LSTC Free Motion Headform

User's Guide

Version: LSTC.FMH.091201 V2.0
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INTRODUCTION

This release (version 2.0) of LSTC's Free Motion Headform (FMH) uses an entirely new mesh generously provided by Ben-Ren Tang of Ford Motor Company with permission from James Cheng. The new mesh features a grid pattern, developed by Bob Armitage of Ford, which facilitates headform positioning. The headform's intended use is for upper interior head impact simulations conducted according to FMVSS 201U [1] specifications.

Version 2.0 also features new material properties for the headform's outer skin. *MAT_VISCOELASTIC, which was used for version 1.0, has now been replaced with *MAT_OGDEN_RUBBER. All other components are modeled using *MAT_RIGID. Detailed inertia and mass properties of the headform can be found in Table 1 and Appendix A.

The unit system used is *mm-ms-kg-kN* (see Appendix B for instructions on unit conversions).

We will continue to enhance this model based on user feedback. Comments and suggestions can be sent to *dilip@lstc.com*.

CALIBRATION

Three calibration tests were conducted and the results are summarized in Table 1. In the first test, the headform was rotated so that the skull cap plate was at an angle of 30 degrees relative to the impact surface (see Figure 1). The headform was then impacted against the rigid surface with an initial velocity of 2.72m/s (corresponding to a drop height of 376mm). Both the peak resultant and lateral acceleration were measured and compared with the allowable ranges. The lateral and resultant acceleration curves are shown in Figures 2 and 3 respectively.

The second and third calibration tests were identical to the first except impact speeds of 4.00m/s and 6.71m/s were used. The 4.00m/s results were compared with physical test data from Chou et al. [2] (see Figure 4), and the 6.71m/s results were compared with physical test data from Chou et al. [3] (see Figure 5). The acceleration data for all three tests were processed with an SAE 1000 filter.

	Test / Spec	**FEA**
Peak Lateral Accel, Gs (2.72m/s)	-15 to 15	0.94
Peak Resultant Accel, Gs (2.72m/s)	225 to 275	235
Peak Resultant Accel, Gs (4.00m/s)	437	456
Peak Resultant Accel, Gs (6.71m/s)	1067	1155
Total Mass, kg	4.54 ± 0.05	4.54
Moment of Inertia, mm·kN·ms^2 (I_{yy})	23,388 ± 11,239	20,788

