“Aircraft Impact on Reinforced Concrete Structures“

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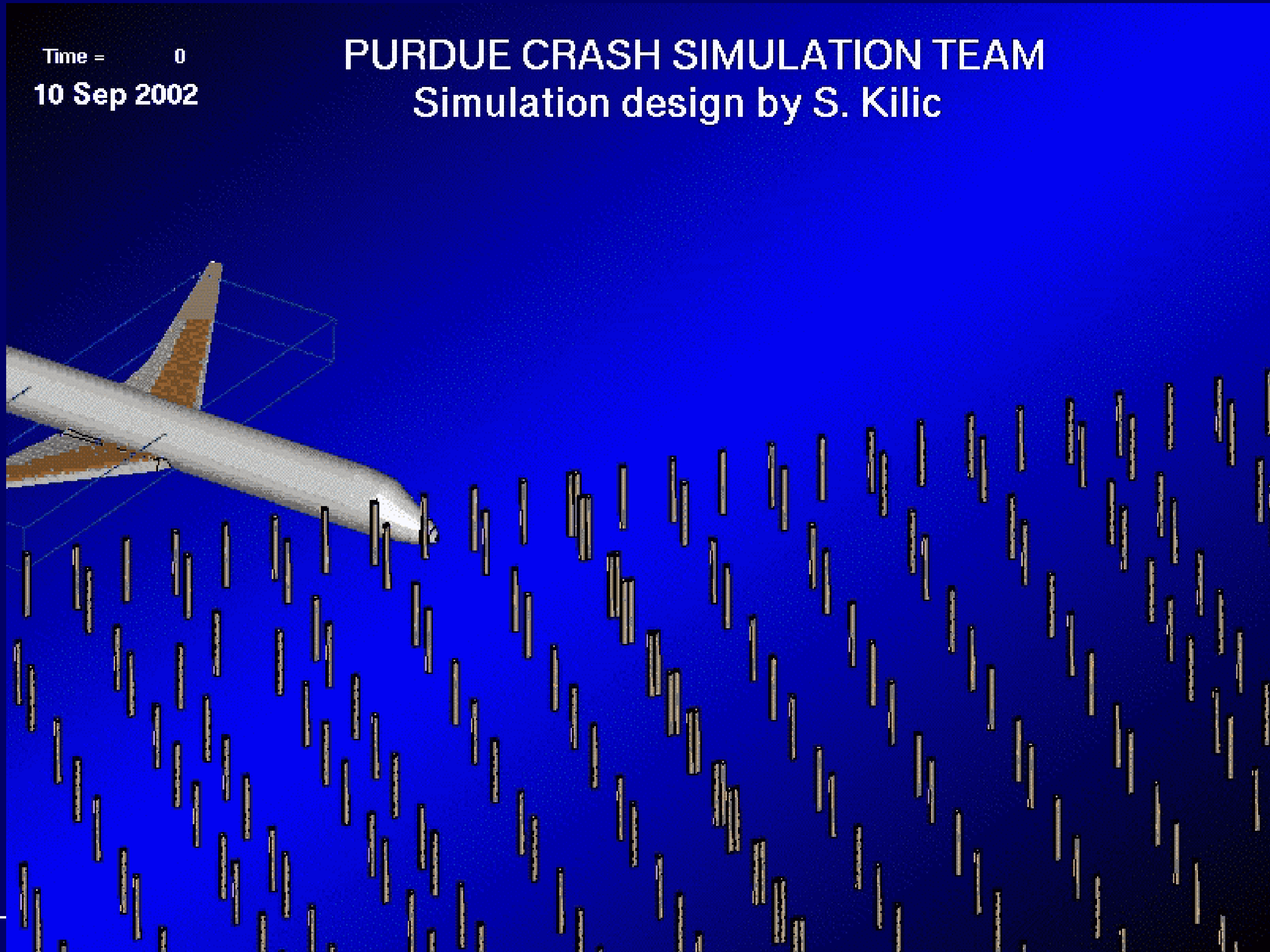
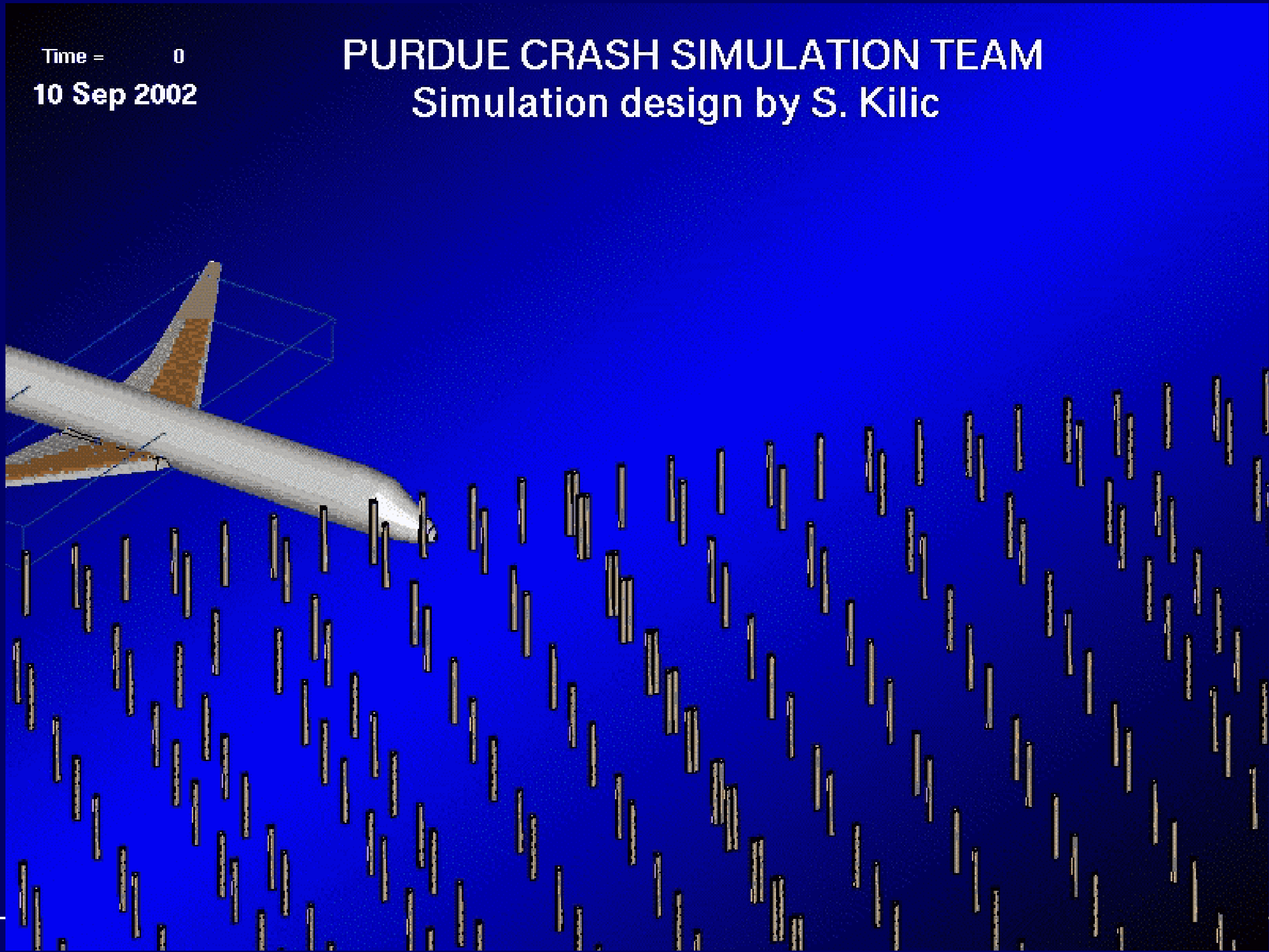
Overview of the Presentation

