

Survivability

GVSETS

GROUND VEHICLE SYSTEMS ENGINEERING & TECHNOLOGY SYMPOSIUM
& ADVANCED PLANNING BRIEFING FOR INDUSTRY



NDIA
Michigan

REDUCED ORDER MODELLING METHOD (ROMM) FOR GROUND VEHICLE ROLLOVER PROTECTION M&S

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- Introduction
 - Objectives
 - Overview of HMMWV Model
 - Sub systems
- M&S Methodology
 - HMMWV Structural model
 - Sub systems development
 - Reduced Order Model Methodology (ROMM)
 - Full Systems Model (FSM)
 - Analysis of Alternatives
- Results, Discussion & Conclusions





➤ Objectives

- ✓ To develop HMMWV rollover M&S models
- ✓ Correlate the M&S responses to the IMMI test results
- ✓ Assess performance of new rollover restraint system concepts

➤ Accomplishments

- ✓ Developed robust HMMWV rollover M&S models
- ✓ Simulated rollover tests and correlated M&S responses to the IMMI tests successfully
- ✓ Analyzed the alternate designs and evaluated the responses

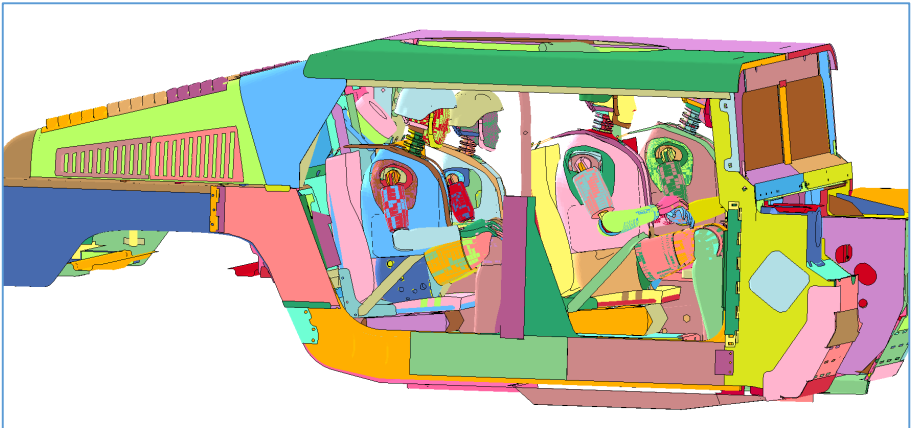




- IMMI conducted two HMMWV tests for rollover assessment. Configuration of the test setup is shown in picture on left.
- GVSC Analytics has developed equivalent HMMWV rollover M&S model shown in picture on right



