



VALIDATION OF THE 5TH PERCENTILE HYBRID III ATD FINITE ELEMENT MODEL

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Outline



- **Human System Interface Requirements (HSIR)**
- **Objective**
- **Finite Element and physical Anthropomorphic Test Dummies (ATD)**
- **Wright Patterson Air Force Research Laboratory Horizontal Impact Accelerator (sled)**
- **Test matrix**
- **Test and simulation results for case 8924**
- **Next steps**

Anthropomorphic Test Device Limits



Injury Assessment Reference Values (IARV) Limits

| ATD Metric | ATD Size ¹ | Non-Deconditioned | | Deconditioned | |
|--|------------------------|-------------------|-------------|---------------|-------------|
| | | Nominal | Off-Nominal | Nominal | Off-Nominal |
| HIC 15 | 5 th Female | 375 | 525 | 375 | 525 |
| | 95 th Male | 325 | 450 | 325 | 450 |
| Head Rotational Acceleration [rad/sec ²] | 5 th Female | 2,500 | 4,200 | 2,500 | 4,200 |
| | 95 th Male | 2,100 | 3,600 | 2,100 | 3,600 |
| N _{ij} | 5 th Female | 0.5 | 0.5 | 0.4 | 0.4 |
| | 95 th Male | 0.5 | 0.5 | 0.4 | 0.4 |
| Peak Neck Axial Tension Force [N] ² | 5 th Female | 890 – 1,840 | | 765 – 1,580 | |
| | 95 th Male | 2,000 – 3,390 | | 1,720 – 2,910 | |
| Peak Neck Axial Compression Force [N] ² | 5 th Female | 890 – 2,310 | | 765 – 1,990 | |
| | 95 th Male | 2,000 – 4,360 | | 1,720 – 3,750 | |
| Flail | 5 th Female | Pass | | | |
| | 95 th Male | Pass | | | |
| Peak Lumbar Axial Compression [N] ³ | 5 th Female | 3,500 | 4,200 | 3,000 | 3,600 |
| | 95 th Male | 6,600 | 7,800 | 5,700 | 6,700 |



¹The following ATDs shall be used to evaluate the metrics:

5th percentile female automotive Hybrid III

95th percentile male automotive Hybrid III with straight spine

²Values in table are evaluated at varying time durations as specified in J

³Required only if Occupant Response Amplification ground rule is not met by the design

Objective



- Characterize performance of Livermore Software Technology Corporation (LSTC) COTS 5th percentile female HIII and 95th percentile male HIII Finite Element ATD models
- Determine Model Uncertainty Factor (MUF) for available COTS FE models using test data from physical ATD testing.
 - What is utility of COTS FE ATD models for program status, design iteration, and selection of conditions for physical ATD compliance testing?
- Develop best modeling practices.



Livermore Software Technology Corporation

PRODUCTS

SUPPORT

APPLICATIONS

SALES

TRAINING

Hybrid III 5th Percentile Female

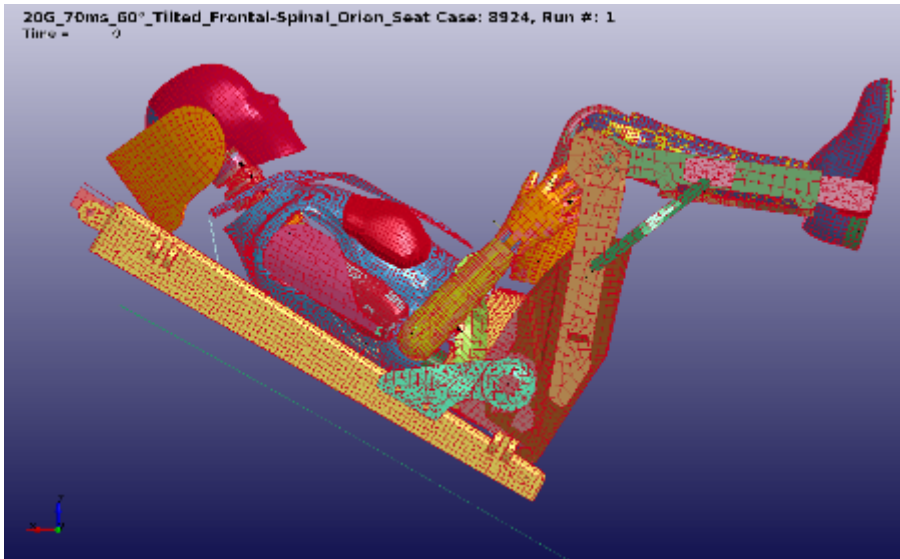
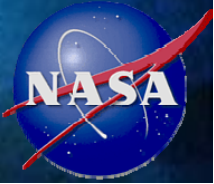
The model of the Hybrid III 5th Percentile Female dummy is a joint development with the [National Crash Analysis Center](#) (NCAC) at The George Washington University. The current release is an ALPHA version. Some documentation is provided at the beginning of the keyword file. Separate and detailed documentation will be included in a later release.

All current models can be obtained through our webpage in the [LSTC Models download section](#) or through your [LS-DYNA distributor](#).

