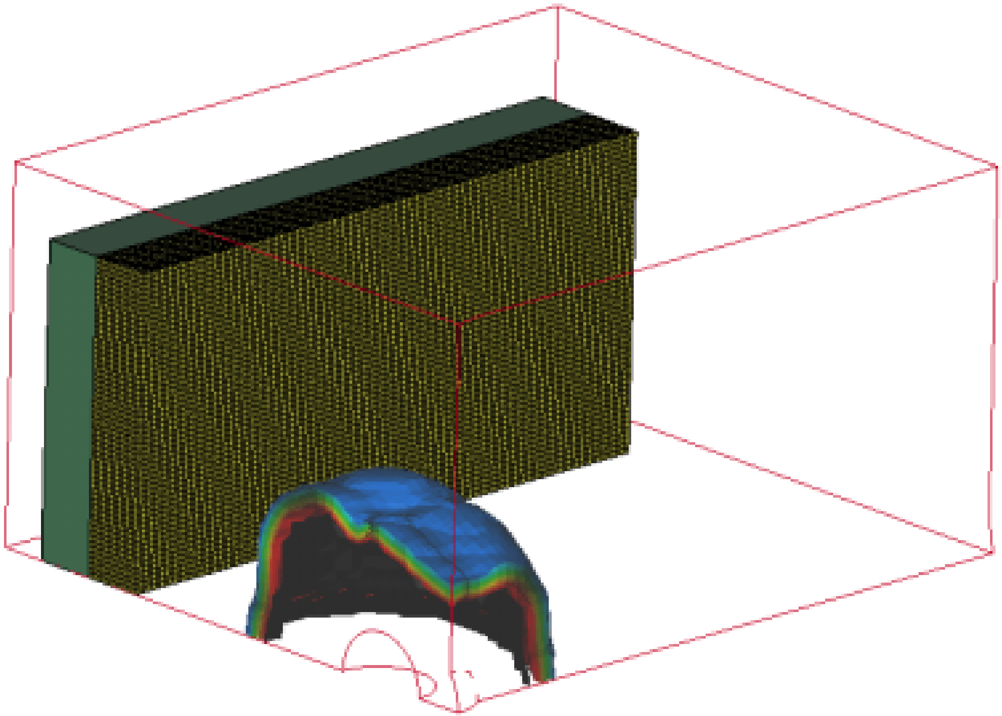
Arbitrary Lagrangian Eulerian Coupling Techniques in Blast Modeling

