Temasek Defence Systems Institute

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Simulation of Hydrodynamic Ram (HRAM) Phenomenon using MSC.Dytran

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Objective

To develop a Finite Element model using MSC.Dytran to analyze the dynamic response of tank structure, and conduct parametric studies on factors that could affect tank wall response during the initial phase of HRAM event

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Model Description

The HRAM model consist of three main parts as shown in Figure 1: Lagrangian mesh for the tank and projectile and Eulerian mesh for the fluid inside the tank.

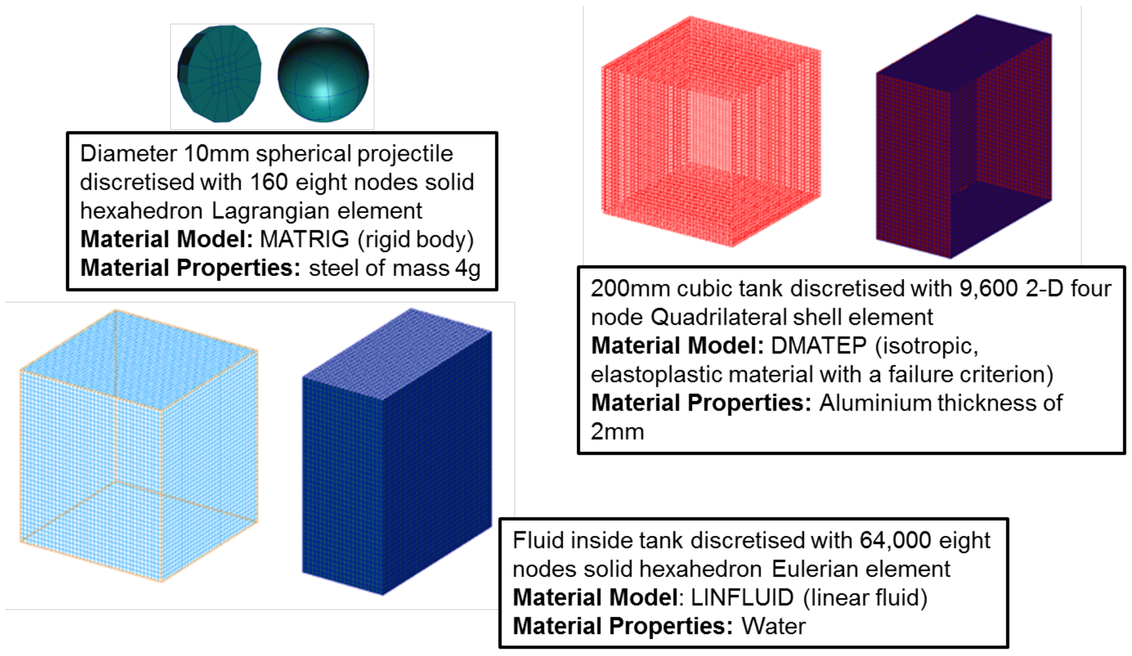

Figure 1. HRAM Model Description

Research Results

Key features of HRAM phenomenon such as the shock wave propagation through the fluid upon impact (Figure 2), drag phase pressures (Figure 3), cavity evolution (Figure 4) and tank walls deformation (Figure 5) could be observed from the model.

