The Use of Hydrocode Modelling in Optimisation of Physical Mitigation Design Solutions for Multiple Weapon Types

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Agenda

- Introduction
- Mitigation
- The stages of problem solving
  - Reaction of a munition to fragment attack
  - Effect of the container and any mitigation
  - Reaction within the stack
  - Reaction between stacks (same or different munitions)
  - Mitigation between stacks
- Validation
- Conclusions

Location & Capabilities

ISO 9001/2000
List X

System Approach

Introduction

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USS Cole after a terrorist attack

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- Threats may be external or internal
- External threats will be reduced in energy by the magazine boundary, but they may have residual energy that remains a threat.
- The reaction of any munition to the residual threat (or any internal threat) may cause further sympathetic reactions.
- Therefore mitigation in the magazine must provide protection from the residual effects of external stimuli and from sympathetic reactions between munitions of different types.

Mitigation

- There are many types of physical mitigation that may be used to protect munitions.
- Examples of these are :–
  - sheet metal
  - plywood
  - water
  - aramid fibre
- Mitigation controls (e.g. stowage plans) can also be used to protect munitions.

The Role of Assessment

- Research small scale and safety test results to predict munition reactions.
- Research physical properties to gauge container and mitigation material effectiveness.
- Down select 2 or 3 mitigation materials to model
- Use basic tools (Kingery etc) to gauge likely ‘safe’ distances

The Hydrocode Model

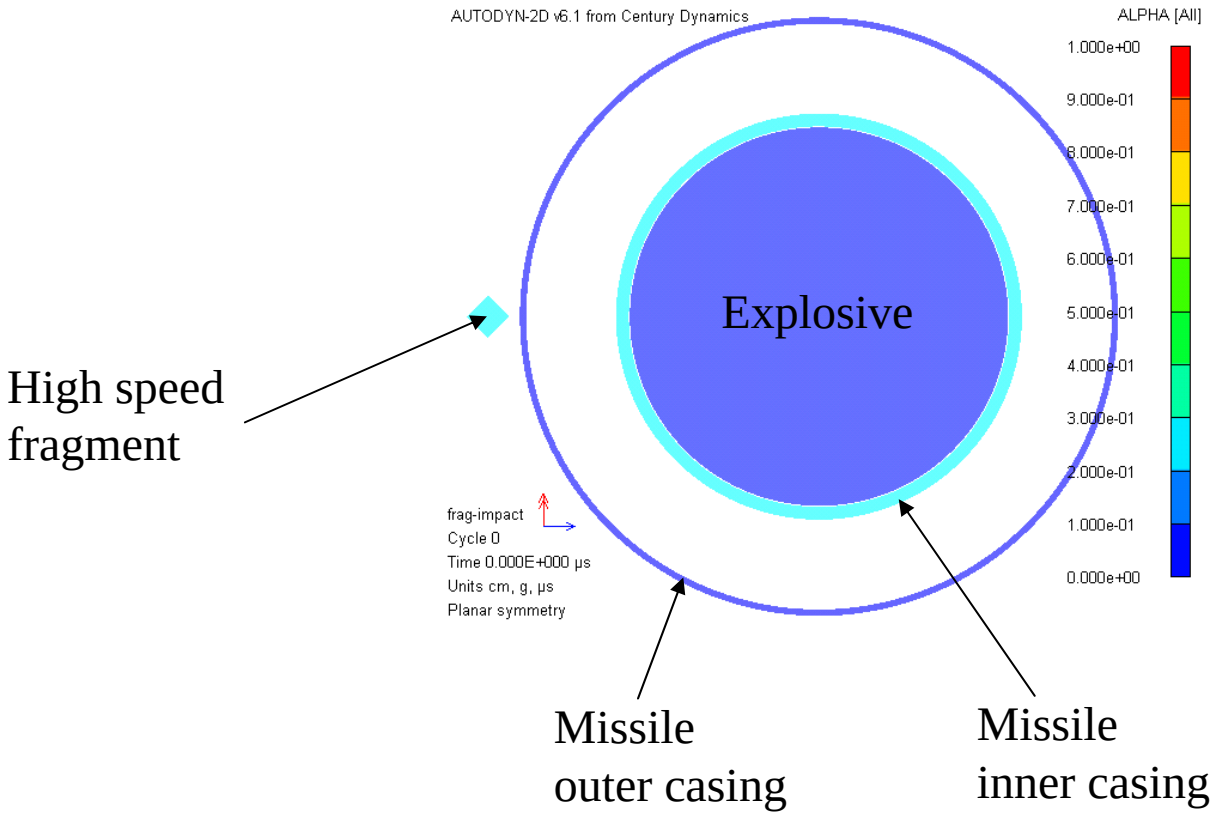
- The use of Autodyn by Century Dynamics to model
  - Fragment impact on plates and explosives
  - Reaction of explosives to stimuli
  - Blast wave expansion and interaction
  - Fragmentation formed from detonations
- 2D or 3D setups can be modelled