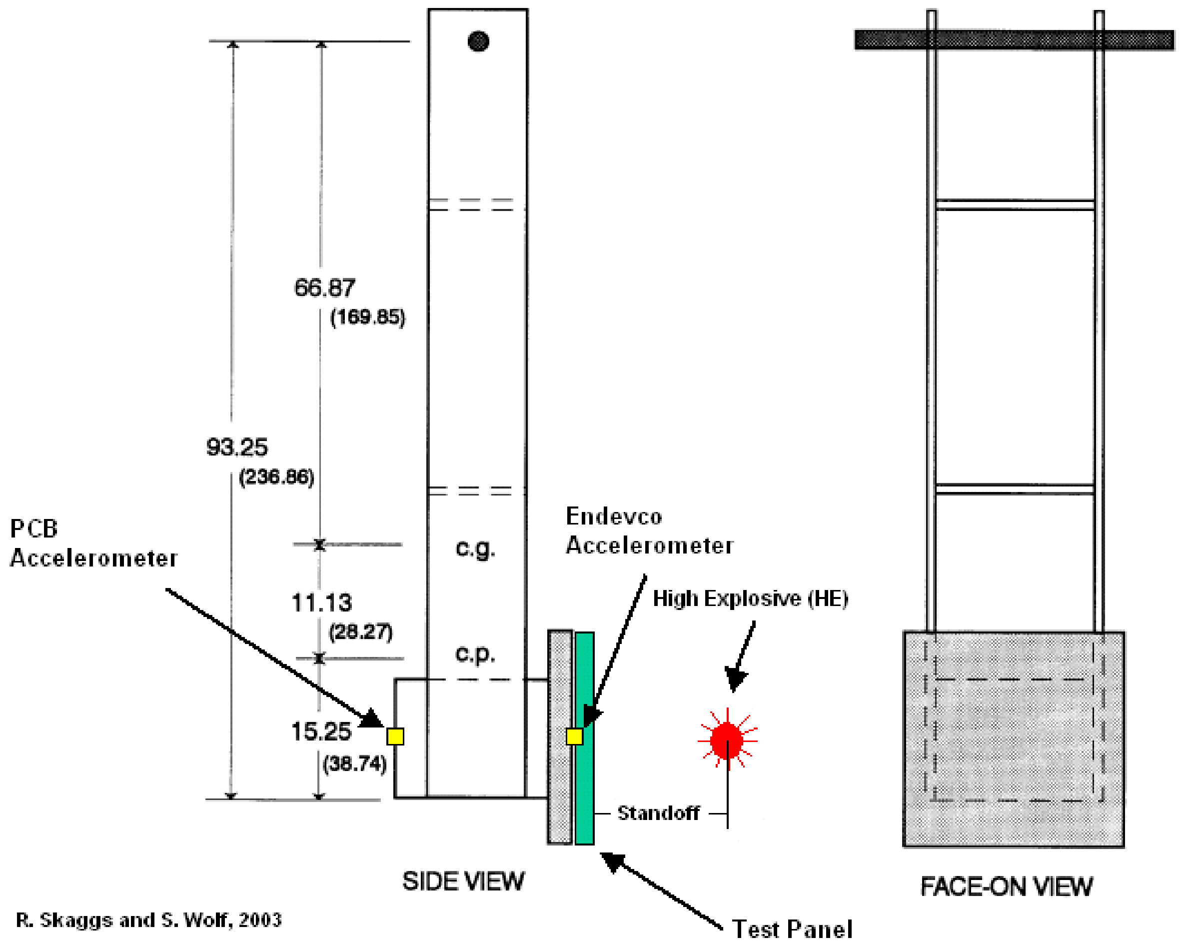


Presented By: Michael Mullin

Motivation

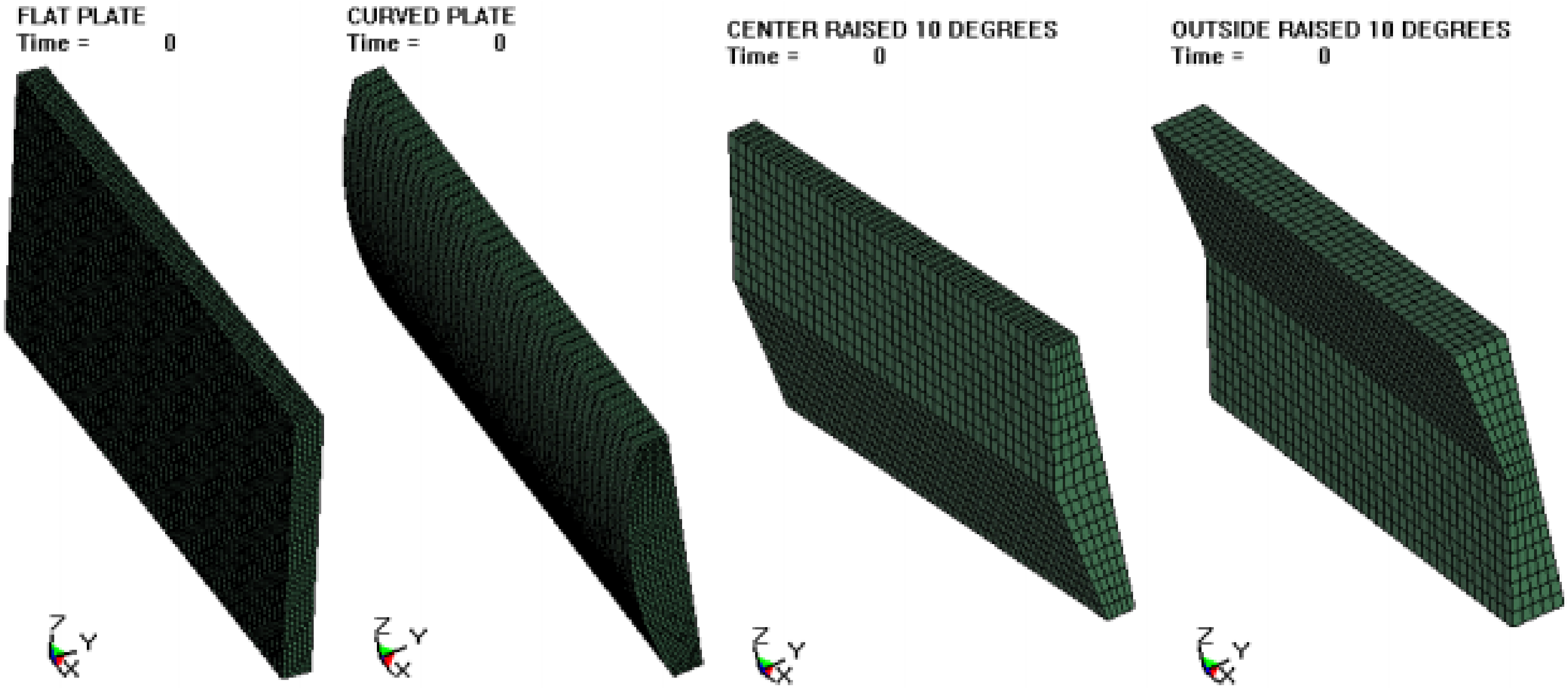
- Energy absorbing materials need to be investigated.
- ALE offers more accurate capabilities.
- Compare results to models using CONWEP.