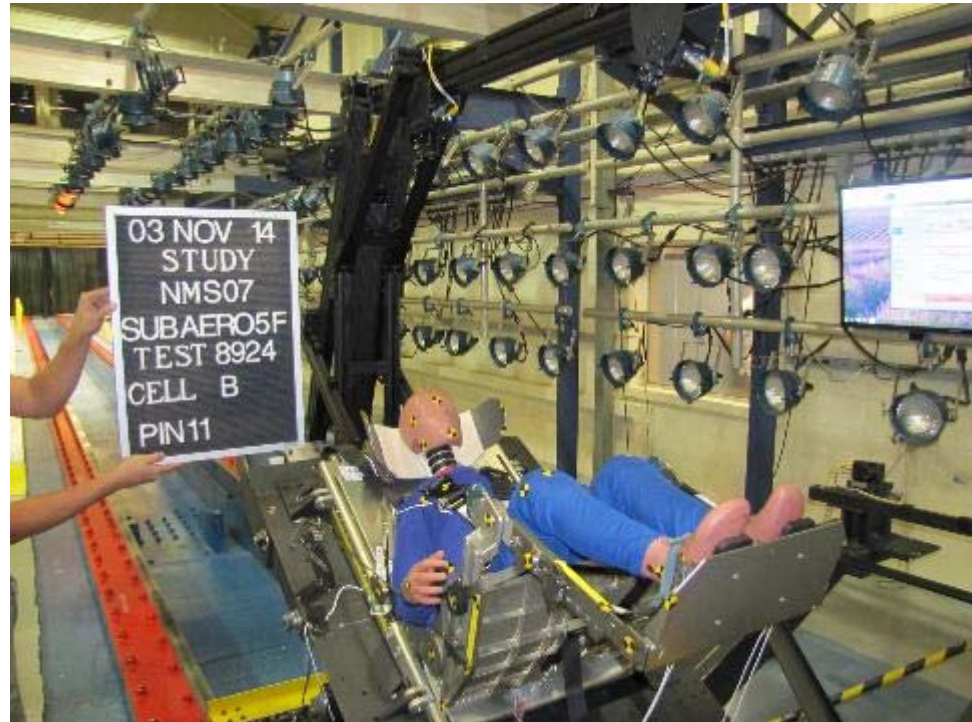
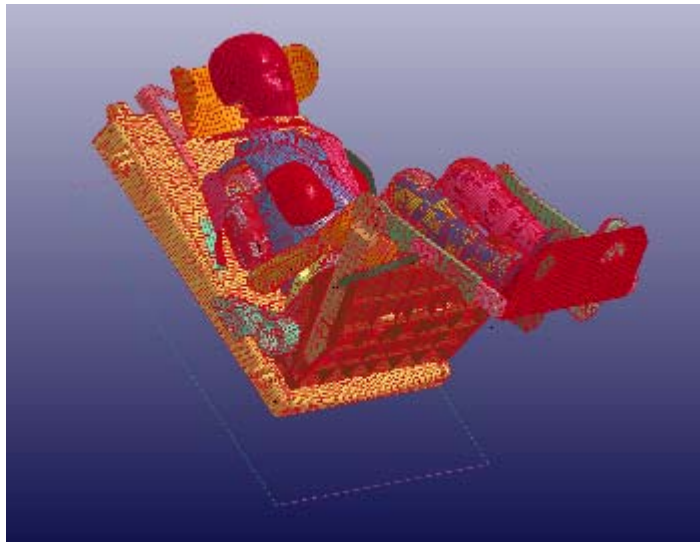
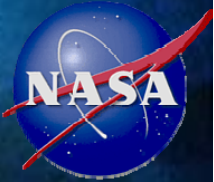
To submit questions, suggestions, or feedback about LSTC's models, please send an e-mail to: atds@lstc.com. Also, please contact us if you would like to help improve these models by sharing test data.



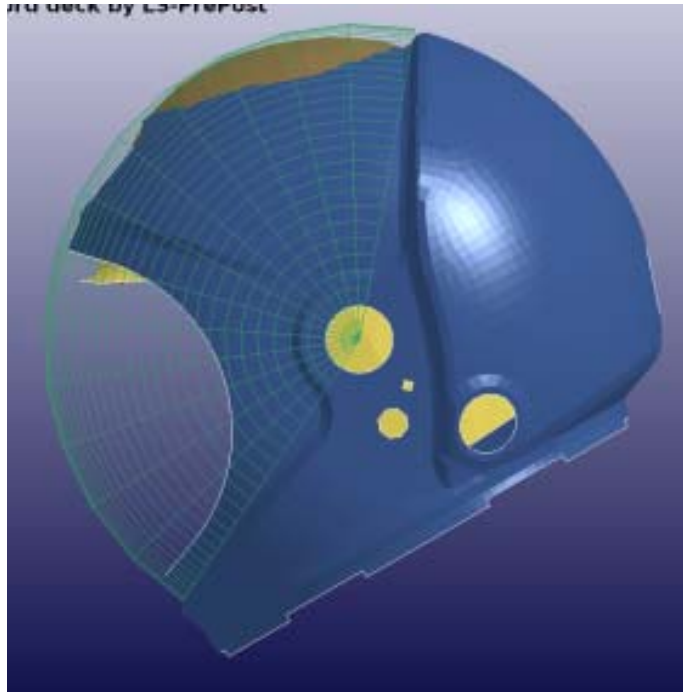
LSTC FE model and aerospace 5th percentile female H3



