

LSTC Free Motion Headform User's Guide

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INTRODUCTION

This is LSTC's initial release of an LS-DYNA finite element model of a Free Motion Headform (FMH). Its intended use is for upper interior head impact simulations conducted according to FMVSS 201U [1] specifications.

The headform was meshed using TrueGrid® based on NHTSA design drawings and outer surface scan data. Efforts were made to keep the finite element model geometry as faithful as possible to the physical headform, but a number of point masses were needed to properly position the center of gravity (CG) and bring the total mass and inertia within the tolerances specified in the NHTSA drawings (see Table 1 and Appendix A for detailed mass properties).

The headform flesh in this initial release is modeled using *MAT_VISCOELASTIC, the material constants for which are based on data provided by Chrysler, LLC. We plan to update the flesh to *MAT_OGDEN_RUBBER upon completion of material testing. All other components were modeled using *MAT_RIGID with the exception of the *MAT_NULL layer that is used for contact.

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, which was set up according to FMVSS 201U specifications, the headform was rotated so that the skull cap plate was at an angle of 28.5 degrees with 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 resultant and lateral 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 4.02m/s and 6.71m/s were used. The 4.02m/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).

	Test / Spec	FEA
Peak Resultant Accel, Gs (2.72m/s)	225 to 275	266
Peak Lateral Accel, Gs (2.72/ms)	-15 to 15	-5.71
Peak Resultant Accel, Gs (4.02m/s)	437	449
Peak Resultant Accel, Gs (6.71m/s)	1067	1031
Total Mass, kg	4.54 ± 0.05	4.58
Moment of Inertia, mm·kN·ms ² (I _{yy})	23,388 ± 11,239	23,920