Table 1 – Calibration Results Summary

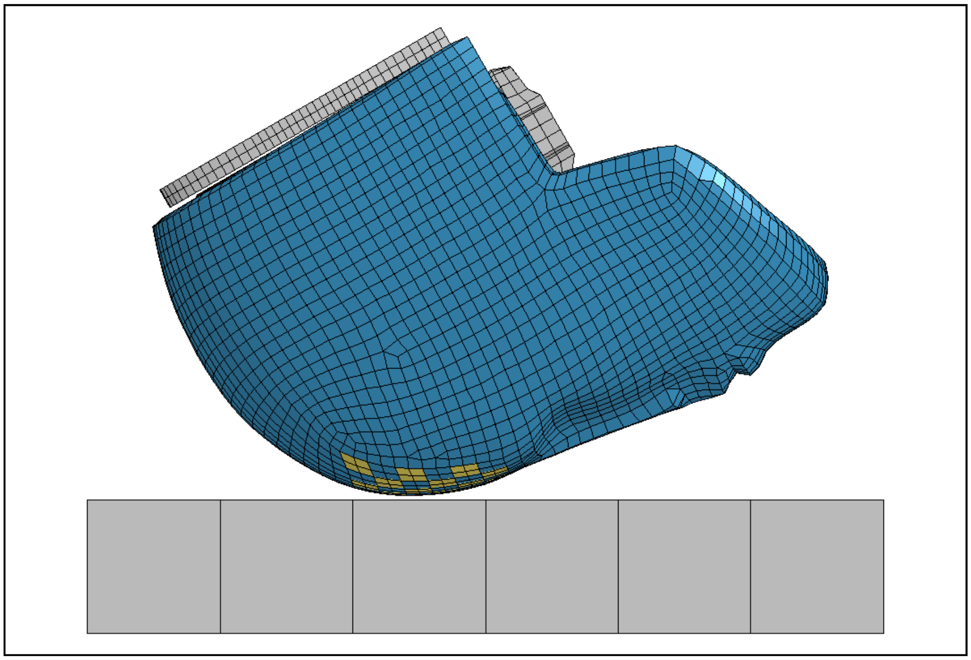

Figure 1 – Calibration Test Setup

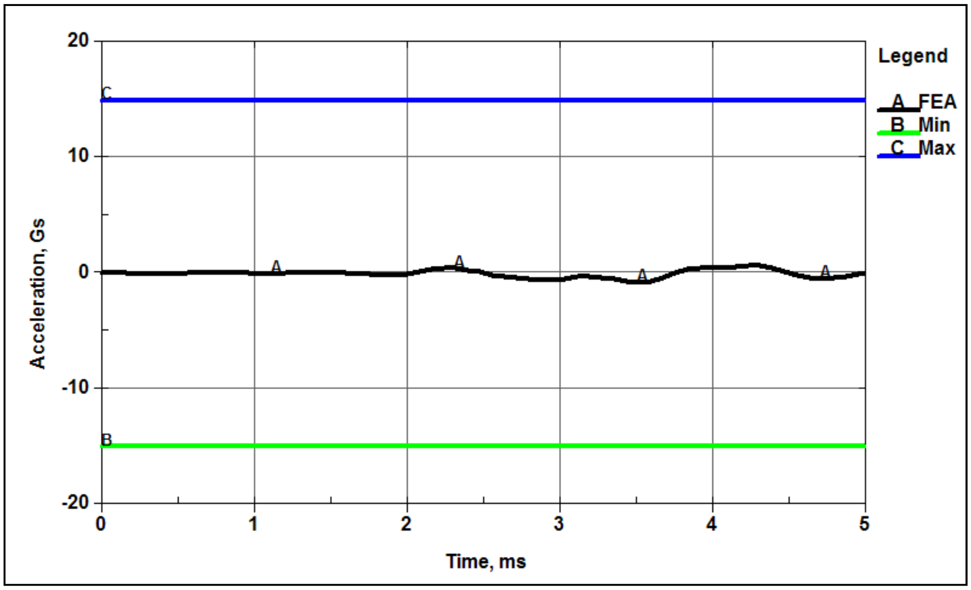

Figure 2 – 2.72m/s Calibration Test, Lateral Acceleration

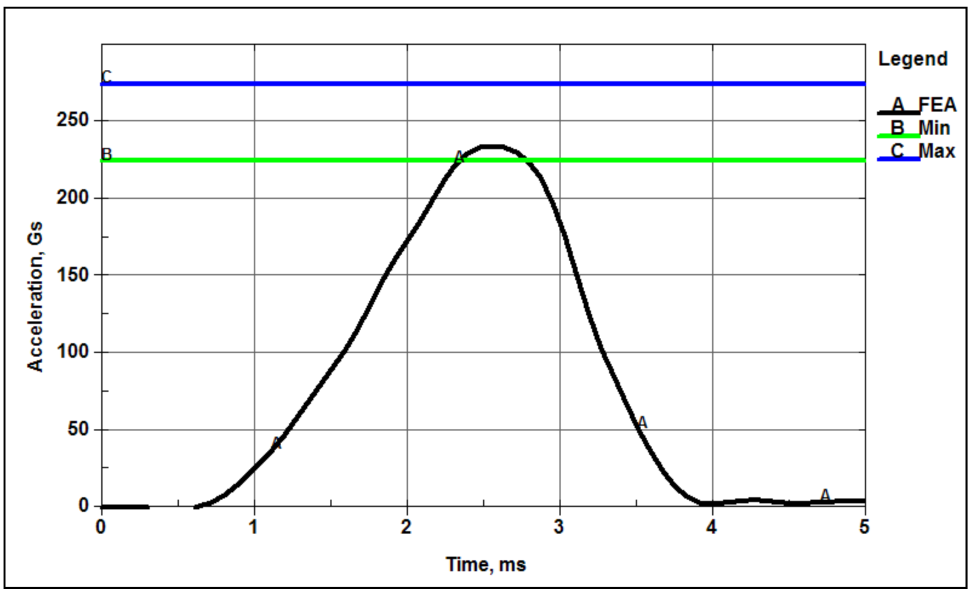

Figure 3 – 2.72m/s Calibration Test, Resultant Acceleration

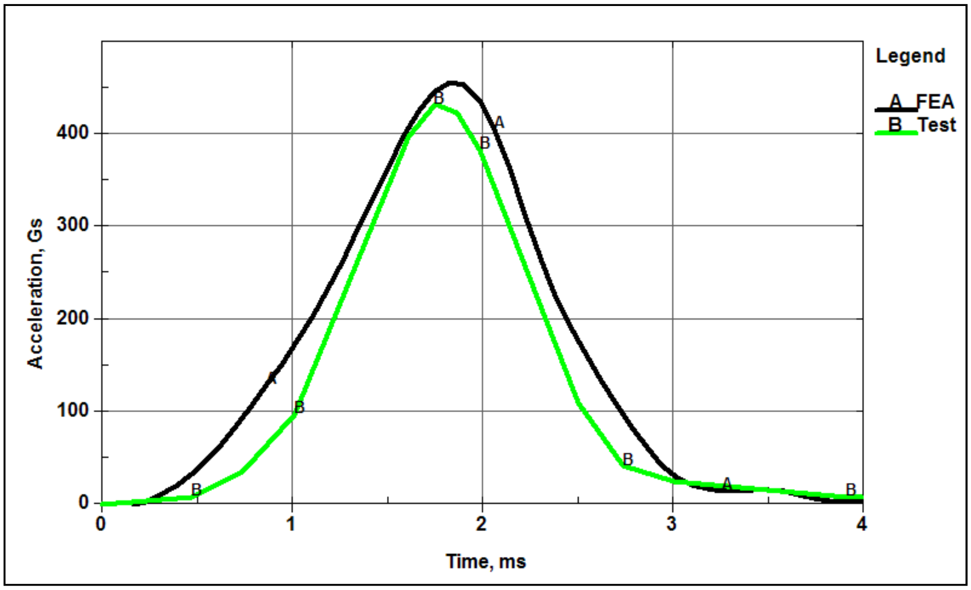

Figure 4 – 4.00m/s Calibration Test, Resultant Acceleration