- Full-size aircraft impact on reinforced concrete structure (earlier work)
- Parametric study on initial impact velocity for a single reinforced concrete column impacted by a block of liquid (Fluid-Structure Interaction – FSI).
- Example simulations about Explosion/ Blast loading.

Earlier Work done on Full-size Aircraft Impact on Reinforced Concrete Structure



LS-Dyna ALE Simulation of Aircraft Impact on a Reinforced Concrete Structure



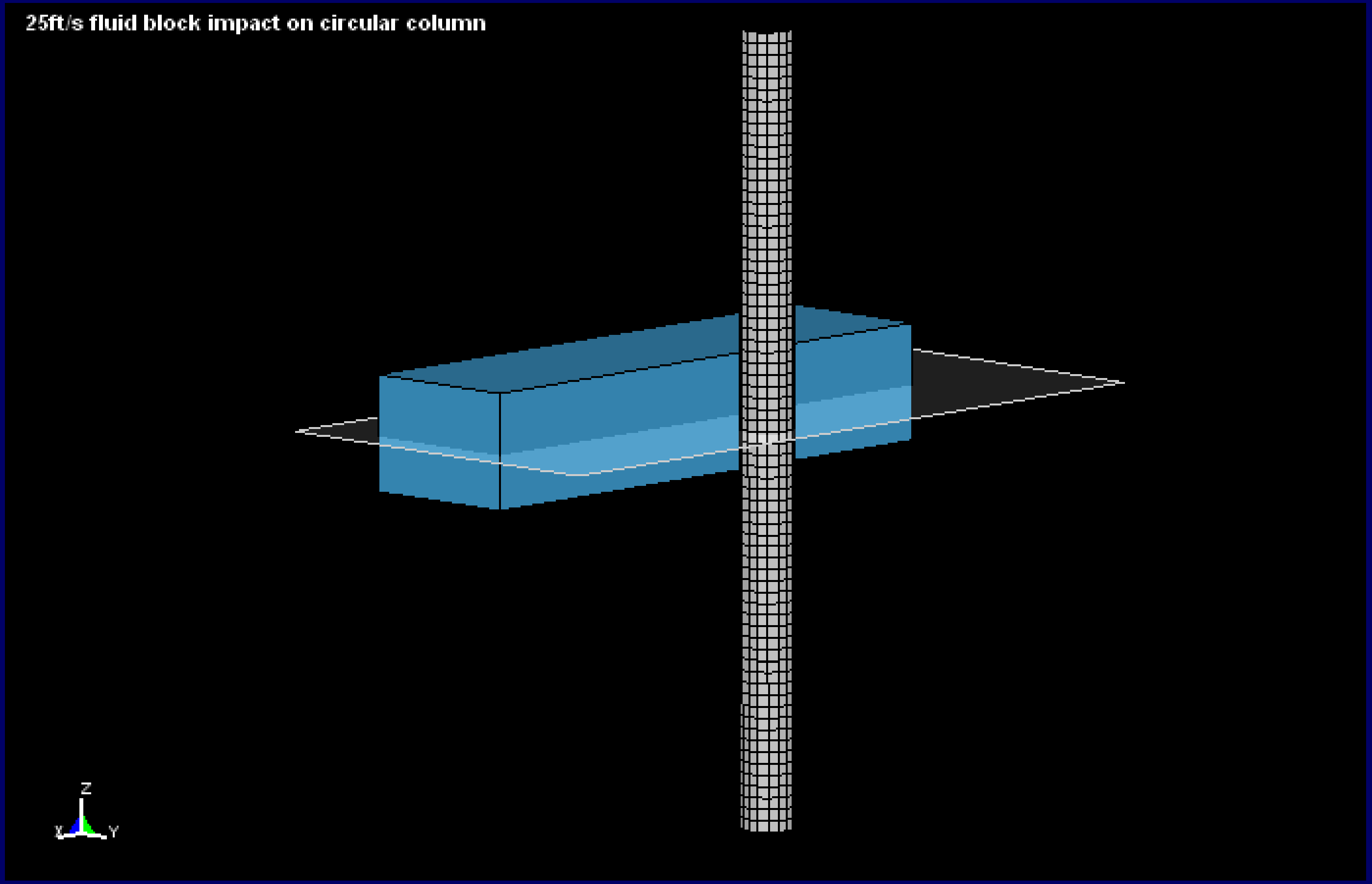
Conclusions

- The Arbitrary Lagrangian-Eularian technique is suitable for modeling Fluid-Structure Interaction (FSI) coupling.
- Wide area damage in the structure is due to the wings. The fuselage causes a narrow tunnel of damage.
- Most of the mass of the wings come from the fuel stored in the wing tanks. The skin of the wings (wing structure) constitutes a smaller amount of mass in comparison.