LSTC FE model and aerospace 5th percentile female H3



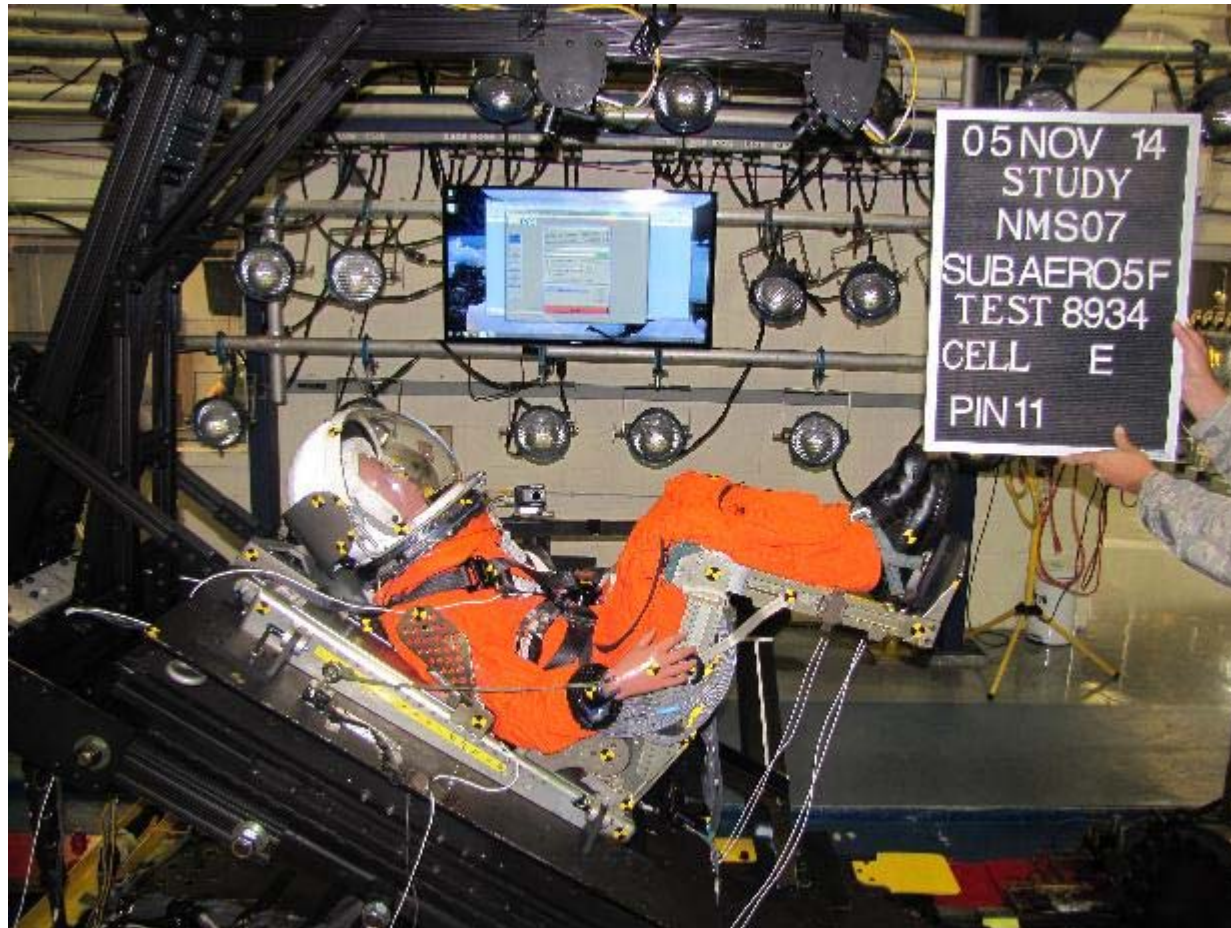
ACES Helmet



ACES helmet finite element model



Suited aerospace 5th percentile female H3



Sample Test Conditions



Unsuited NASA automotive ATD



Spinal impact



Rear/lateral impact

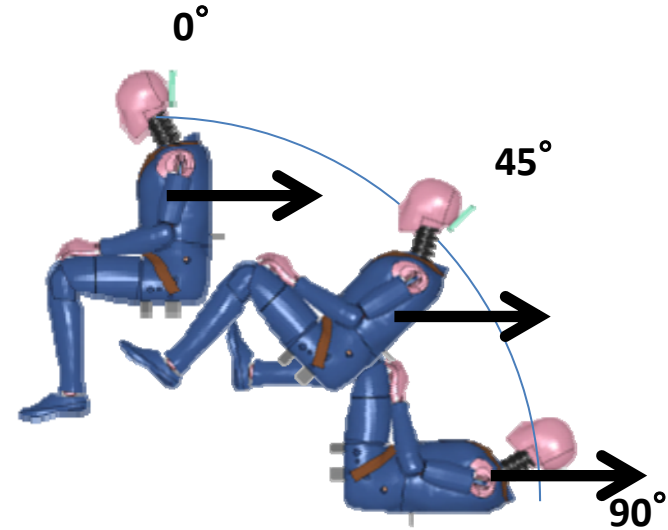


Rear impact (launch abort)

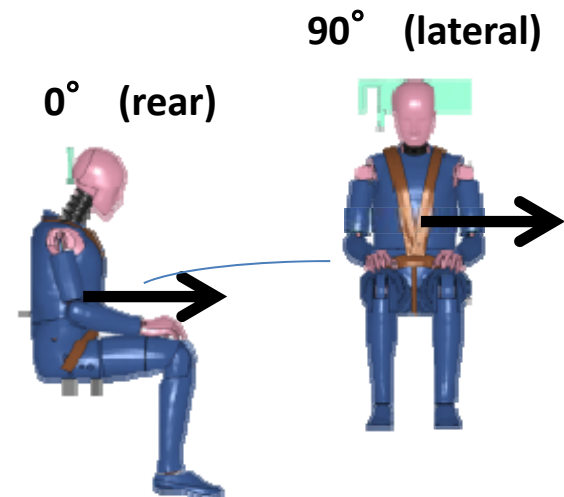
Impact Orientations



- X/Z
 - Tilt Angles
 - 0, 22.5, 45, 67.5, 90°
 - G Levels
 - 10, 15, 20, 25 G
 - Rise Times
 - 30, 60, 90, 120, 150 ms
 - 100 possible cases



- X/Y
 - Rotation Angles
 - 0, 15, 30, 45°
 - G Levels
 - 5, 10, 15 G
 - Rise Times
 - 30, 60, 90, 120, 150 ms
 - 60 possible cases



Test Matrix

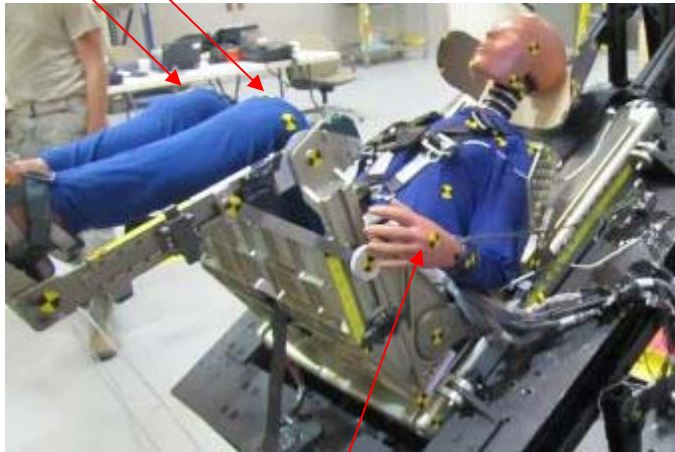


| | | Cell | Run Number | Impact Vector | Impact Direction | Orientation | Impact Level G | Rise Time (ms) | Metering Pin | Manikin Type | Manikin Provider | Seat Configuration | Helmet | Suit | Harness |
|----|------------|------|------------|---------------|------------------|-------------|------------------|----------------|--------------|---------------|------------------|--------------------|--------|------|---------|
| 1 | | | | | | | | | | | | | | | |
| 2 | 11/3/2014 | B | 8924 | -X/+Z | Front/Spinal | 60° | 20 | 70 | 11 | 5% HBIII Aero | AFRL | Orion | None | None | Orion |
| 3 | 11/3/2014 | B | 8925 | -X/+Z | Front/Spinal | 60° | 20 | 70 | 11 | 5% HBIII Aero | AFRL | Orion | None | None | Orion |
| 4 | 11/4/2014 | B | 8926 | -X/+Z | Front/Spinal | 60° | 20 | 70 | 11 | 5% HBIII Aero | AFRL | Orion | None | None | Orion |
| 5 | 11/4/2014 | A | 8927 | -X/+Z | Front/Spinal | 60° | 20 15 | 70 | 11 | 5% HBIII Aero | AFRL | Orion | None | None | Orion |
| 6 | 11/4/2014 | A | 8928 | -X/+Z | Front/Spinal | 60° | 20 15 | 70 | 11 | 5% HBIII Aero | AFRL | Orion | None | None | Orion |
| 7 | | | | | | | | | | | | | | | |
| 8 | 11/4/2014 | C | 8929 | -X/+Z | Front/Spinal | 60° | 15 | 70 | 11 | 5% HBIII Aero | AFRL | Orion | ACES | ACES | Orion |
| 9 | 11/4/2014 | C | 8930 | -X/+Z | Front/Spinal | 60° | 15 | 70 | 11 | 5% HBIII Aero | AFRL | Orion | ACES | ACES | Orion |
| 10 | 11/4/2014 | C | 8931 | -X/+Z | Front/Spinal | 60° | 15 | 70 | 11 | 5% HBIII Aero | AFRL | Orion | ACES | ACES | Orion |
| 11 | | | | | | | | | | | | | | | |
| 12 | 11/5/2014 | D | 8932 | -X/+Z | Front/Spinal | 60° | 20 15 | 70 | 11 | 5% HBIII Aero | AFRL | Orion | ACES | ACES | Orion |
| 13 | 11/5/2014 | D | 8933 | -X/+Z | Front/Spinal | 60° | 20 15 | 70 | 11 | 5% HBIII Aero | AFRL | Orion | ACES | ACES | Orion |
| 14 | | | | | | | | | | | | | | | |
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| 47 | | | | | | | | | | | | | | | |
| 48 | 11/14/2014 | M | 8955 | -X/+Z | Front/Spinal | 60° | 20 | 110 | 19 | 5% HBIII Aero | AFRL | Orion | None | None | Orion |
| 49 | 11/14/2014 | M | 8956 | -X/+Z | Front/Spinal | 60° | 20 | 110 | 19 | 5% HBIII Aero | AFRL | Orion | None | None | Orion |
| 50 | | | | | | | | | | | | | | | |
| 51 | 11/18/2014 | N | 8959 | +X | Abort | 0° | 15 | 50 | 2 | 5% HBIII Aero | AFRL | Orion | None | None | Orion |
| 52 | 11/18/2014 | N | 8960 | +X | Abort | 0° | 15 | 50 | 2 | 5% HBIII Aero | AFRL | Orion | None | None | Orion |