Table 1 – Calibration Results Summary

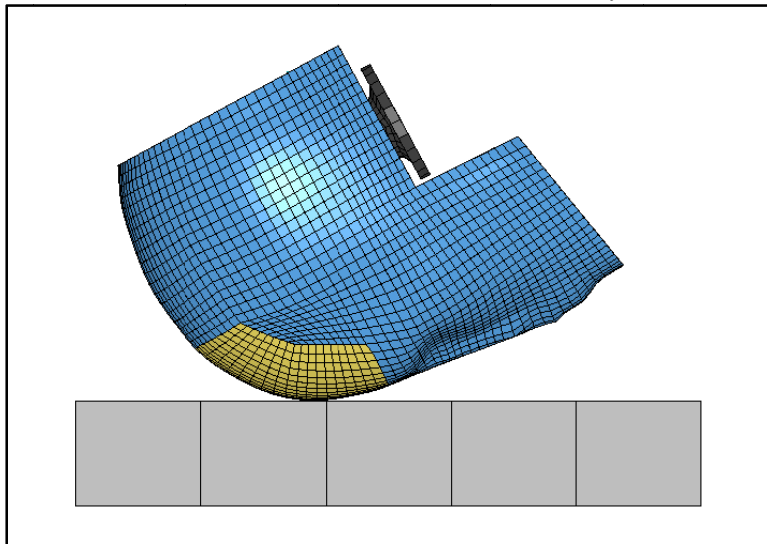


Figure 1 – Calibration Test Setup

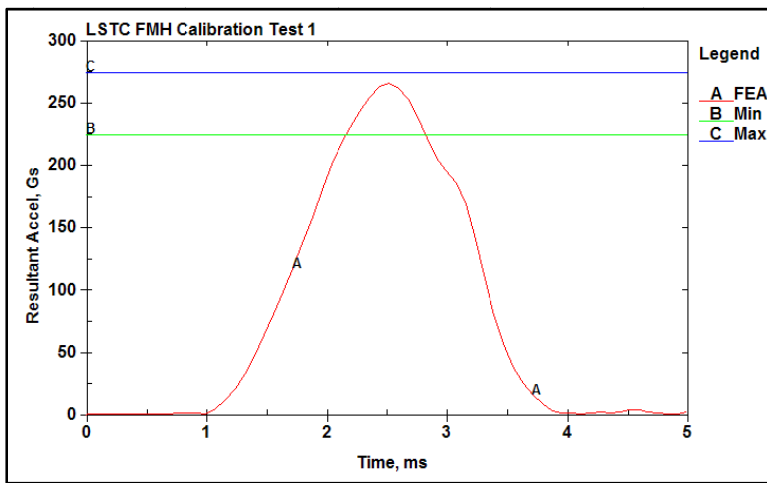


Figure 2 – 2.72m/s Calibration Test, Resultant Acceleration

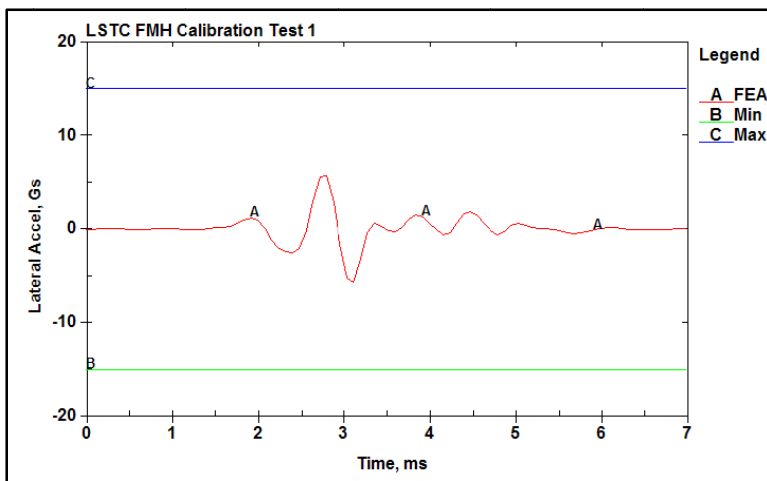


Figure 3 – 2.72m/s Calibration Test, Lateral Acceleration

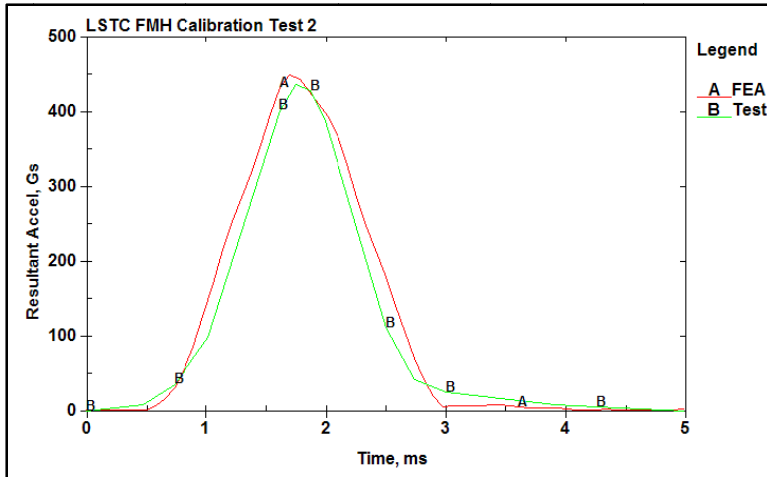


Figure 4 – 4.02m/s Calibration Test, Resultant Acceleration

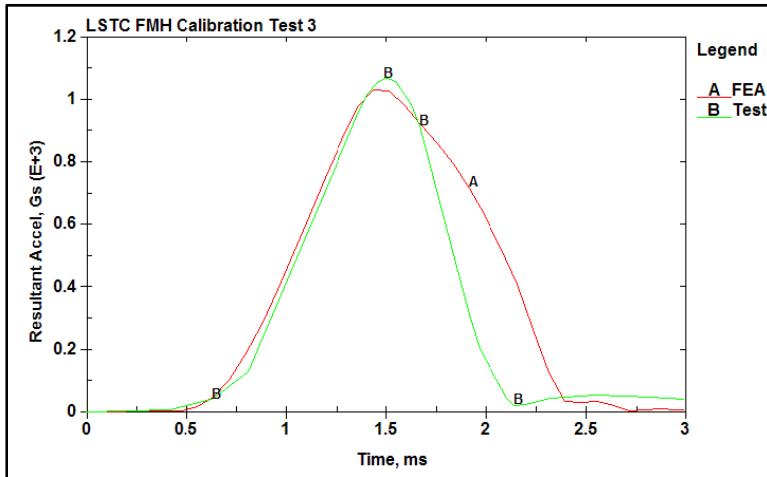


Figure 5 – 6.71m/s Calibration Test, Resultant Acceleration

CG LOCATION

The CG of the headform is located 63.5mm forward of the skull cap plate outer surface and 35.56mm above the outer machined surface of the skull as shown in Figure 6.