IMMI – Test setup

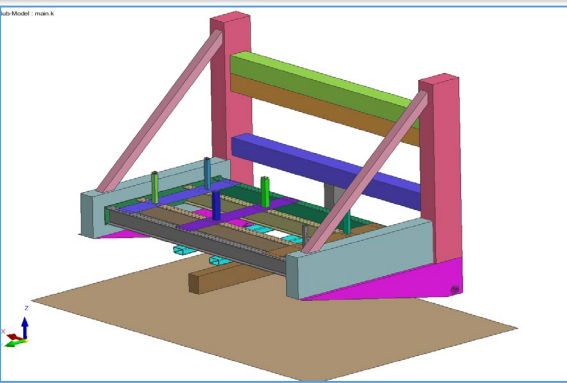


M&S – Model setup

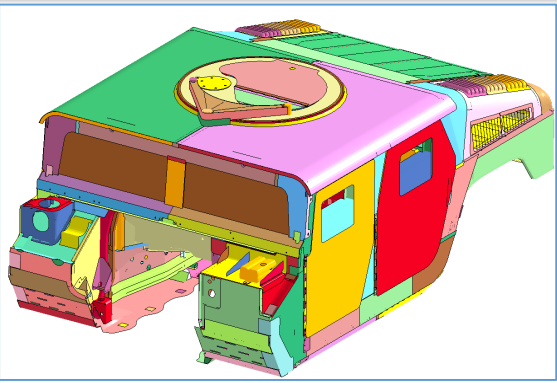


Ground Vehicle Rollover M&S - HMMWV Subsystem Models

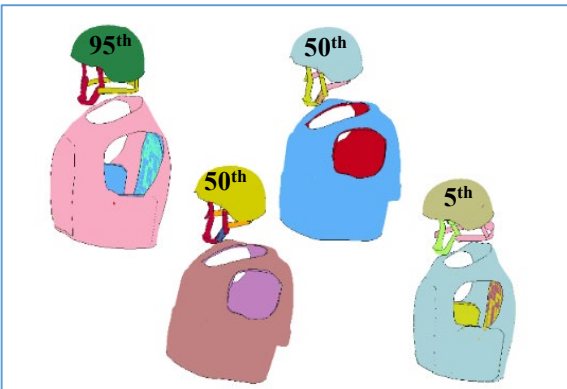
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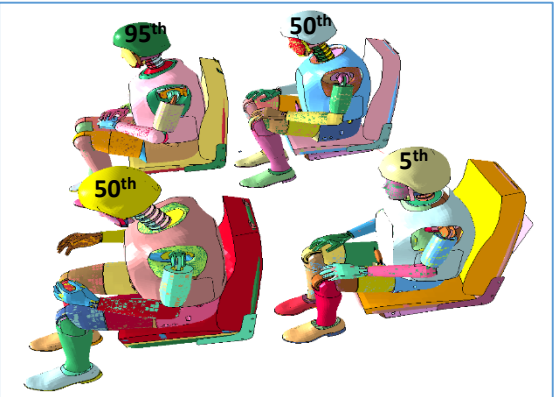
IMMI Cape Fixture



HMMWV Structure



Helmet & Vest models for dummies



Occupants, Seats and Seat Restraints

HMMWV subsystem models used in this rollover simulation



Ground Vehicle Rollover M&S

- Why ROMM Model ?

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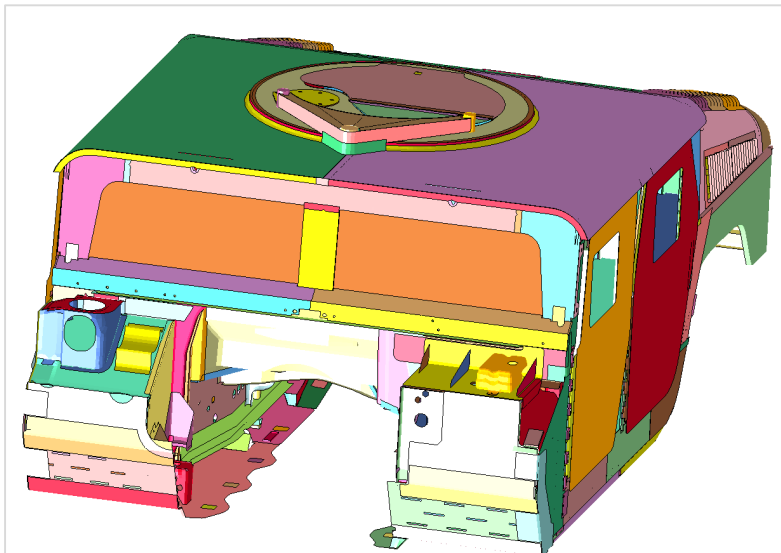


- Rollover simulation started with full system approach with all the subsystems integrated into it.
 - ✓ Initial simulations encountered numerical instabilities such as negative volume, retractor convergence, at 1.5 seconds once the roll stopped
 - ✓ Would take 48 hours before terminating due to error
- To root cause some of the numerical instabilities, reduced order model (ROMM) was developed. Also used to analyze design alternatives quickly
- Based on LS_DYNA Interface Component Analysis
- What is Inter Component Analysis?
 - ✓ Interface component analysis is a unique feature in LS_DYNA that helps to speed design variation studies for non-structural components using a model fragment of the full system model.
 - ✓ Stores the nodal displacement time-history of user selected nodes and segments into a binary file
 - ✓ By using this binary file containing nodal displacement time-history, users can use it in their subsystem models to study design variations.
 - ✓ Simplified model, faster run time and easy to analyze alternate designs.



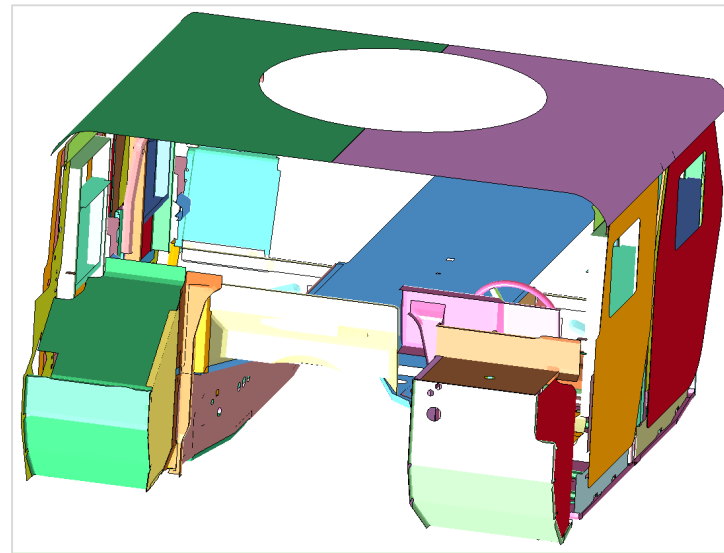


- Full system model (FSM)