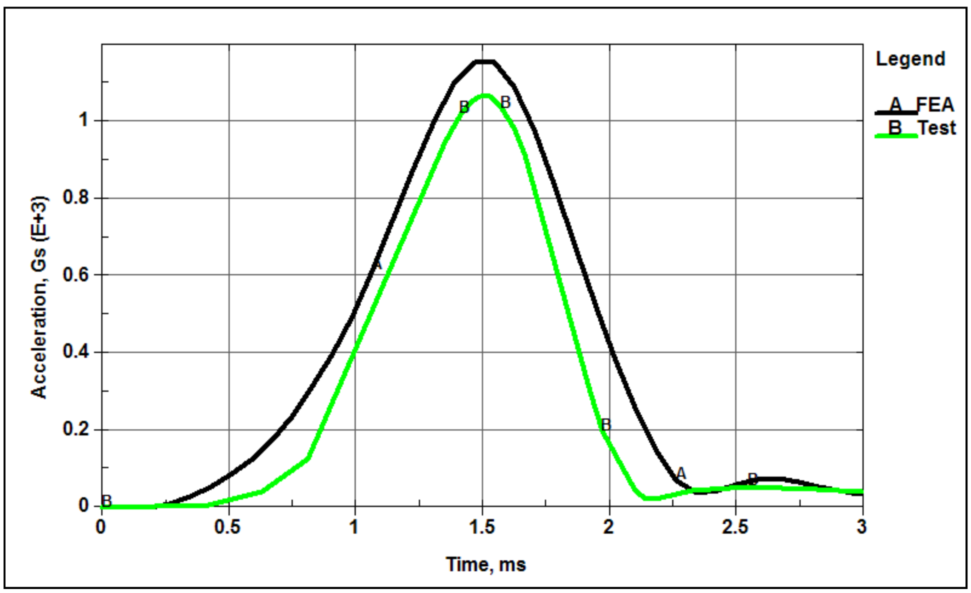

Figure 5 – 6.71m/s Calibration Test, Resultant Acceleration

CG LOCATION / INSTRUMENTATION

The CG of the headform is located at NID 1 as shown in Figure 6. An accelerometer sits at this node with its local x-axis pointing forward, and this node that should be monitored when processing acceleration data from the *nodout* file.