The Problems

- Problem 1 – Fragment strike on a munition
- Problem 2 – Sympathetic reaction within stack
- Problem 3 – Reaction between stacks
- Problem 4 – Mitigation between stacks

Problem 1

- High velocity fragment impact on bare missile



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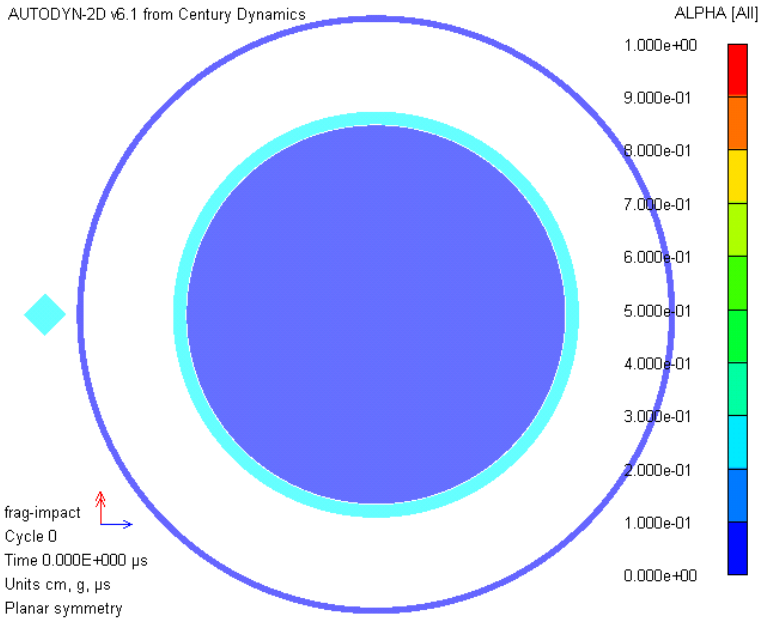
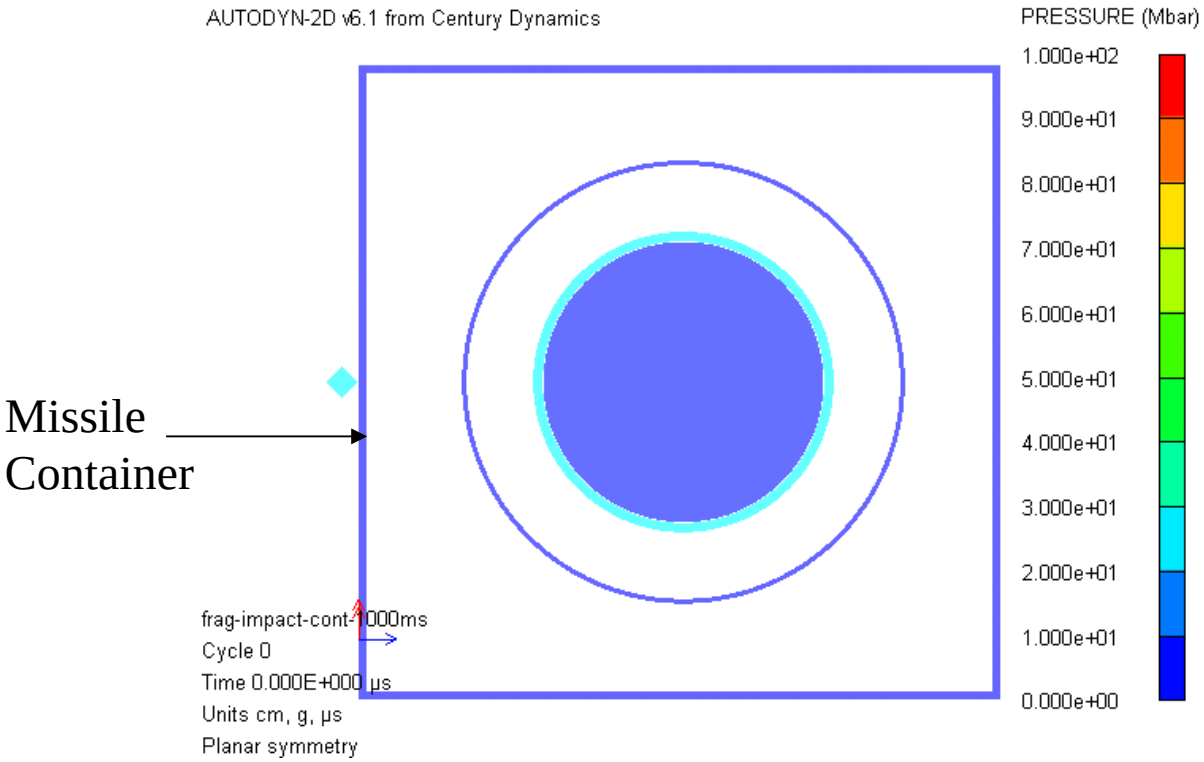