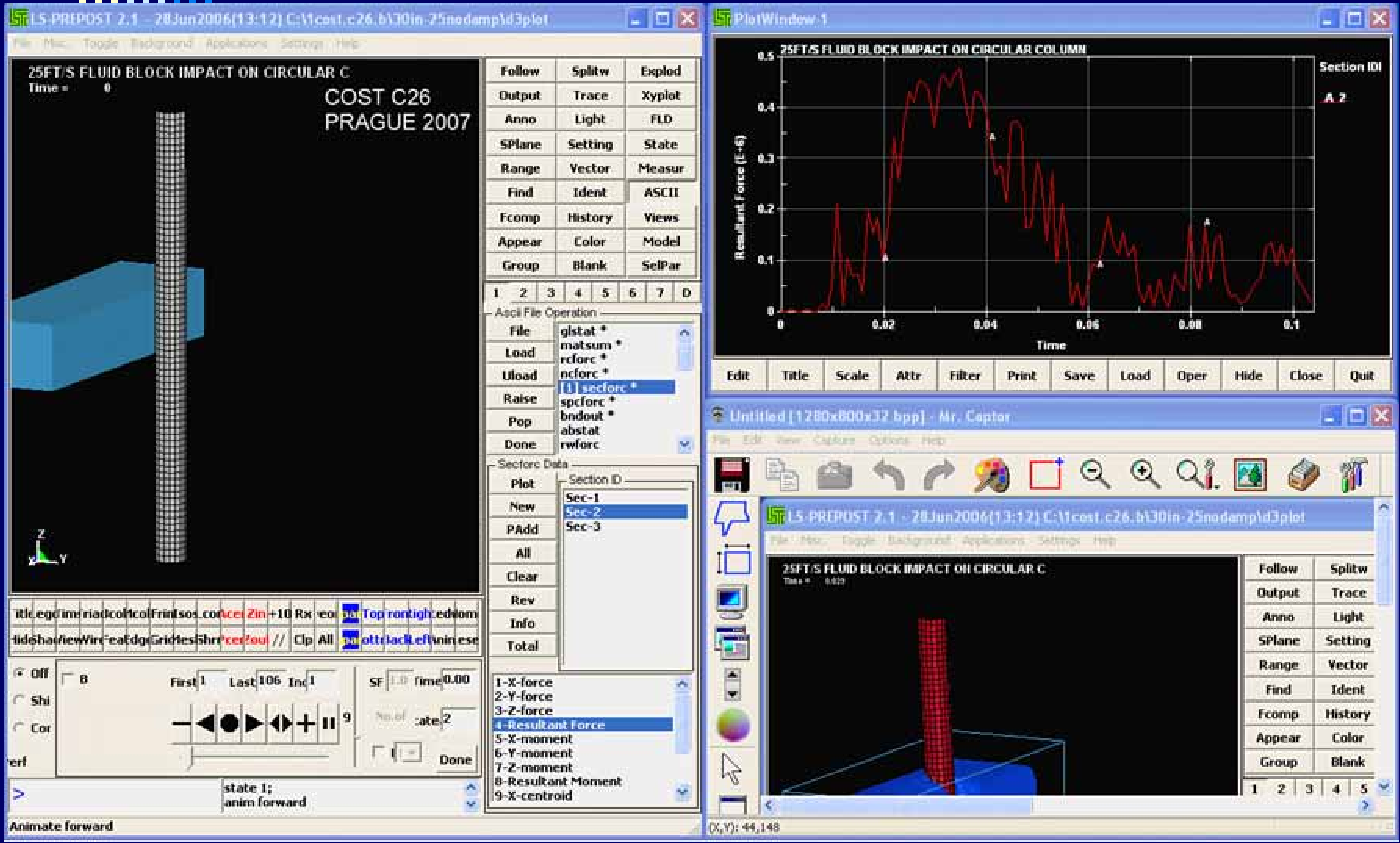
Simulating Fluid-Structure Interaction (FSI) for a Single Reinforced Concrete Column Hit by a Block of Liquid

- Concrete unconfined compressive strength; f’c= 28 MPa.
- Yield stress of reinforcement rebars; fy= 310 MPa.
- Concrete elements erode at a strain level of 0.05.
- Reinforcement rebars rupture at a plastic strain level of 0.20.
- Initial velocities of Vo=25 feet/sec and Vo=100 feet/sec are investigated.