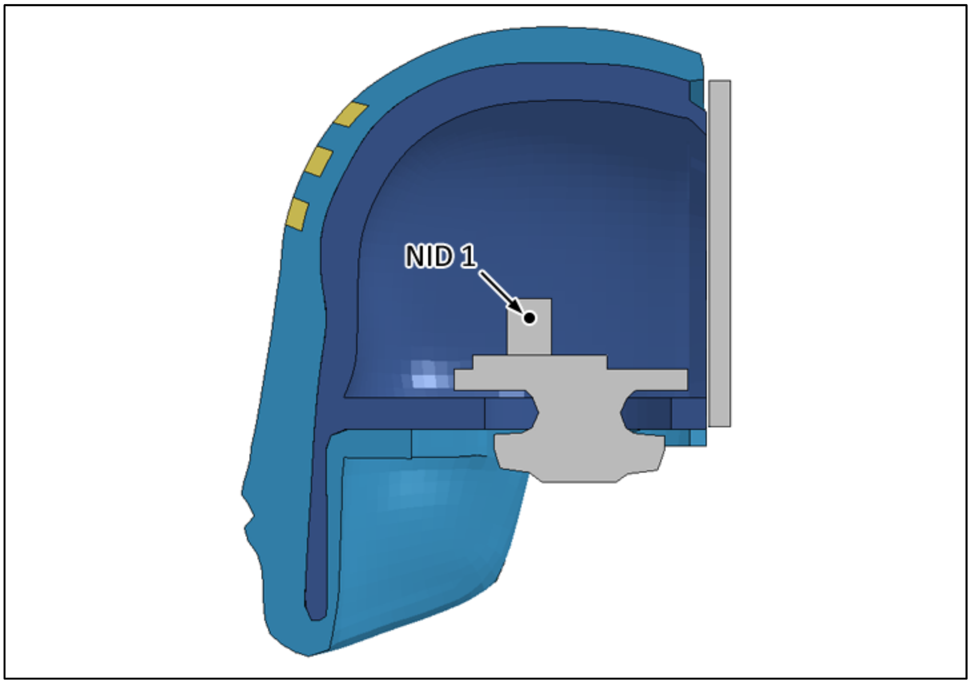

Figure 6 – CG / Accelerometer Location

FOREHEAD IMPACT ZONE

The grid pattern, shown in figure 7, was developed to comply with widely accepted (by Ford, NHTSA, and others) standards for lab testing and CAE process automation. All points on the grid fall within the forehead impact zone defined by NHTSA Laboratory Test Procedure for FMVSS 201U.