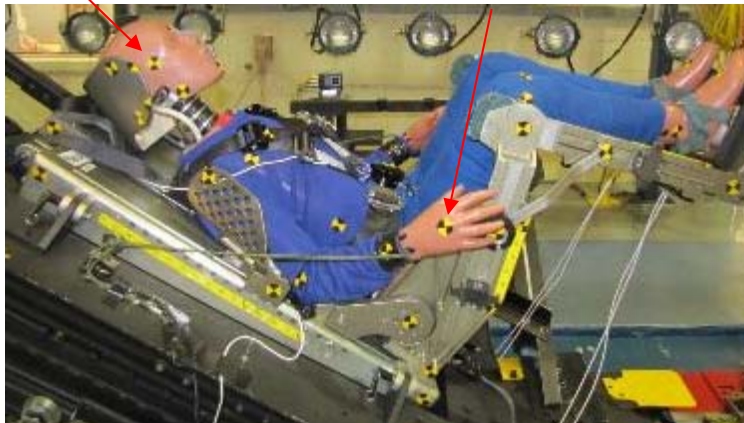
Positioning Targets



H5 H6



H4



H7 H8

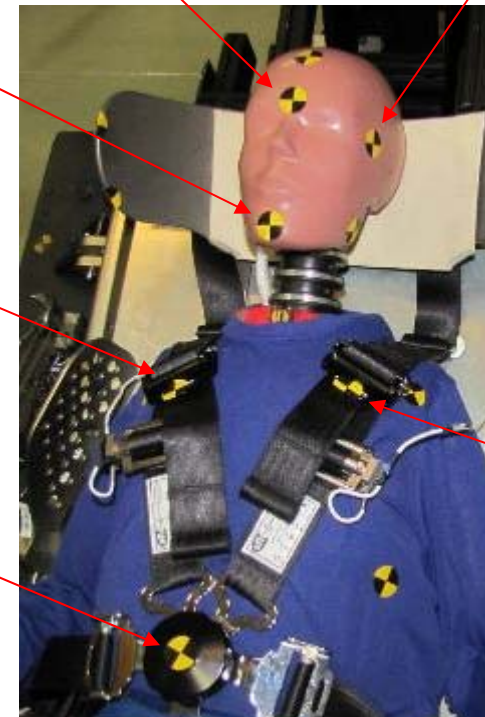
H1

H3

H2

H10

H11



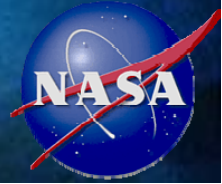
H9



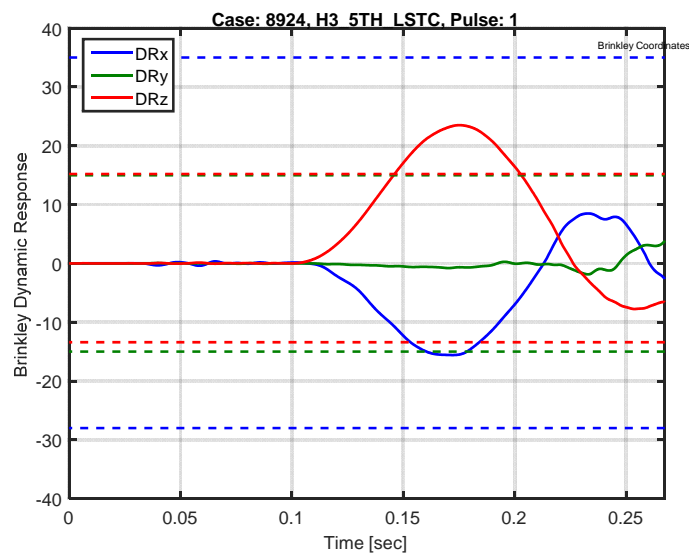
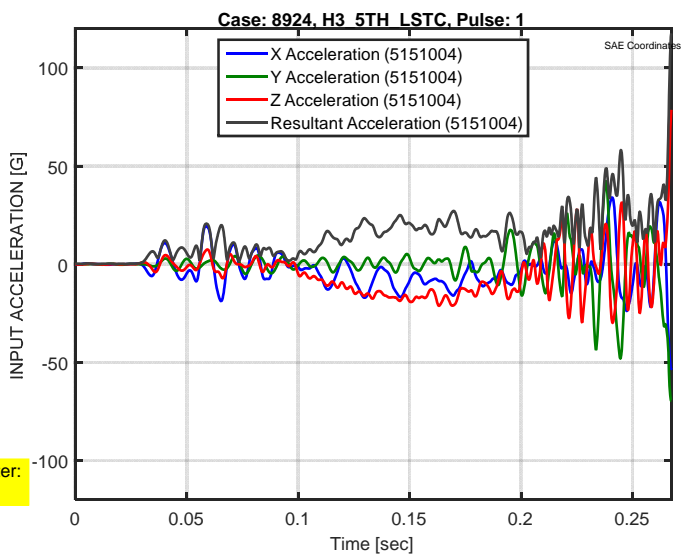
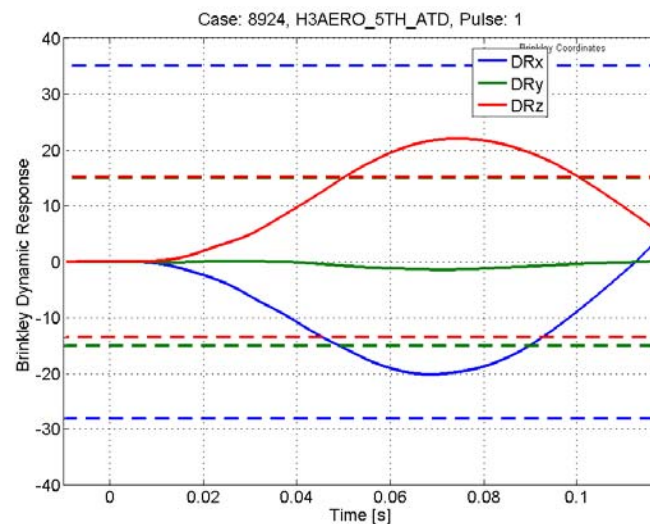
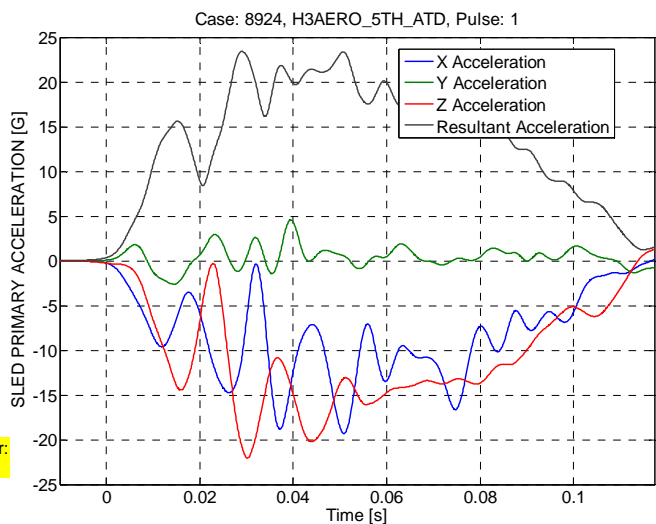
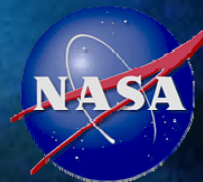
Test: 8924