Problem 1

- Effect of container on the fragment



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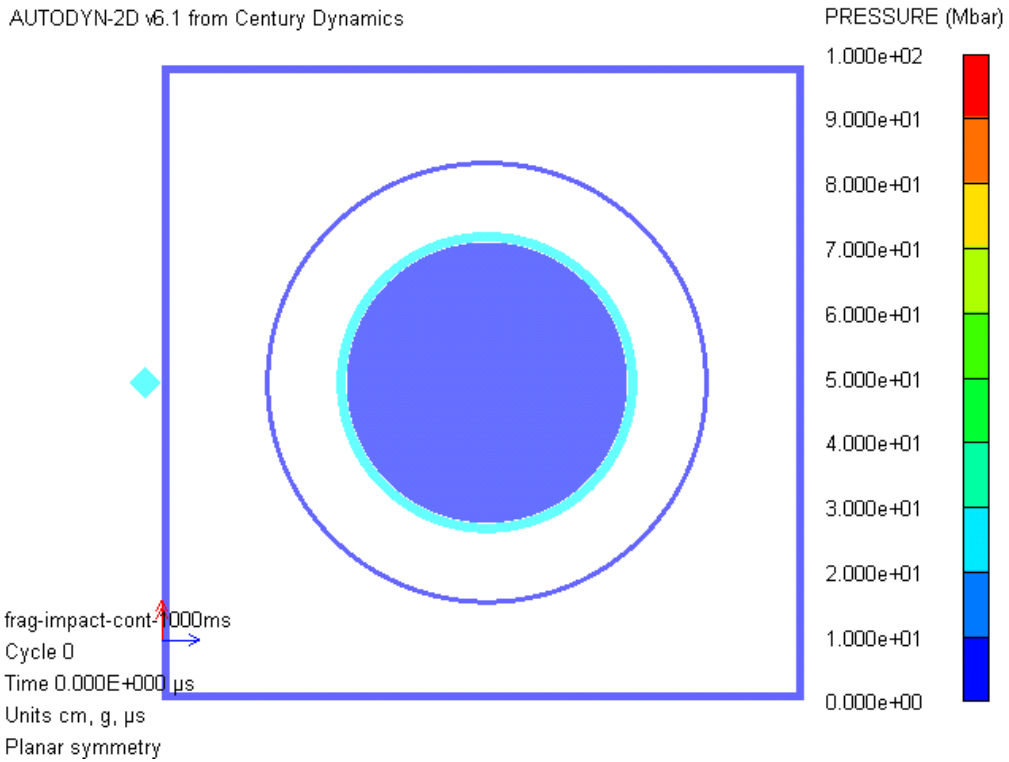

Container not sufficient to prevent initiation

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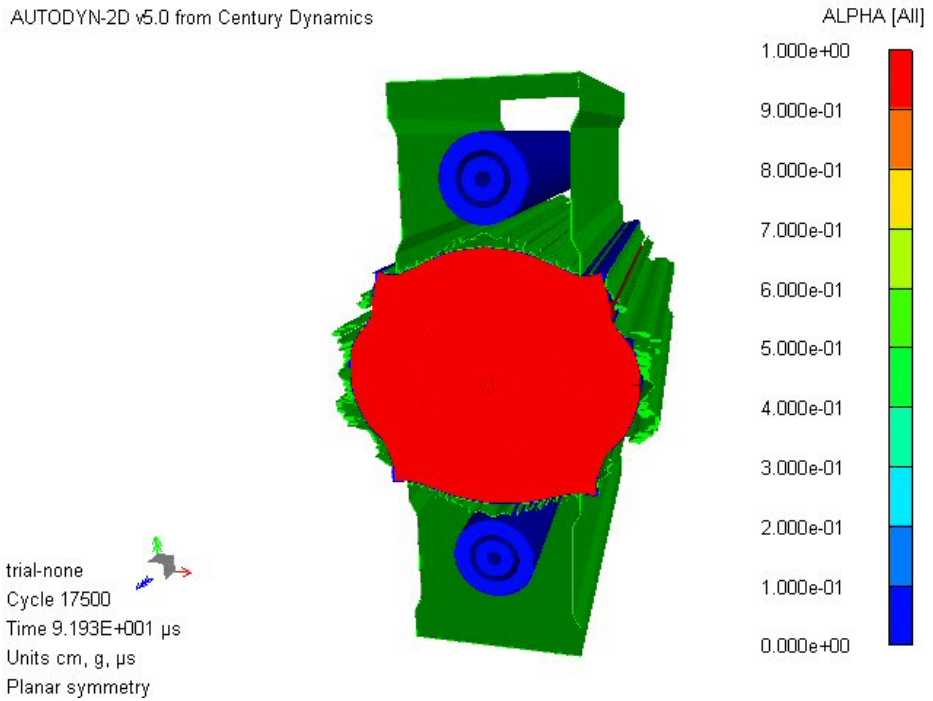

