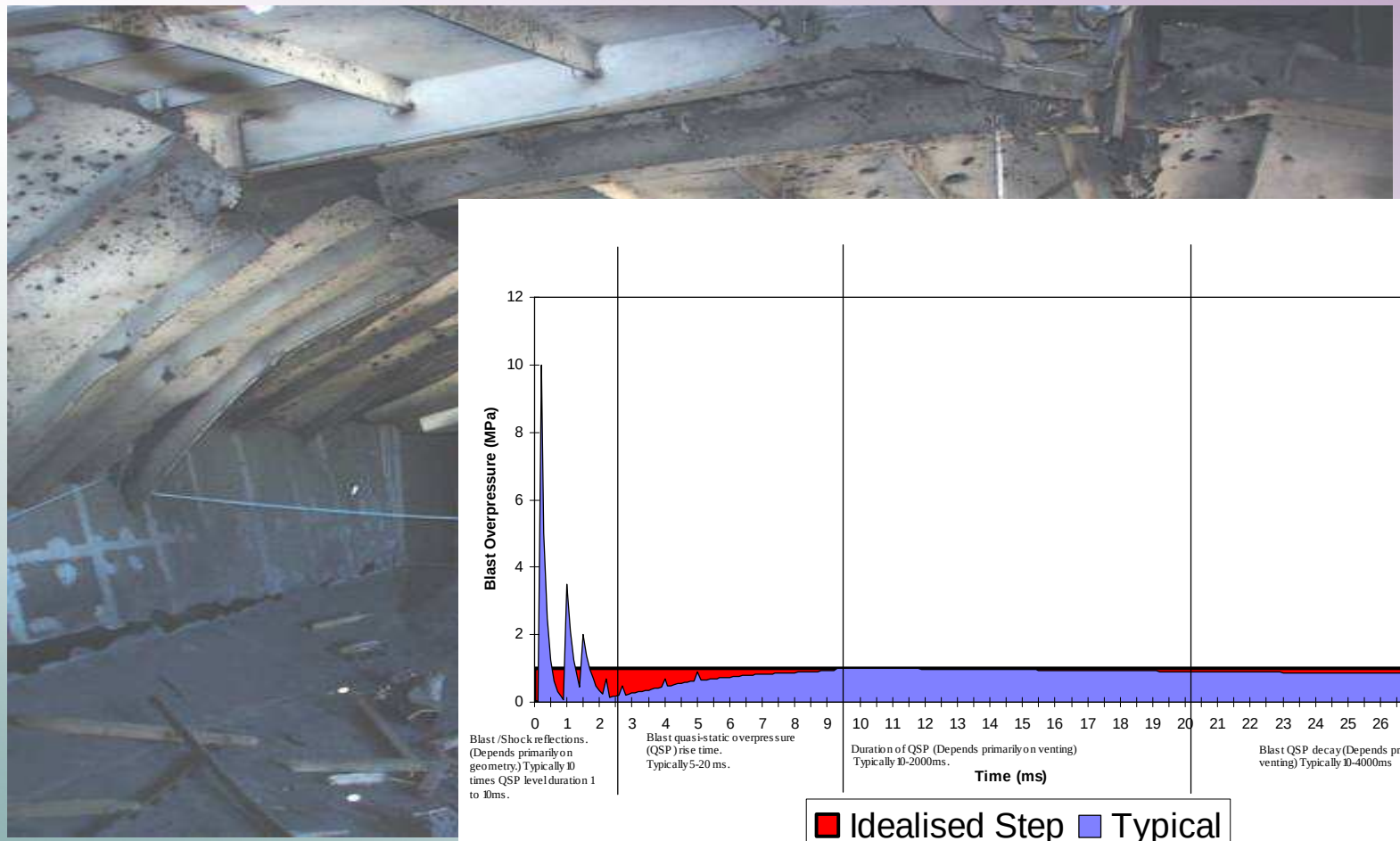
Consequence Analysis

Tolerable Criteria

- Operational Loss of ship – key design driver to maintain operational capability (Float, move, fight functions).
- Crew Risk – Capability, Health and Safety law (UK Health & Safety Executive Guidelines).
- Societal Risk – Risk to 3rd parties - key driver for explosive safety when in Harbour.
- Environmental Risk - Including MARPOL, EIA or Local Regs

- What is the maximum size of an initiation event that is tolerable?
  - Measured by Effective NEQ (TNT Equivalent)
  - Design target for Unitised size of Munition Stowage.