Ballistic Pendulum

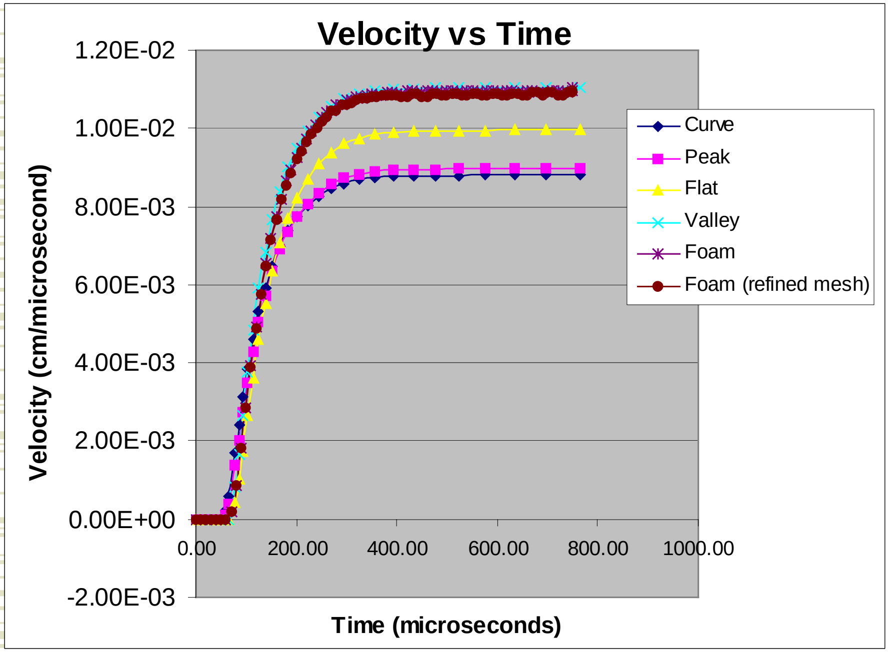


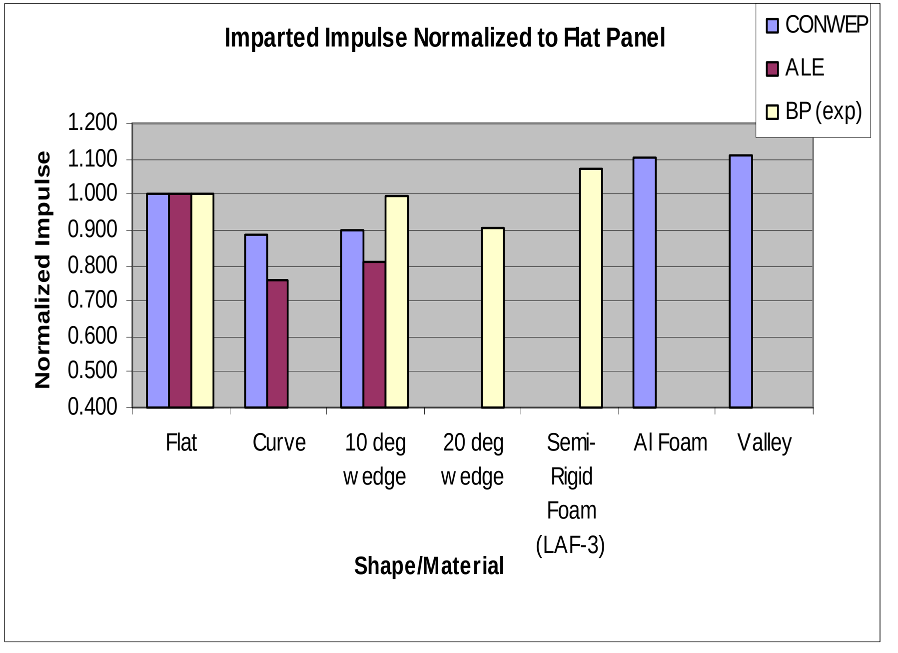
R. Skaggs and S. Wolf, 2003

Previous Studies: Sled Shapes



Previous Studies: Results





- Results from previous CONWEP and ALE parametric studies compared to experiment results.

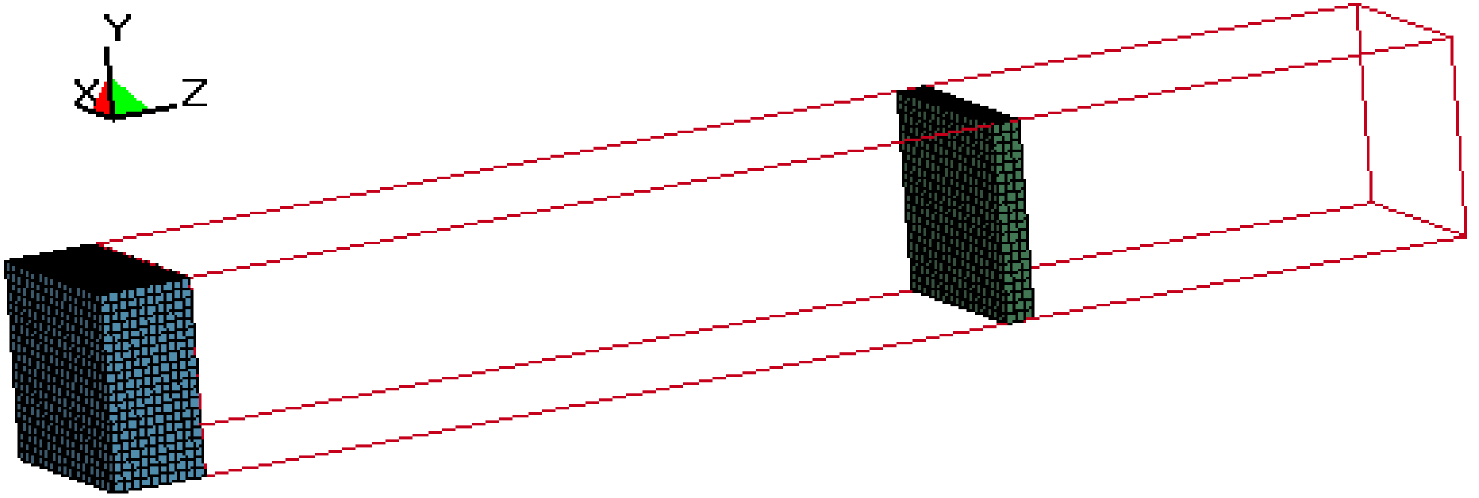
Long Term Objectives

- Effectively simulate blast phenomenon.
- Know the difference between CONWEP and ALE techniques and when each are appropriate.
- Optimize Al foam parameters to mitigate blast damage.