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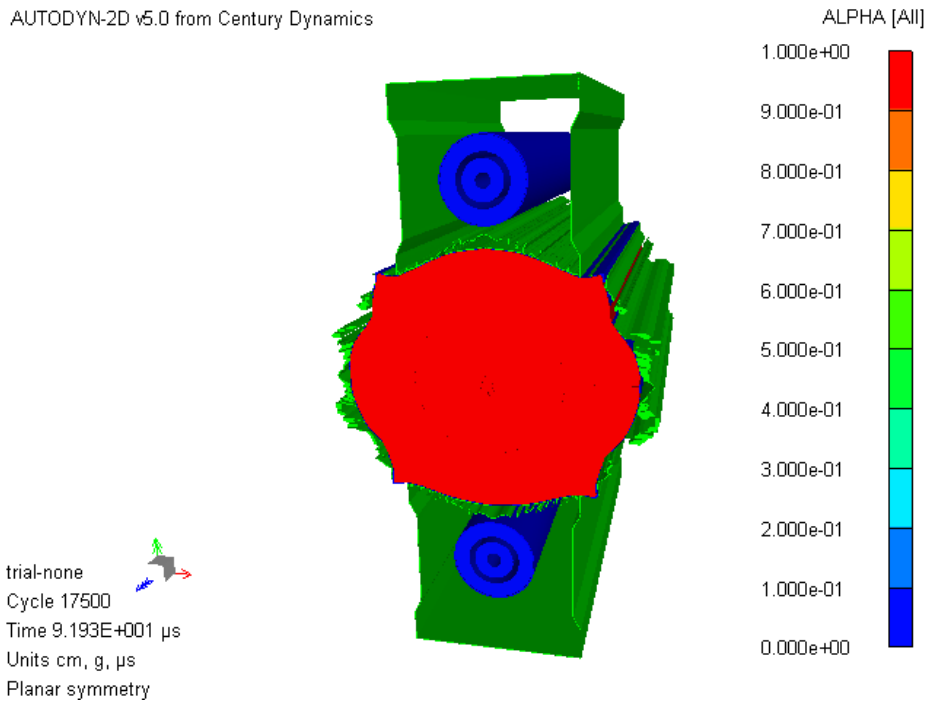
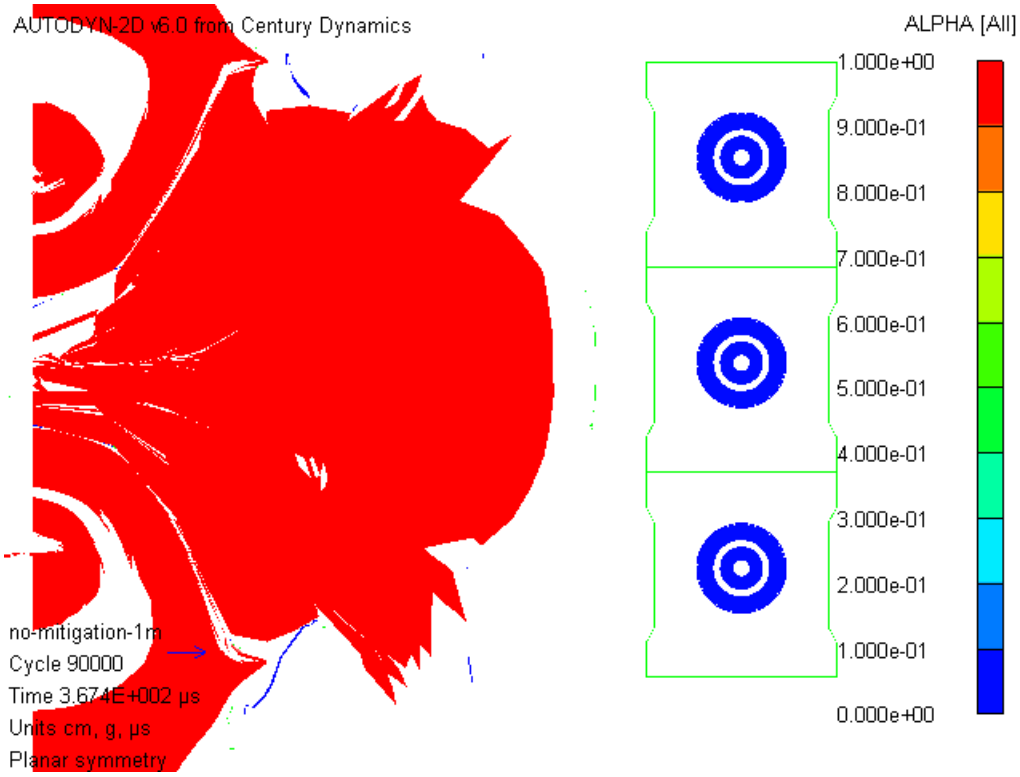