Consequence Analysis - Blast Damage



Consequence Analysis - Blast Damage

•General variation of Carroll Formula to predict failure of single membrane mild steel panels.

$$Ps=((Kj+Km)*t/l)$$

Where:
PS is the survival level quasi-static overpressure in Mpa
Kj is the joint style constant and
Km is a constant representing the steel type.
t = Plate Thickness (mm)
l = The effective panel structure span (M).

•Estimate of QSP level for internal explosions may be obtained from Weibull formula.

$$P_{qsp}=2.25x10^{6}(W_c/V)^{0.72}$$

Where :-
P_{qsp} = quasi-static overpressure in N/m^2
V = the volume of detonation compartment in m^3
W_c = the TNT equivalent quantity of explosives in kg

•Re-arranging allows estimate of Charge Weight (TNT equivalent) for tolerable level of QSP volume damage to a platform.

•Shock holing Calculations are completed to assess localised panel loading.

Consequence Analysis - Fragment Damage

For Prediction of Fragment Residual Velocities and weights

THOR Polynomial

$$Vr=Vs-10^{C1}(TA)^{C10}m^{C3}\cos\theta^{-C4}\ v^{C5}$$

$$m_R=m-10^{C6}\ (TA)^{C7}\ m^{C8}\ \cos\theta^{-C9}\ v^{C10}$$

Where
Vr = Residual Velocity (m/s)
Vs = Striking Velocity (m/s)
m_R=residual mass (kg)
m = striking mass (kg)
T = Target Thickness (m)
A = presented area of target (m^2)
Q= incident angle
C_1-C_{10}= constants dependant on target material

OME Characterisation

4.5 Inch Mk 8 Ammunition

- Intrinsic Performance of 4.5 Inch HE Conventional and Improved Ammunition was assessed.
- Munition Characteristics established
  - ENEQ was derived (Peak Static) - propellant does not contribute to detonic shockwave.
  - Fragment profiles obtained including base debris.
  - SDT Initiation thresholds obtained.
  - SR Initiation is primarily by fragment impact.
- Established CA and IA shell will SR (Type I Detonation).
  - CA propagation may run out
  - IA full propagation of all stacked rounds.

Platform & OME Protection Strategy

Prevention Measures

- Location of stowage within the Platform - Separation from adjacent magazines.
- Others include - Armour, Rapid Fire Suppression Systems, Operating Procedures.

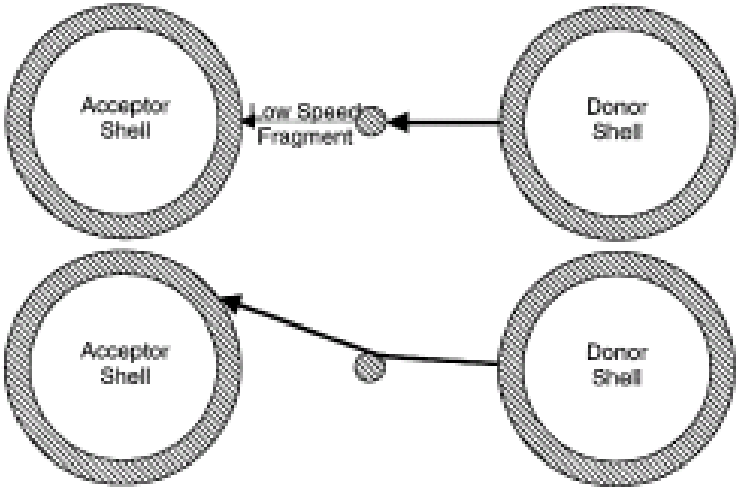
Mitigation Measures

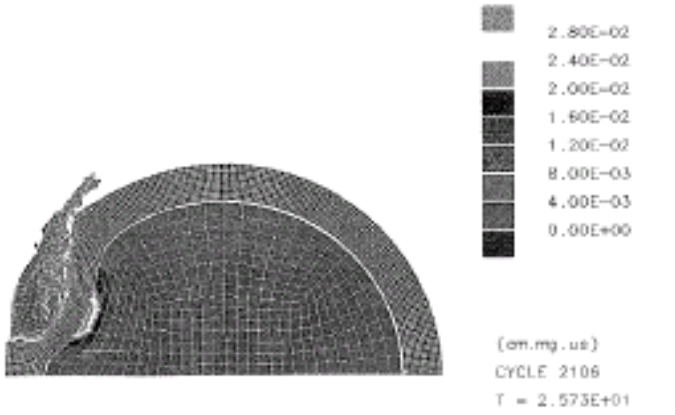
- Blast Resistant Structure, over-pressure Venting routes.
- Stowage Plans and configuration of munitions - Reducing propagation (Orientation of rounds).
- Unitised Stowage Barriers, Packaging Measures, IM munitions.