Project Objectives

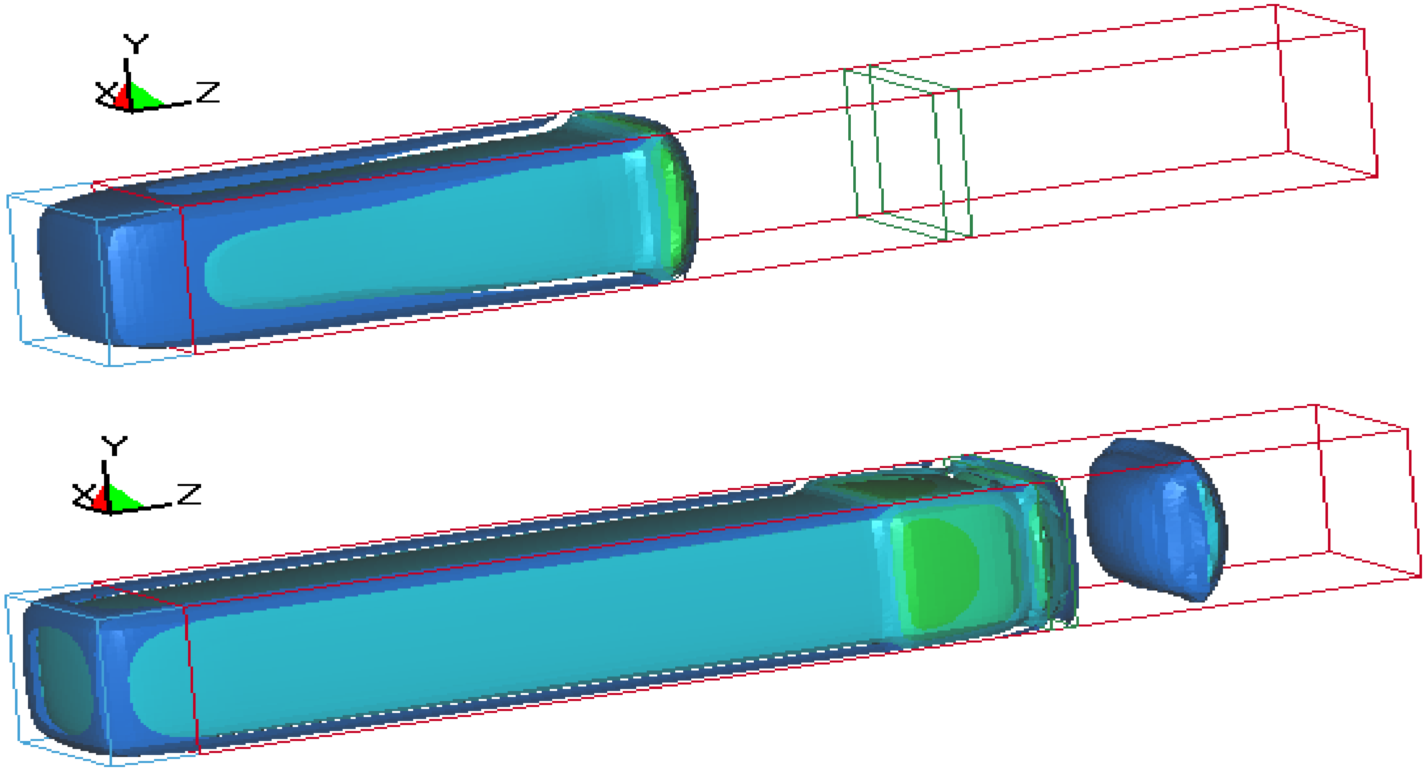
- Create a model that simulates fluid structure interaction.
- Learn the required input cards associated with ALE and the effect each parameter plays on the model.
- Be able to compare steady state velocity of the foam panel against previous tests.