Problem 3

- Transfer to the adjacent stack of a like munition
  - Anti tank missiles with 1m stack separation



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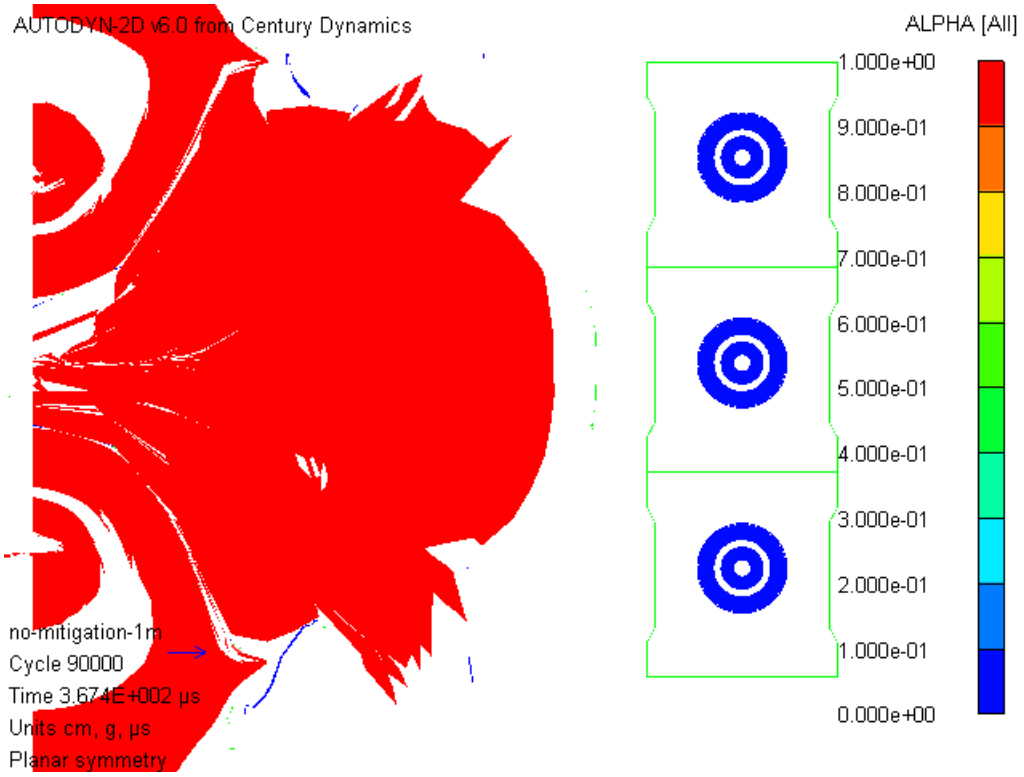
- Transfer to the adjacent stack of a like munition
  - Anti tank missiles with large stack separation



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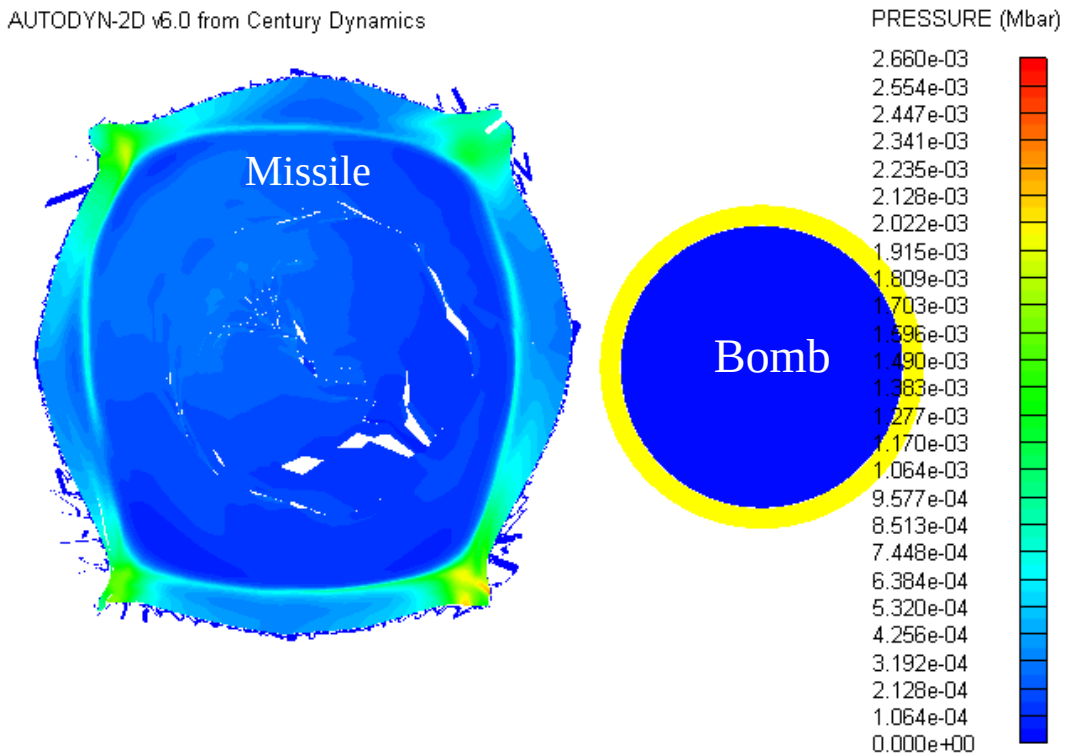
- Transfer to the adjacent stack of a different munition
  - Anti tank missile adjacent to large bomb