Initial Vo= 25 feet/sec= 7.62 m/sec
Cross-section Definition for Resultant Force



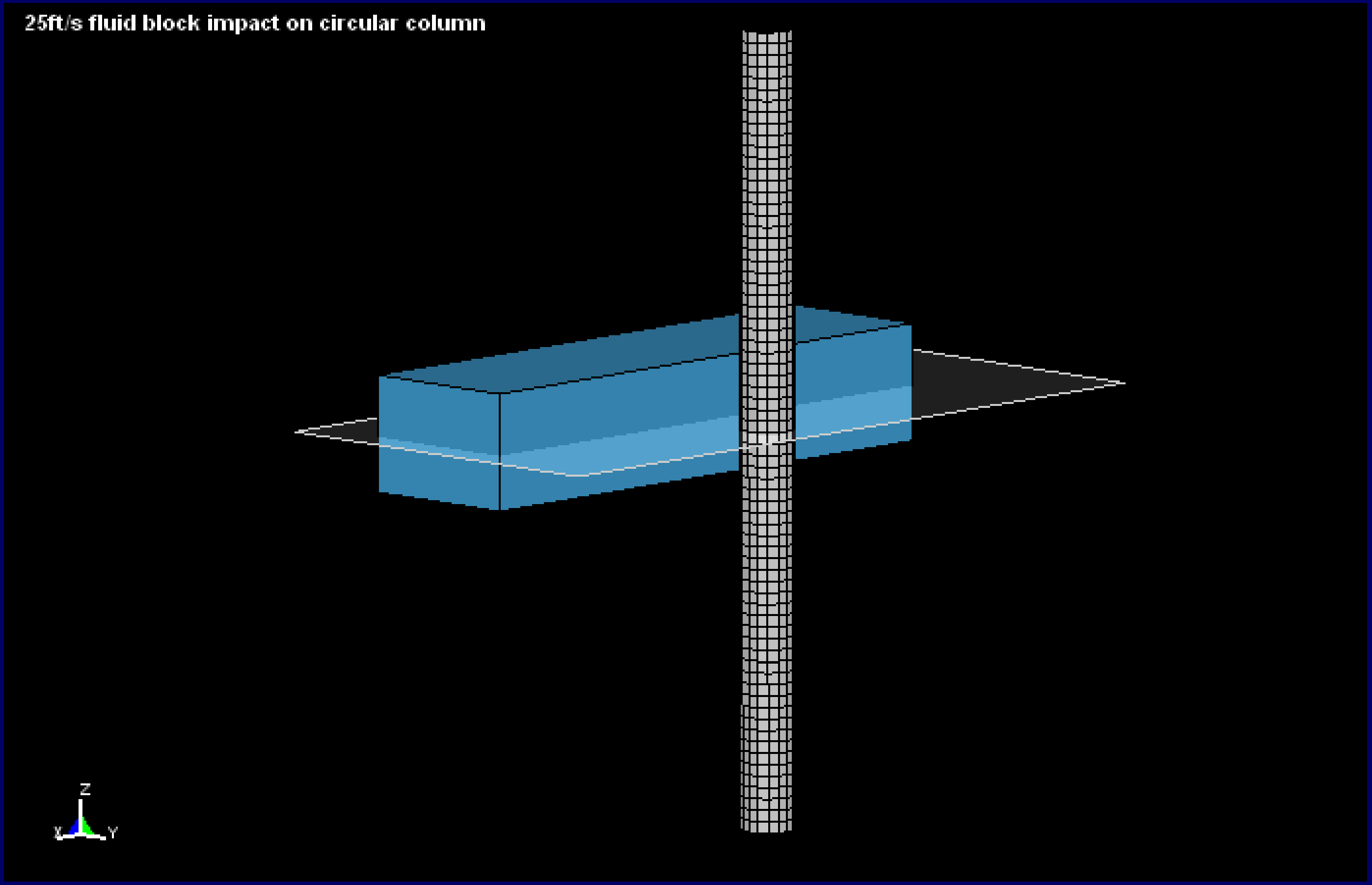
Vo= 25 feet/sec = 7.62 m/sec



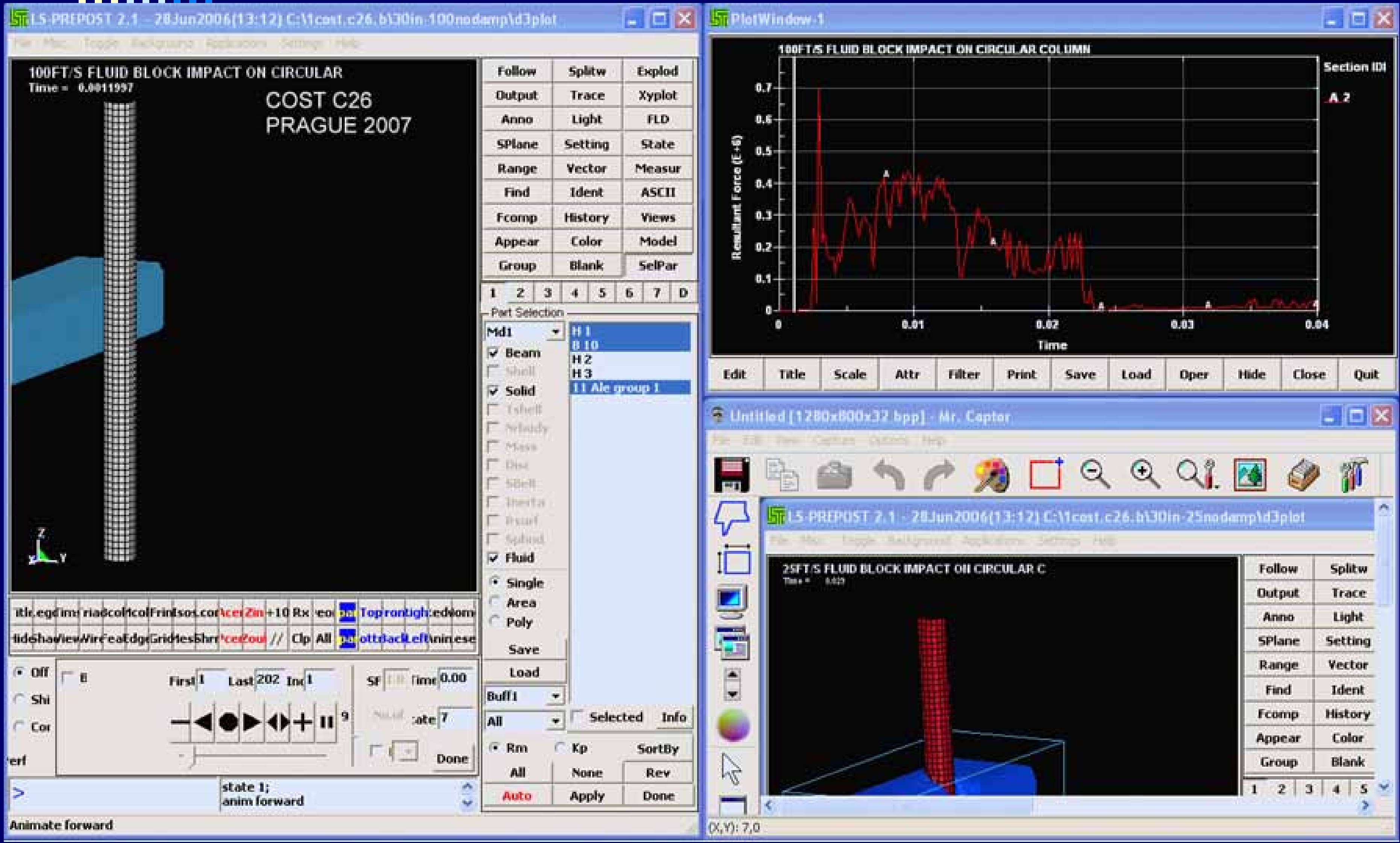
Conclusions

- The outer face of the concrete column erodes without significantly affecting the overall integrity.
- A few reinforcement rebars rupture.
- The column stays in place after the impact.