Hybrid III Aero 5th Percentile Female ATD Test Results

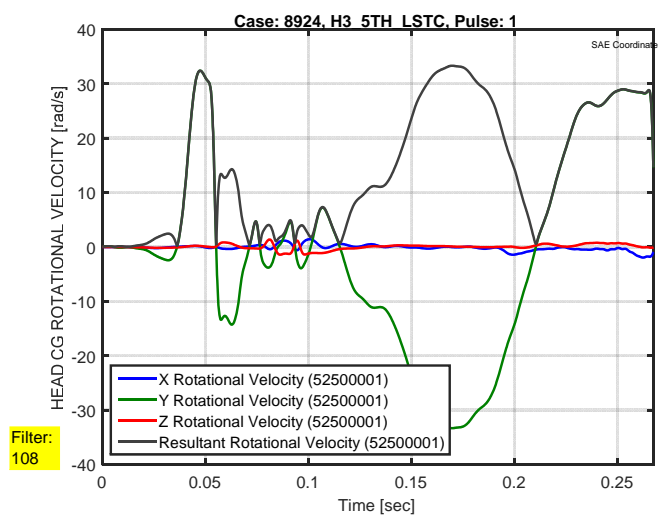
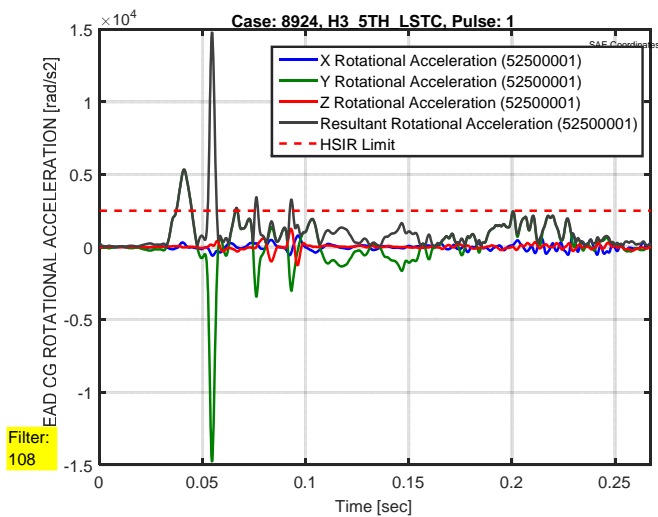
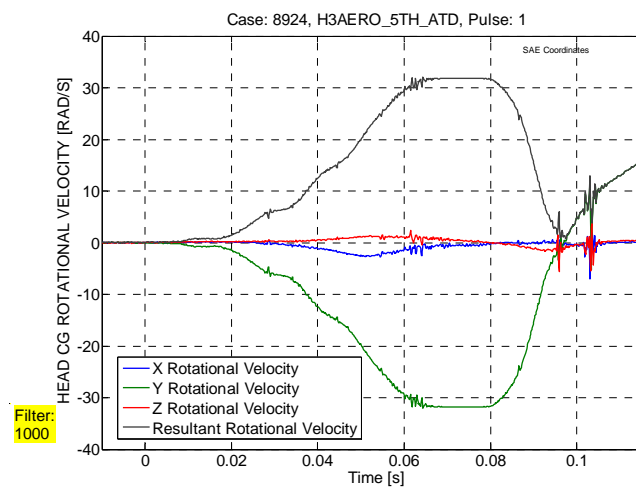
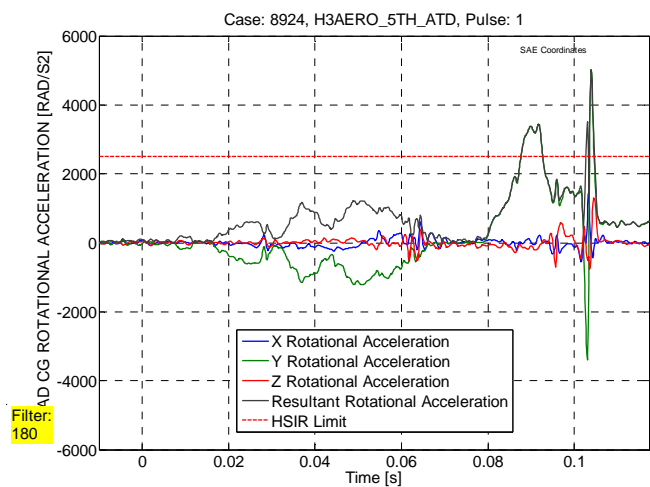
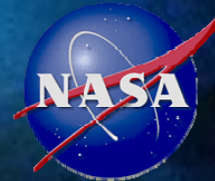
8924 Video