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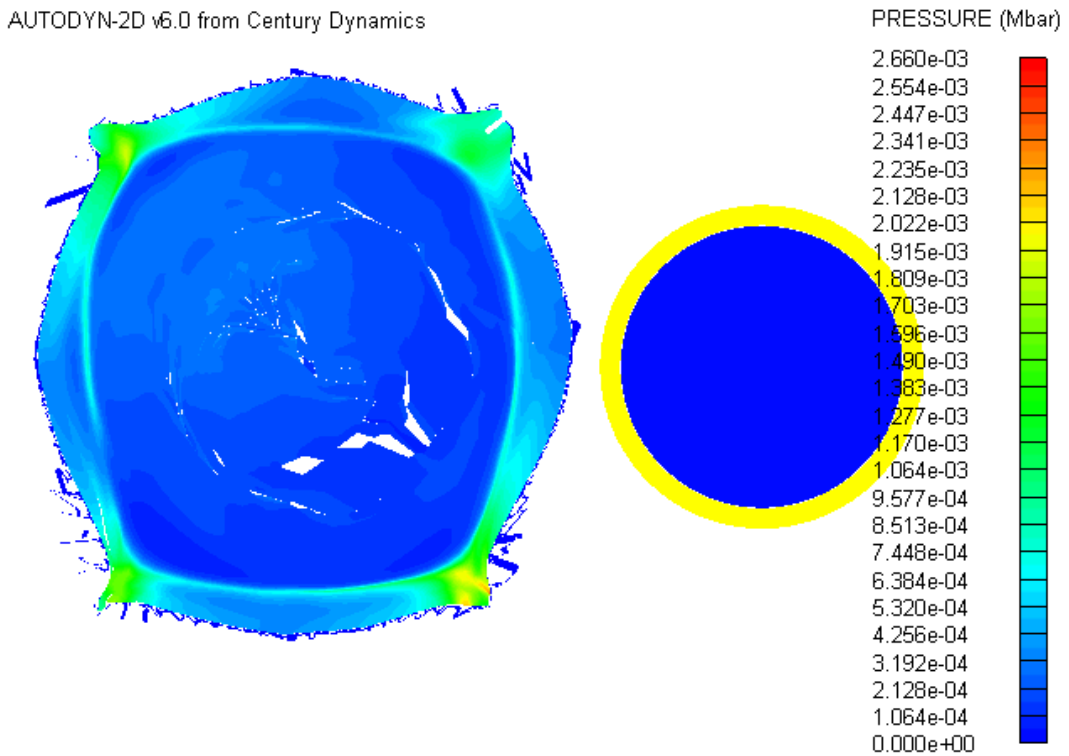

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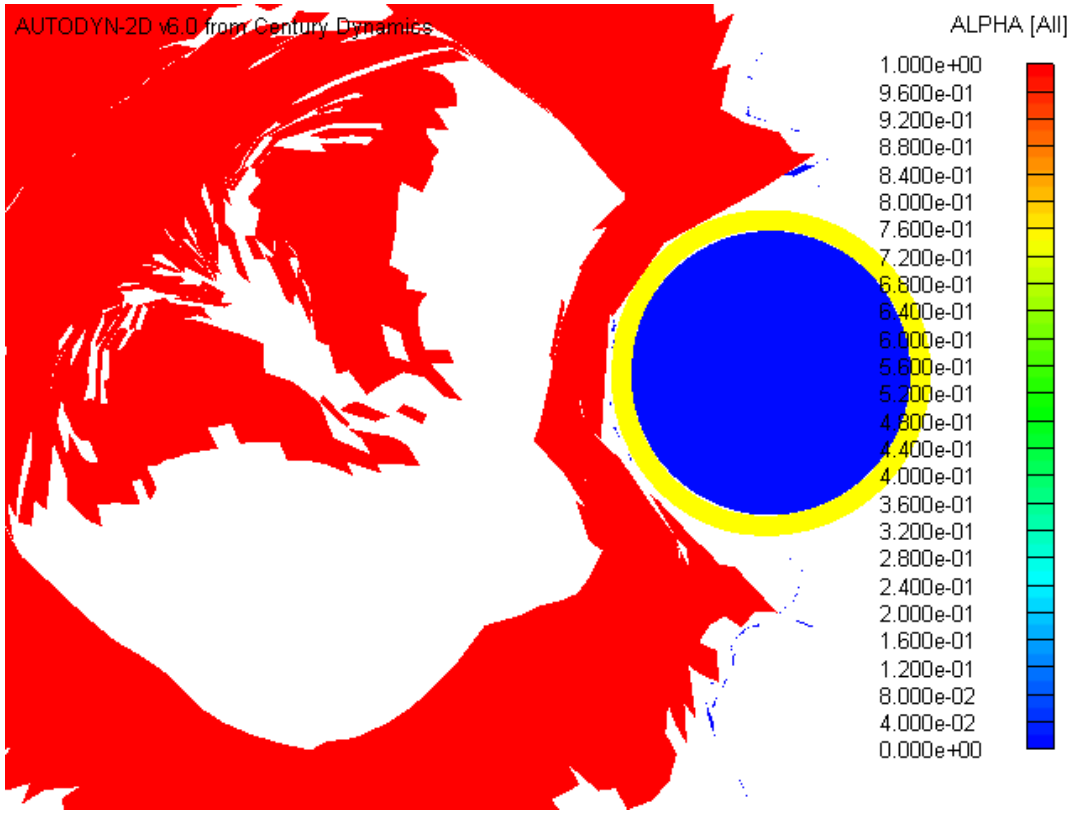