- Peak resultant force is 0.48 MN.

Initial Vo= 100 feet/sec= 30.48 m/sec
Cross-section Definition for Resultant Force



Vo= 100 feet/sec = 30.48 m/sec

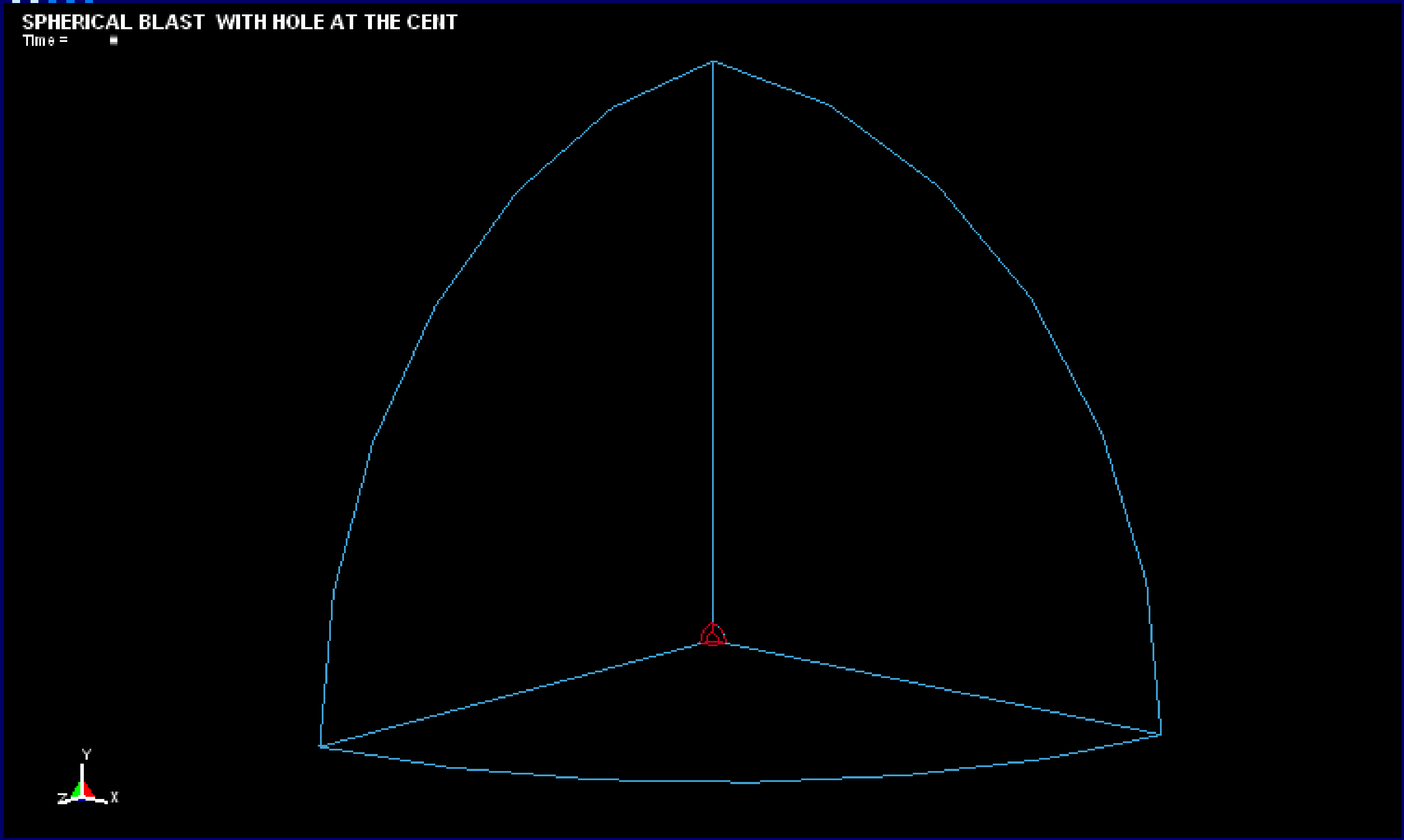


Conclusions

- The column is split into half, losing all of its integrity; complete failure occurs.
- This example demonstrates the sensitivity of FSI on initial impact velocity.
- Peak resultant force is 0.70 MN.