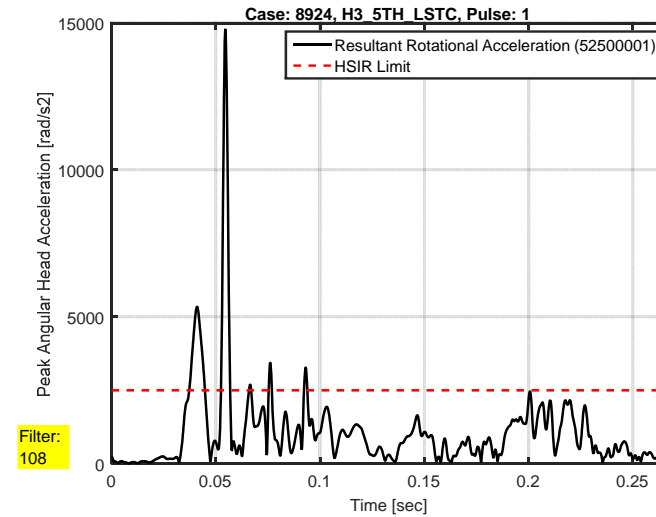
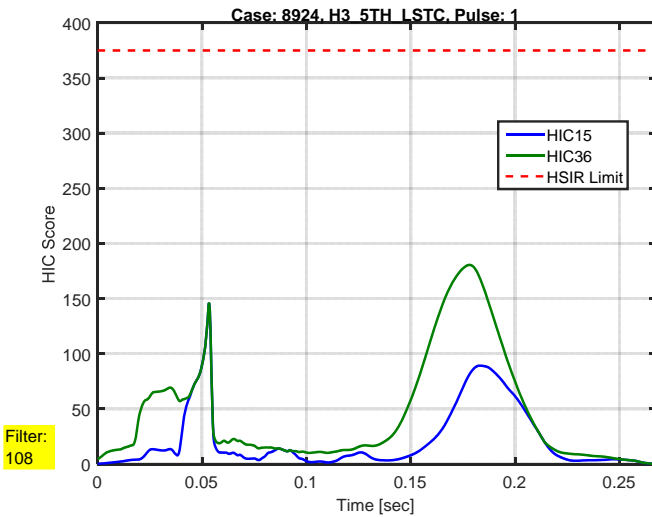
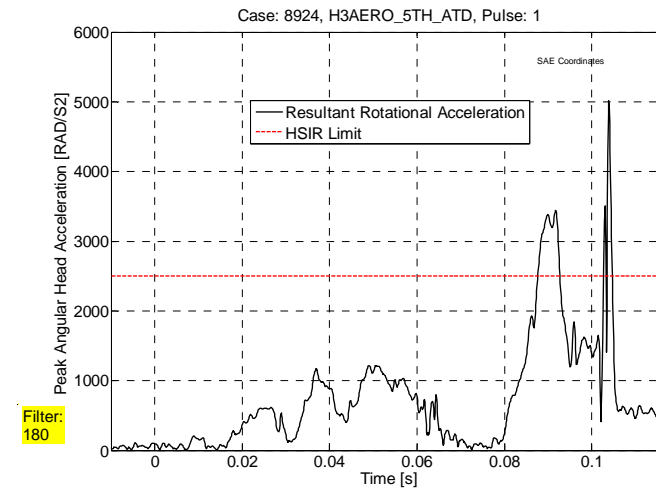
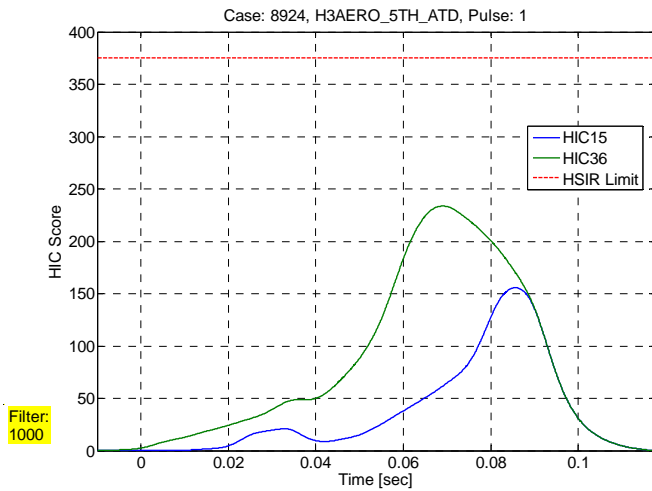
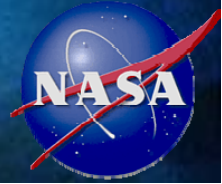
Brinkley Accelerations