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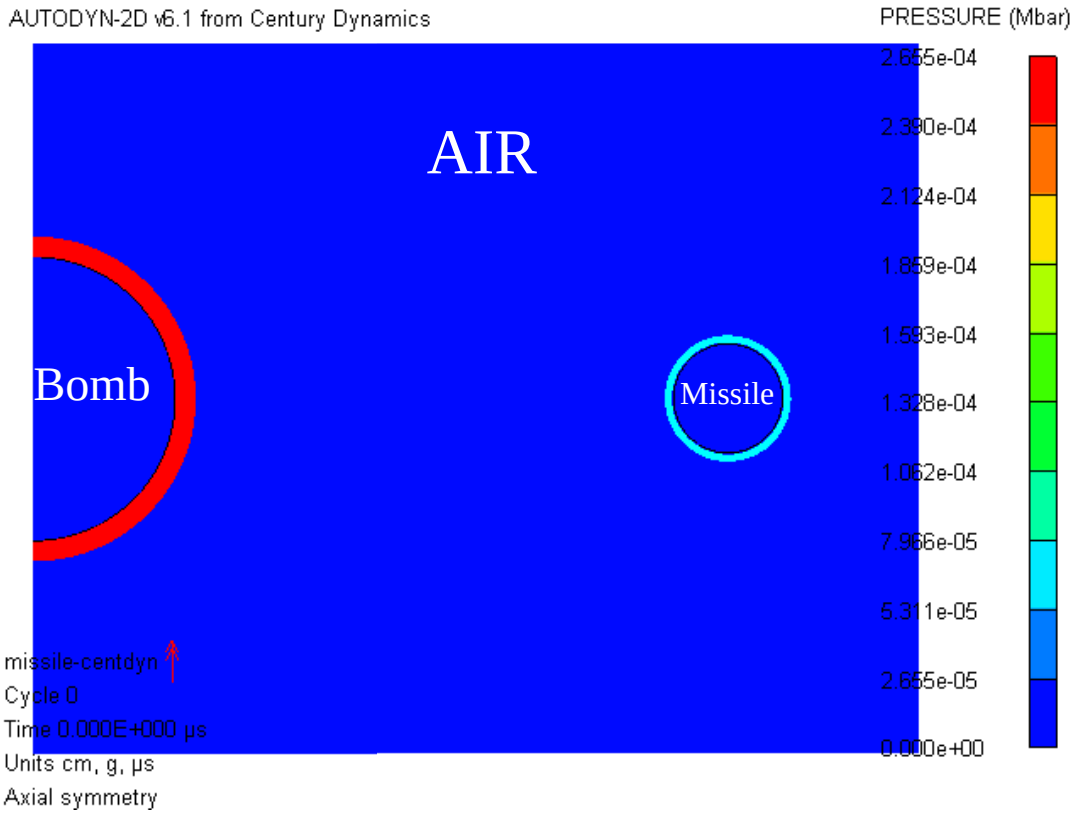