Practice Model



- 60,000 Eulerian elements
- 396 Lagrangian

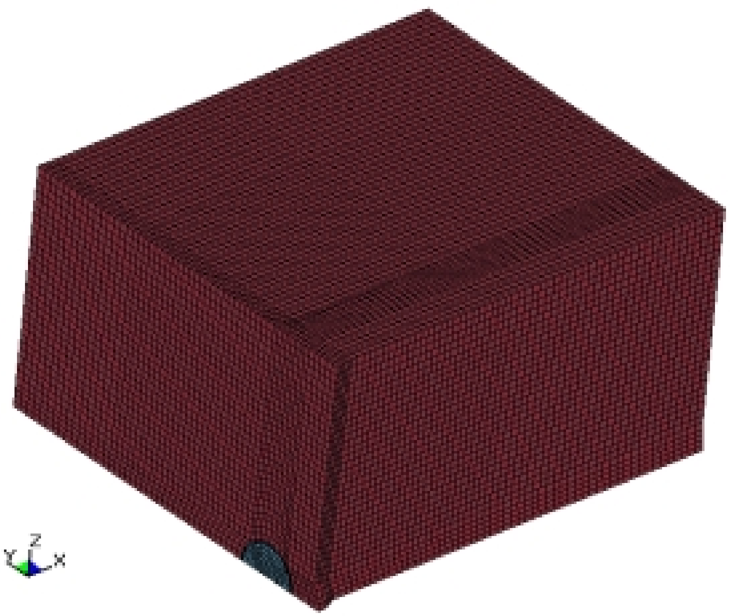
Practice Model cont.

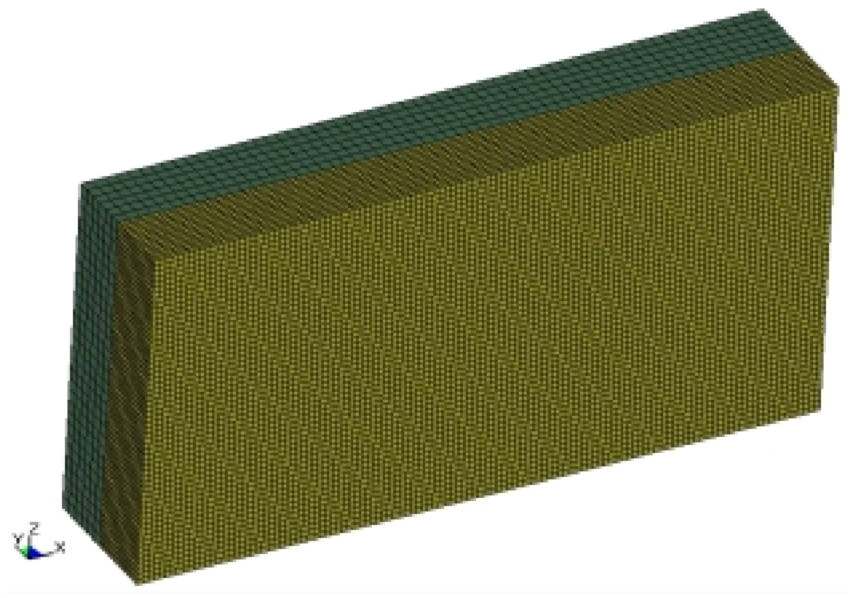


Important Cards

```
*CONTROL_TIME_STEP
$---+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
$   DTINIT    TSSFAC      ISDO    TSLIMT     DT2MS      LCTM     ERODE     MSIST
       0.0      0.25
$
$
*CONTROL_ALE
$---+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
$      DCT      NADV      METH      AFAC      BFAC      CFAC      DFAC      EFAC
         3         1         2        -1
$    START       END     AAFAC     VFACT      PRIT       EBC      PREF   NSIDEBC
                                                             0.10132
$
$
*CONSTRAINED_LAGRANGE_IN_SOLID
$---+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
$    SLAVE    MASTER     SSTYP     MSTYP     NQUAD     CTYPE     DIREC     MCOUP
         3         1         1         1         4         5         3         0
$    START       END      PFAC      FRIC    FRCMIN      NORM   NORMTYP      DAMP
       0.0    1.0E10      0.25                 0.0
$       CQ      HMIN      HMAX     ILEAK     PLEAK   LCIDPOR
       0.0       0.0       0.0         1
```