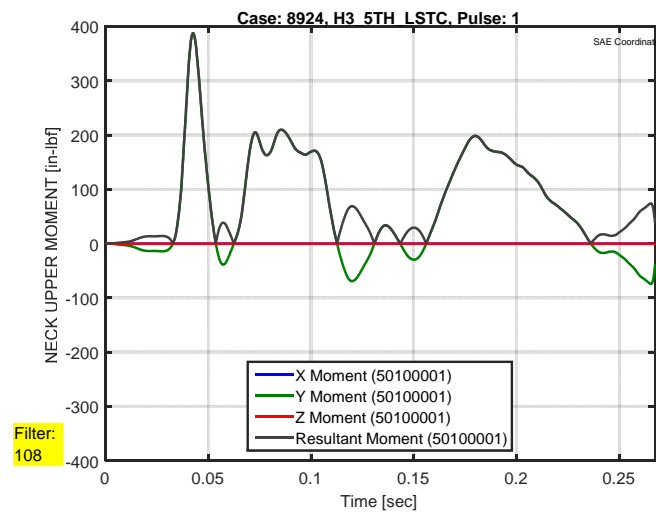
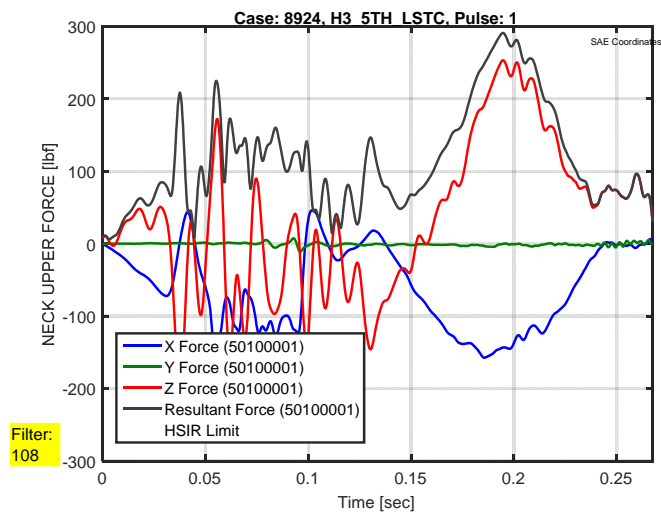
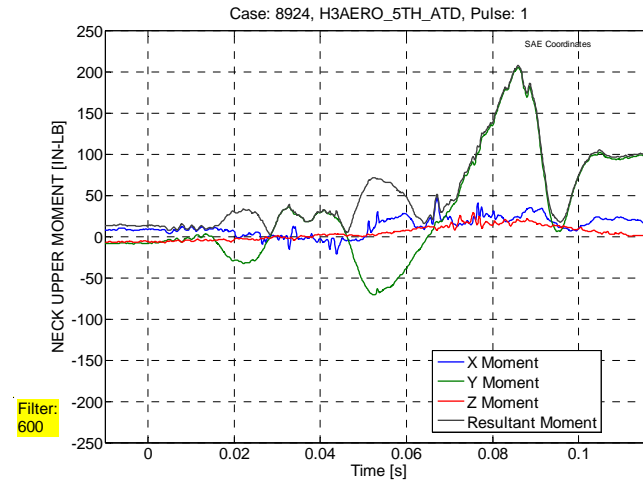
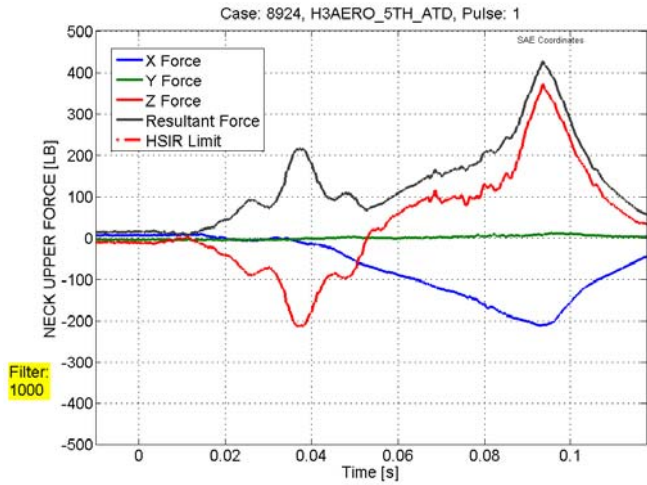
Head Rotational Acceleration and Velocity



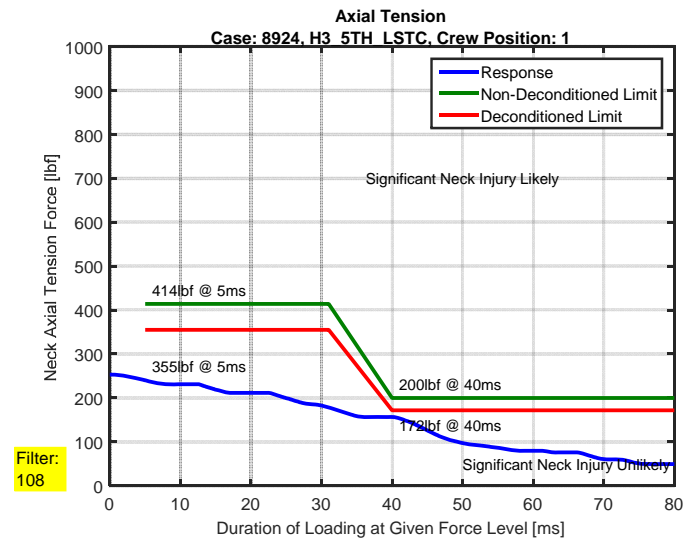
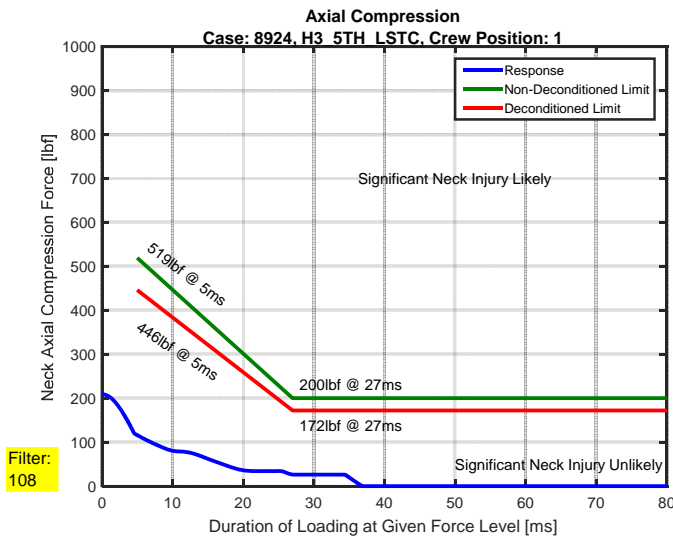
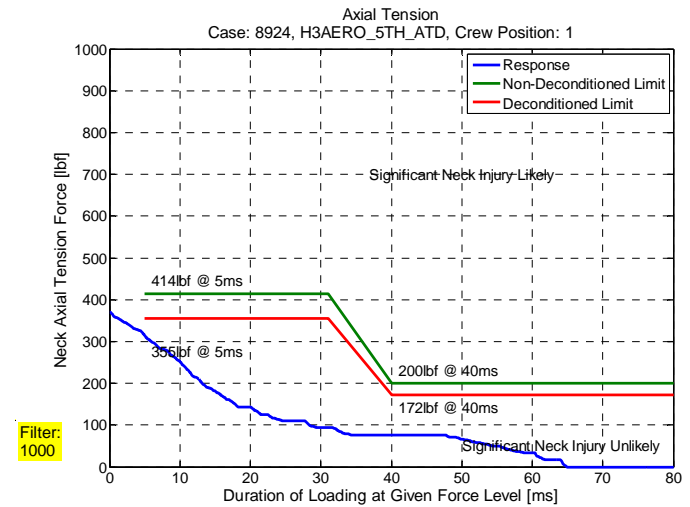
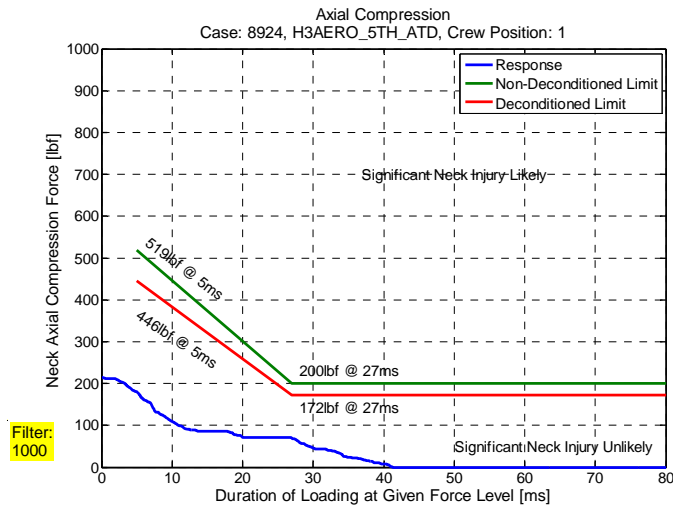
Head Injury Criteria