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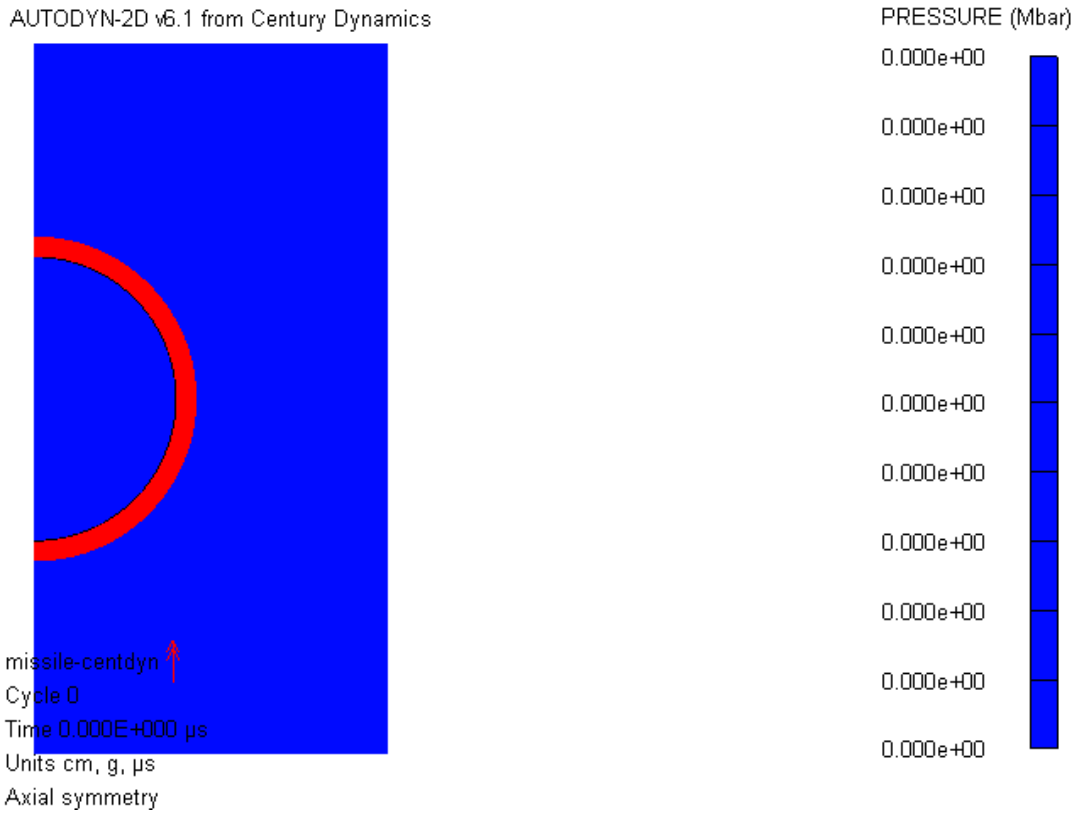
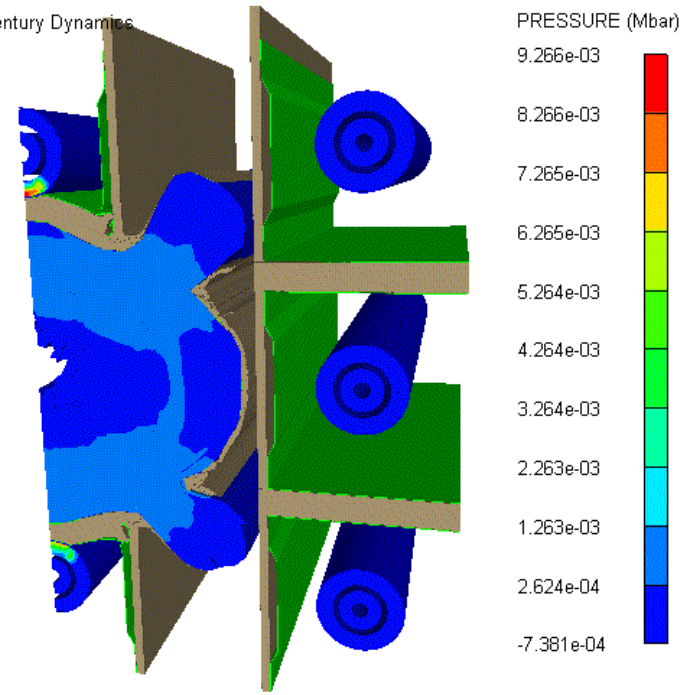


Problem 4

- Provision of mitigation in order to reduce risk and maximise stowage capability

- The addition of mitigation has reduced the stack spacing by 67%



Small Stack separation

- Therefore tripling the stowage capacity

Validation

- Compare trial firings of single fragments at several velocities with models of new mitigation and container materials.
- Compare munition reaction model results with Large Scale Gap Test, Fragment Attack Tests/Assessments and Sympathetic Reaction test results.
- If practicable and affordable, carry out full-scale demonstration of model result for confidence building.

Photos courtesy of Ratheon

Summary

- Munition response to fragment impact can be determined through modelling.
- The probability of sympathetic reaction within stack can be calculated.
- The effect of the separation distance can be determined and potentially this is the most effective form of ‘mitigation’. Less sensitive munitions can be used as a from of mitigation.
- By the addition of mitigation, the separation distance between the stacks can be significantly reduced, thus maximising the stowage capacity of the magazine.

Questions?