Foam Model





- 106,190 Air Elements
- 608 HE Elements

- 86,400 Al Foam Elements
- 10,800 Rigid Body Elements

Important Cards

```
*CONTROL_TIME_STEP
$---+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
$    DTINIT    TSSFAC      ISDO    TSLIMT     DT2MS      LCTM     ERODE     MSIST
        0.0      0.10
*CONTROL_ALE
$---+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
$       DCT      NADV      METH      AFAC      BFAC      CFAC      DFAC      EFAC
          3         1         2      -1.0
$     START       END     AAFAC     VFACT      PRIT       EBC      PREF   NSIDEBC
                                                               0.10132
$
*CONSTRAINED_LAGRANGE_IN_SOLID
$---+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
$     SLAVE    MASTER     SSTYP     MSTYP     NQUAD     CTYPE     DIREC     MCOUP
         22         1         0         1         2         5         3         0
$     START       END      PFAC      FRIC    FRCMIN      NORM   NORMTYP      DAMP
        0.0    1.0E10      0.30                 0.0
$        CQ      HMIN      HMAX     ILEAK     PLEAK   LCIDPOR
        0.0       0.0       0.0         1
$
*SET_PART_LIST
$       SID
         22
$      PID1      PID2
          3         4
```

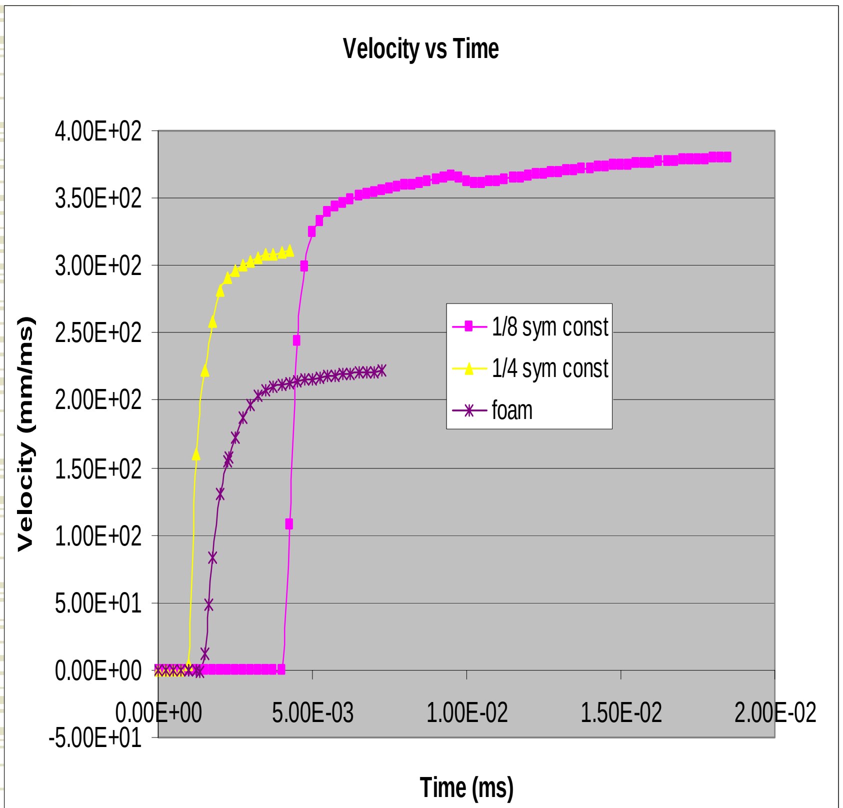
Important Cards

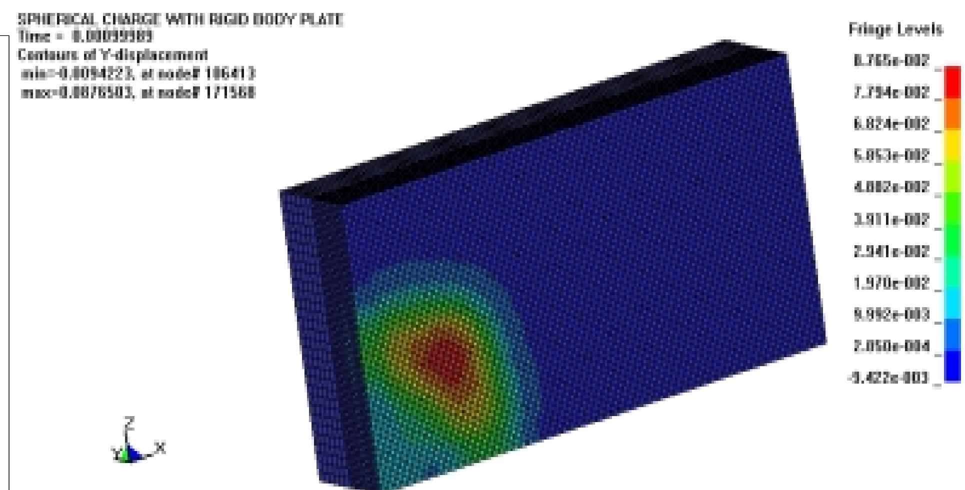
```
.
*SECTION_SOLID_ALE
$---+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
$    SECID    ELFORM       AET
         6         1
$     AFAC      BFAC      CFAC      DFAC     START       END     AAFAC

$
*MAT_ADD_EROSION
$---+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
$      MID      EXCL
         4