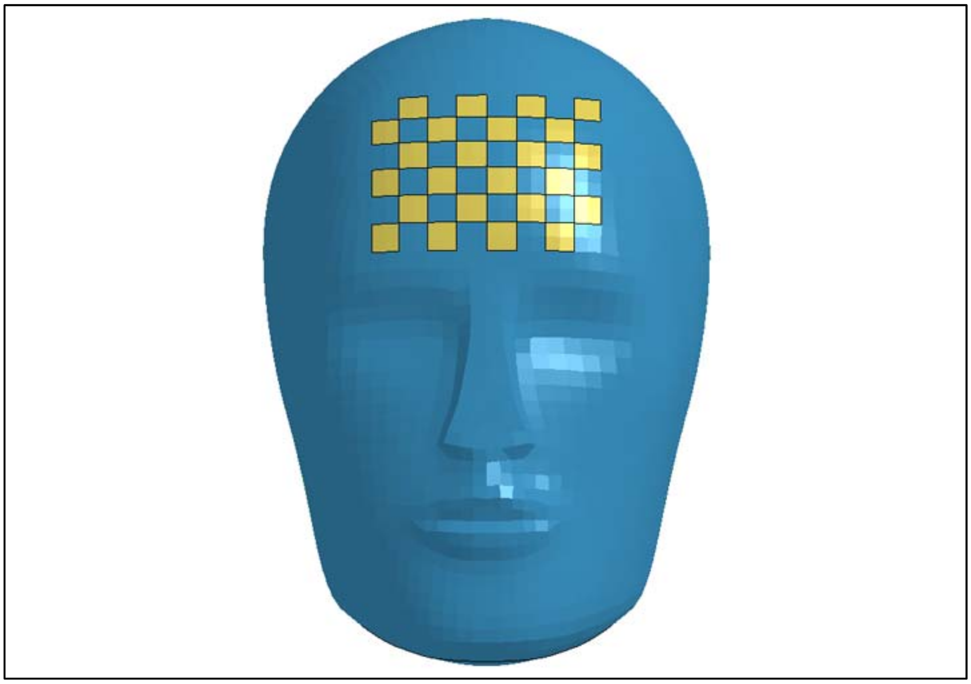

Figure 7 – Forehead Impact Zone

ADDITIONAL NOTES

A local coordinate system (CID 1) is provided in the input file for applying initial velocity to the headform.

*CONTACT_AUTOMATIC_SURFACE_TO_SURFACE is recommended for contact with the headform.   This keyword is provided following *END in the input file (master side must be defined by the user).

REFERENCES

[1] Federal Motor Vehicle Safety Standard 201: Occupant Protection in Interior Impact, Federal Register, Vol. 62, No. 67, April 8, 1997.

[2] Chou C.C., Zhao Y., Huang Y., Lim G.G., (1996), "Development and Validation of a Deformable Featureless Headform Model Using LS-DYNA3D", ESV Paper 96-S8-O-08, 1996.

[3] Chou C.C., Barbat S.D., Liu N., Li G.F., Wu F., Zhao Y., (1997), "Additional Notes on Finite Element Models of Deformable Featureless Headform", SAE Paper 970164, 1997.

APPENDIX A – Mass Properties

The mass properties of the headform shown below were taken from the *d3hsp* file:

```
total mass of body          = 0.45393376E+01
x-coordinate of mass center = 0.27855332E-02
y-coordinate of mass center =-0.47575890E-04
z-coordinate of mass center =-0.49468488E-02

inertia tensor of body
row1=     0.1684E+05     0.9095E-03    -0.2964E+04
row2=     0.9095E-03     0.2079E+05    -0.1806E-03
row3=    -0.2964E+04    -0.1806E-03     0.1627E+05
```

APPENDIX B – Unit Transformation

Two input files are provided to help transform the headform into alternate unit systems. Running either with produce a new file called *dyna.inc* which is the converted headform model. The working portion of each file is listed below for reference. Please refer to the files themselves for an explanation of how the scale factors (*fctmas*, *fcttim*, and *fctlen*) were derived.

Run *Transform_mm-ms-kg_To_mm-s-tonne.k* to convert the dummy to mm-s-tonne-N:

```
*KEYWORD
*INCLUDE_TRANSFORM
$# filename
LSTC.FMH.091201_V2.0.k
$#  idnoff    ideoff    idpoff    idmoff    idsoff    idfoff    iddoff
         0         0         0         0         0         0         0
$#  idroff
         0
$#  fctmas    fcttim    fctlen    fcttem   incout1
     0.001     0.001     1.000     1.000         1
$#  tranid
         0
*END
```

Run *Transform_mm-ms-kg_To_English_Units.k* to convert the dummy to English units:

```
*KEYWORD
*INCLUDE_TRANSFORM
$# filename
LSTC.FMH.091201_V2.0.k
$#  idnoff    ideoff    idpoff    idmoff    idsoff    idfoff    iddoff
         0         0         0         0         0         0         0
$#  idroff
         0
$#  fctmas    fcttim    fctlen    fcttem   incout1
  0.005708     0.001   0.03937     1.000         1
$#  tranid
         0
*END
```