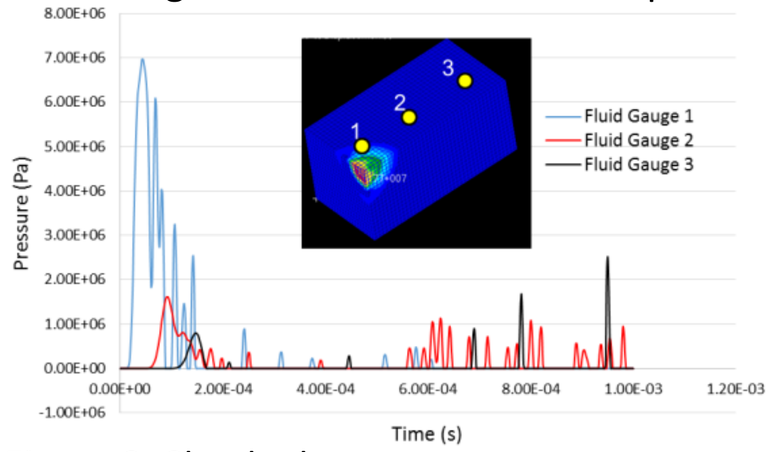

Figure 2. Shock phase ram pressure propagation

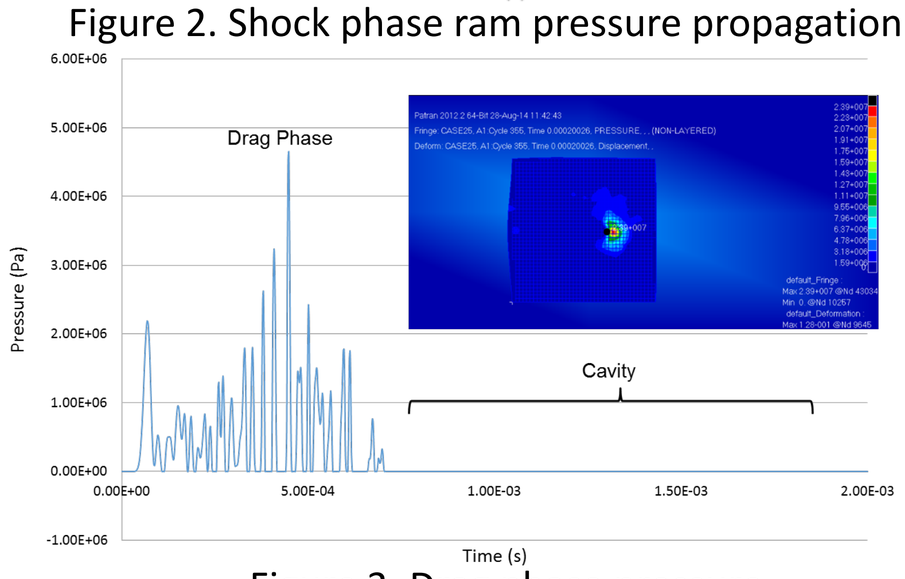

Figure 3. Drag phase pressure

Parametric studies were conducted with the model to investigate exit wall response to varying parameters such as Fluid Filling Levels, Fluid Density, Tank structure Material Modulus of elasticity, Tank structure Material Density, Projectile Weight and Projectile Velocity.

Of all the factors tested, Projectile velocity is found to have the strongest influence on the deformation of the exit wall. Damage to exit wall could be greatly reduced if the projectile velocity could be reduced significantly by the entry wall after penetration.

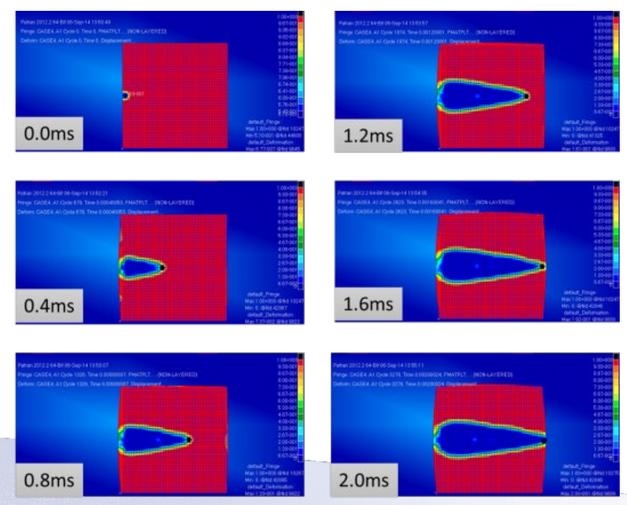

Figure 4. Cavity Evolution

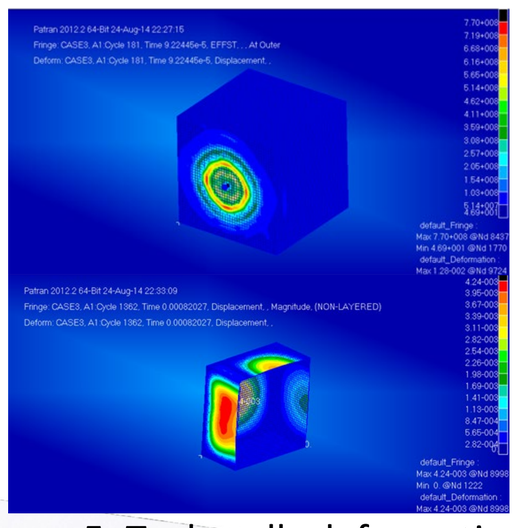

Figure 5. Tank walls deformation

Benefit of the research

Provide a better understanding on the source and magnitude of the pressure waves generated in the fluid and the dynamic response of the coupled tank structure due to HRAM event. The ultimate goal of HRAM analysis and research is to design aircraft fuel tank structures to withstand HRAM loads, or to develop HRAM mitigation techniques so as to better protect aircraft and increase its survivability.

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