Example Simulations about Explosion/Blast Explosive Detonated in a Spherical Mesh

Example Simulations about Explosion/Blast -Explosive Detonated in a Spherical Mesh



Example Simulations about Explosion/Blast -Explosive Detonated in a Spherical Mesh

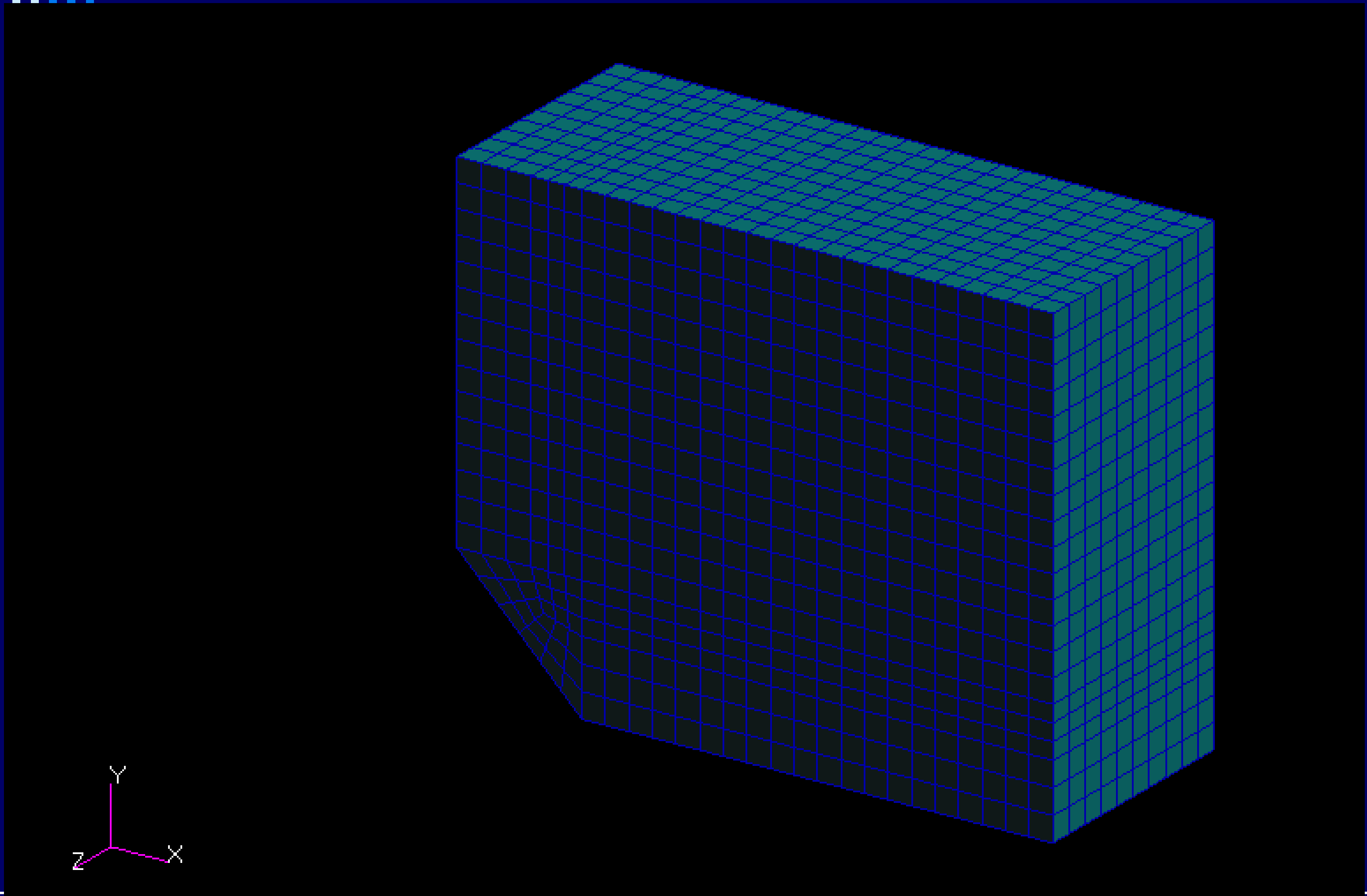
Remarks:

- *MAT_HIGH_EXPLOSIVE_BURN constitutive model available in LS-Dyna for modeling explosive material.
- *EOS_JWL equation of state available for pressure-volume relationship of the blast wave.
- Need more data for the various parameters used in these models.
- Blast wave pressure propagation should be checked against available:

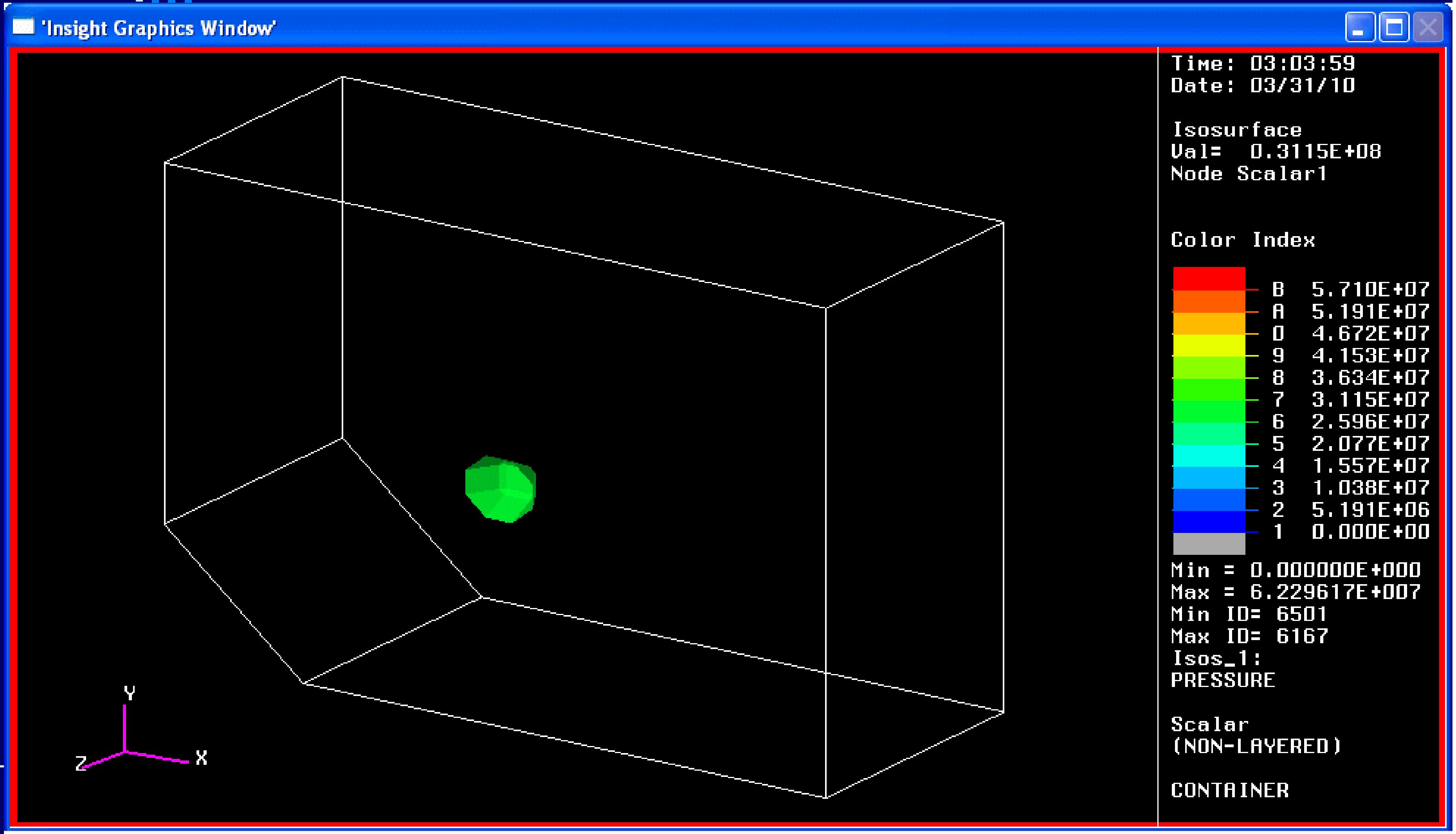
  (a) experimental data

  (b) numerical data from CONWEP or ATBLAST or AIR3D (Cranfield University, UK) programs.

Example Simulations about Explosion/Blast -Blast in a Closed Luggage Container



Example Simulations about Explosion/Blast -Blast in a Closed Container



Conclusions

- For the lower speed of Vo=25 feet/sec, the single column survives the impact without losing integrity.
- Quadrupling the initial speed of the liquid increases the kinetic energy 16-folds. The higher speed of Vo=100 feet/sec cuts the column in half, causing complete failure.
- The Arbitrary Lagrangian-Eularian technique will be extensively used to model blast wave propagation and blast-structure interaction. Simulation will be carried out using both LS-Dyna and MSC.Dytran finite element codes using explicit time integration.
- Benchmark problems are needed for the blast wave propagation simulations (both experimental and numerical).