Example of Mitigation Control Measures

4.5 Inch Anti-Fratricide Assembly

- Size and position of bar critical to intercept and deflect frags above critical impact angle.
- Bar Shape reduces momentum by cancelling internal vectors.
- Bar Area has relatively reduced impulse loading into acceptor.
- Bar does not act as initiator.





Small Scale Trials

Small Scale Trials

- Various materials tested for bars - Mild and Stainless Steels preferred.
- Enhanced fragment velocities examined - Second layer bars intercept and deflect frags lower than threshold levels.
- Momentum transfer into acceptors examined - Lobbing distances predicted and validated.
- Orientation of Acceptors to Donor tested - No propagation observed.

Stack Trials

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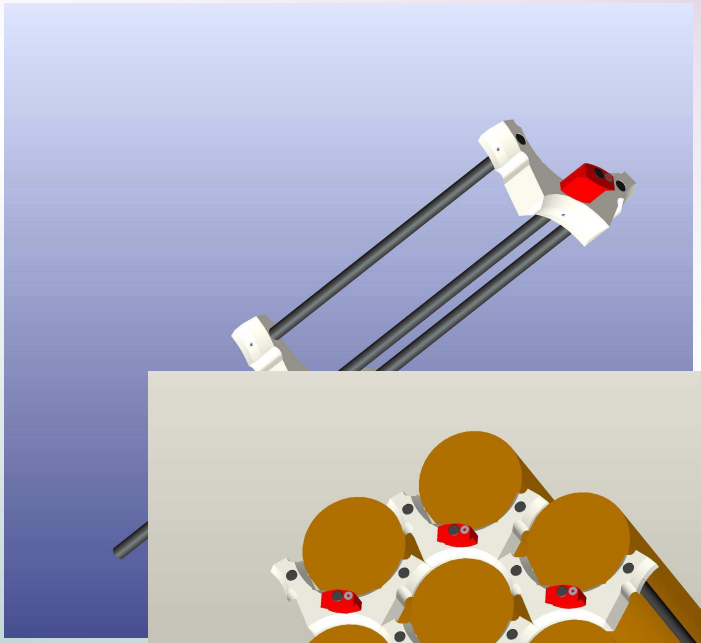
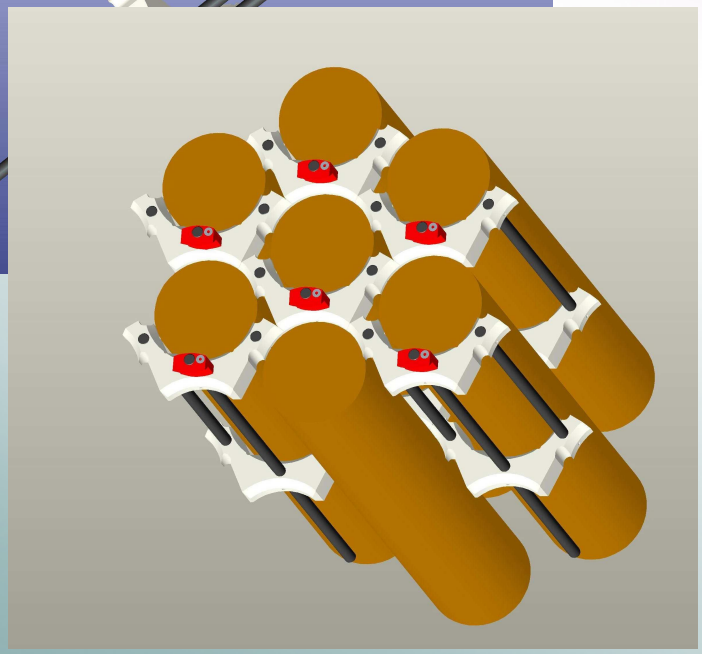
Prototype Development





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Summary 1

Platform & OME Integration

- Described THA Design methodology
  - develops Platform and OME Protection Strategies including measuring IM benefits.
- Described examples of consequence analysis methods to derive tolerable levels of damage.
  - maintaining Safety and Capability.
  - deriving a unitised size for munition stowage.

Summary 2

OME Characterisation and Protection Strategy

- Described Characterisation of 4.5 Inch HE Ammunition.
- Described examples of Prevention and Mitigation Measures.

4.5 Inch Anti Fratricide Assemblies

- AF Assemblies require no retrospective action on ships.
- No additional weight increase to existing containers.
- Implemented by supply in N6 transportation crates to ships.
- Controls event to one round only.
    - A reduction in magazine ENEQ to <1%.
- Compatible with future IM variant minimising event size further and reducing consequences against Naval Environment Threats.

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QUESTIONS?