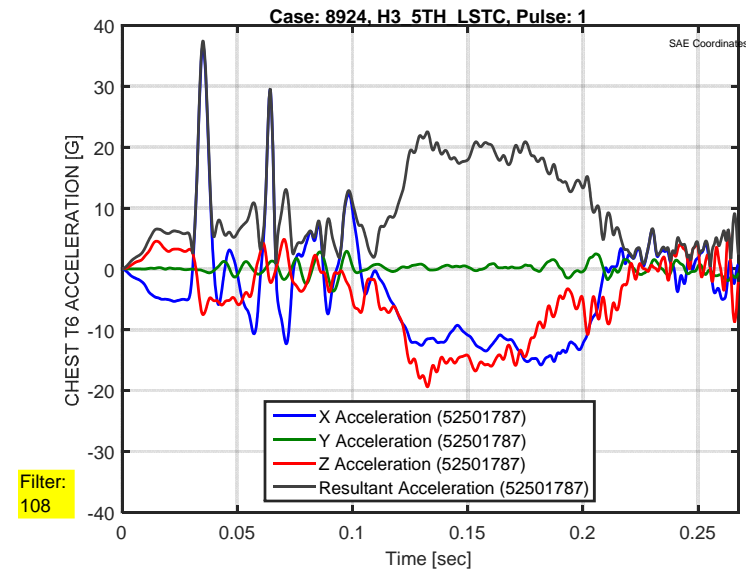
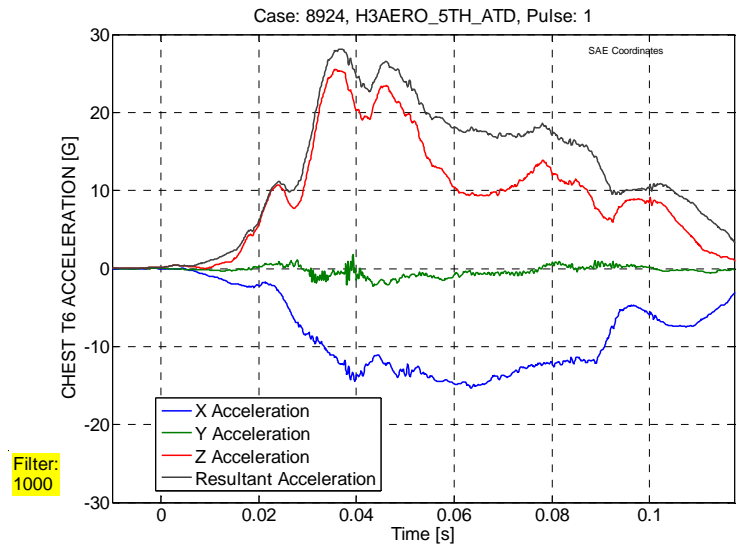
Upper Neck



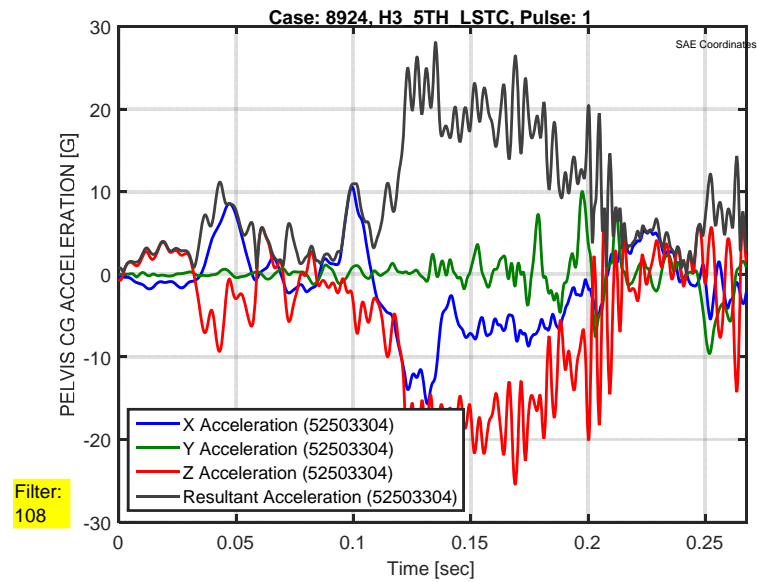
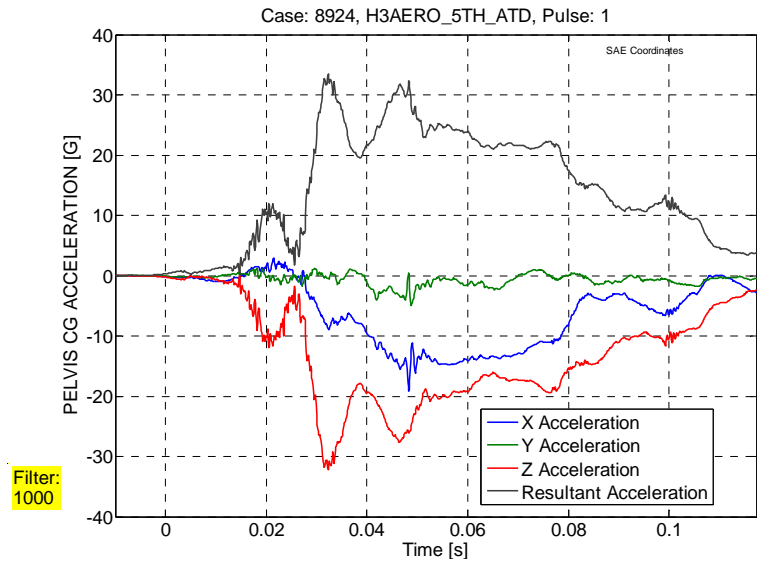
Neck Axial Force Duration



Chest Acceleration



Pelvis Acceleration



Next Steps



- **Generate simulation results for remainder of test cases using**
 - **Measured target locations to help position ATD in seat**
 - **Measured HIA (sled) impact accelerations to drive model**
- **Compare test and analysis for**
 - **Unsuited ATD**
 - **Suited ATD**
- **Resolve differences between WPAFRL aerospace and NASA automotive 5th percentile H3**
- **Determine best modeling practices**
- **Determine modeling uncertainty factor (MUF)**