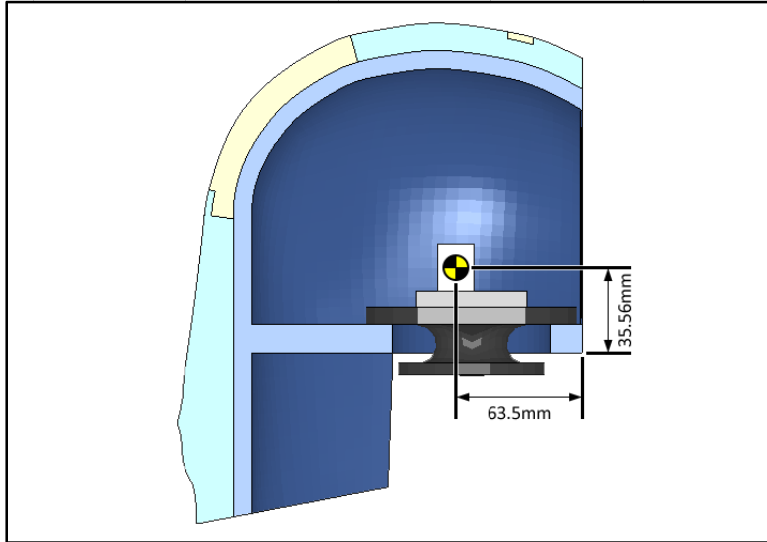


Figure 6 – CG Location

INSTRUMENTATION

An accelerometer is located at the CG of the headform and is oriented as shown in Figure 7. The node corresponding to this location is NID 1, and it is this node that should be monitored when processing acceleration data in the *nodout* file.

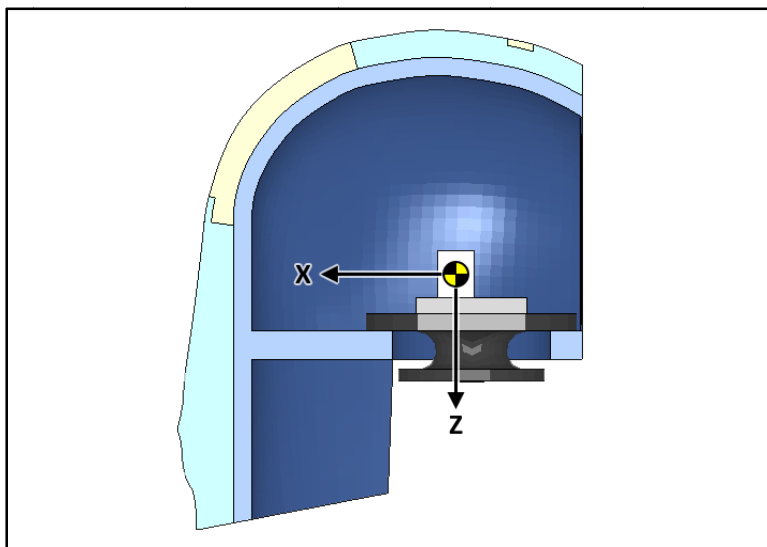


Figure 7 – Accelerometer Location and Orientation

FOREHEAD ZONE

The forehead impact zone was modeled according to the NHTSA Laboratory Test Procedure for FMVSS 201U. It is 125mm wide (along the surface), 100mm tall, and starts 69mm forward of the center of the threaded hole on top of the headform as shown in Figure 8. We recommend using NID 2, located midway along the lower edge of the forehead zone, whenever possible when positioning the headform. This will help minimize rotation of the headform during impact thereby producing more conservative HIC values.

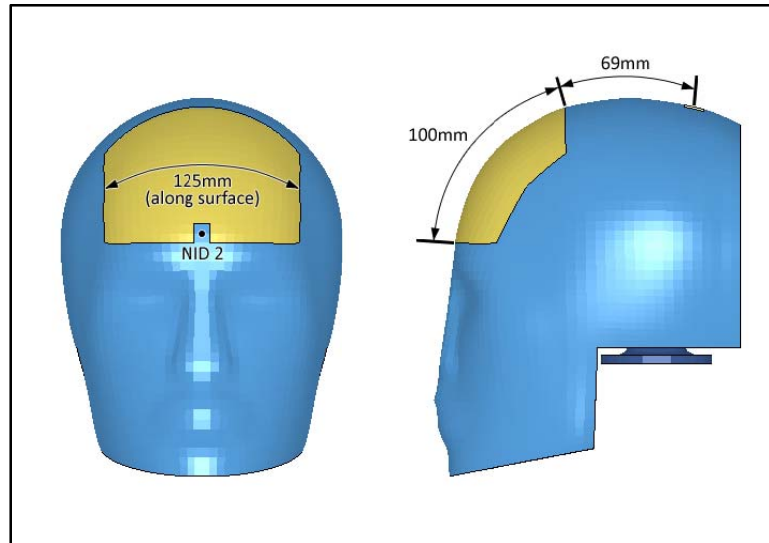


Figure 8 – Forehead Impact Zone

ADDITIONAL NOTES

A node set (S ID1) and local coordinate system (CID1) are 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 = 0.45774817E+01
x-coordinate of mass center = -0.37318563E+00
y-coordinate of mass center = 0.29603636E-01
z-coordinate of mass center = -0.11776492E+00

inertia tensor of body

row1=	0.1676E+05	-0.9371E+00	-0.2078E+04
row2=	-0.9371E+00	0.2392E+05	0.2755E+01
row3=	-0.2078E+04	0.2755E+01	0.2073E+05

APPENDIX B – Unit Transformation

Two input files are provided to help transform the headform into alternate unit systems. Running either will 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.011808_v1.0.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.011808_v1.0.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
```