$    PFAIL     SIGP1     SIGVM     EPSP1     EPSSH     SIGTH   IMPULSE    FAILTM
               100                1.15
$
*CONTACT_TIED_SURFACE_TO_SURFACE_OFFSET
$---+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
$     SSID      MSID     SSTYP     MSTYP    SBOXID    MBOXID       SPR       MPR
         2         1         0         0
$       FS        FD        DC        VC       VDC    PENCHK        BT        DT

$      SFS       SFM       SST       MST      SFST      SFMT       FSF       VSF
```

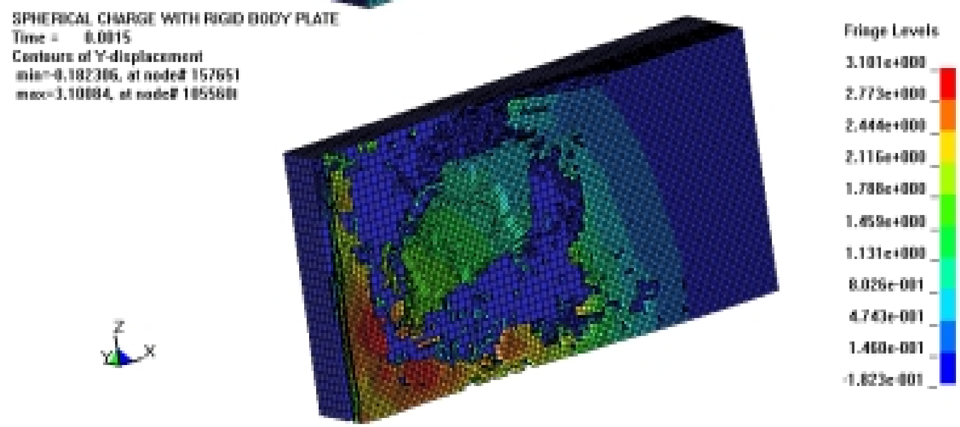
Results

- Successfully coupled Lagragian and Eulerian parts.
- Preliminary models show foam as effective for reducing imparted impulse compared to a similar model with a rigid body flat panel.

Results


Velocity vs Time
Velocity (mm/ms)
Time (ms)
4.00E+02
3.50E+02
3.00E+02
2.50E+02
2.00E+02
1.50E+02
1.00E+02
5.00E+01
0.00E+00
-5.00E+01
0.00E+00
5.00E-03
1.00E-02
1.50E-02
2.00E-02
1/8 sym const
1/4 sym const
foam


SPHERICAL CHARGE WITH RIGID BODY PLATE
Contours of Y-displacement
Fringe Levels
Z
Y
X


SPHERICAL CHARGE WITH RIGID BODY PLATE
Time = 0.0015
Contours of Y-displacement
Fringe Levels
Z
Y
X

Conclusion

- Techniques for ALE are set, now to make the models more accurate.
- Air mesh needs to be improved.
- Material and EOS parameters need to be scrutinized.
- Need to examine erosion criteria more closely.

Future Work

- Concentrate on material and EOS parameters.
- Examine effect of erosion criteria.
- Construct an improved air mesh.
- Compare ALE models with CONWEP models and experiments
- Perform an optimization study on Al foam material properties to minimize the imparted impulse.