- ❑ Structure consists of
 - ✓ 621 Parts
 - ✓ 429,476 elements

- ROMM Model



- ❑ Structure consists of
 - ✓ 121 Parts
 - ✓ 159,476 elements
 - ✓ Only 37% of FSM



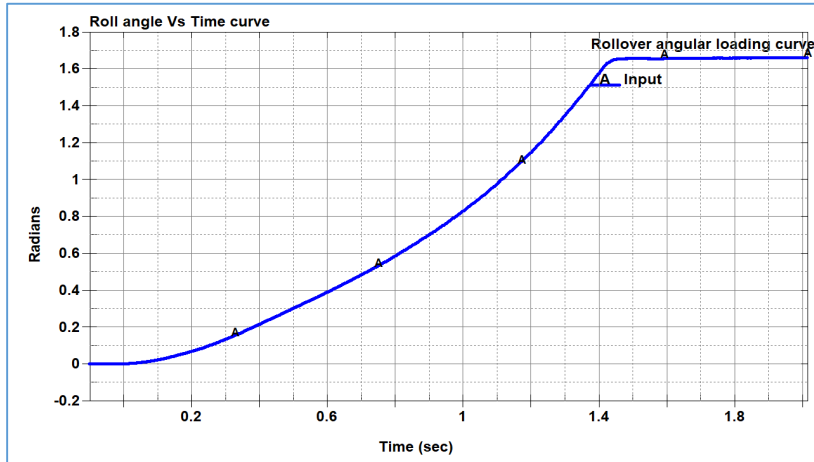
Ground Vehicle Rollover M&S

- HMMWV Rollover Model Statistics

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➤ Input curve for rollover simulation



➤ Full system model statistics

Total no. of parts	2230
Total no. of elements	1,434,312
No. of CPU's	20
Termination time	2 seconds
Completion time	79 hours

- Using the roll angle vs. time input curve, full system model (FSM) rollover was run without the occupants and restraints systems
- Generated the binary Interface Segment File (ISF) to be used with occupants and restraints systems in subsequent simulations

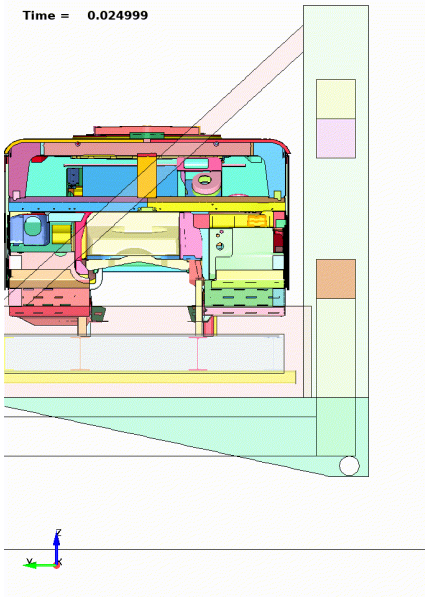


Ground Vehicle Rollover M&S - HMMWV ROMM Model

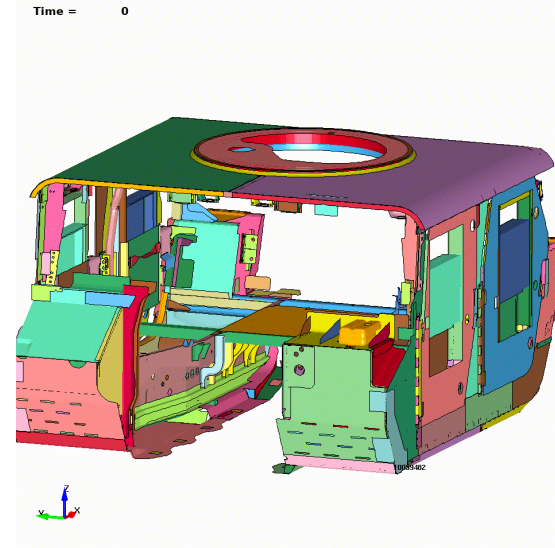
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➤ Full system rollover w/o occupants



➤ ISF model

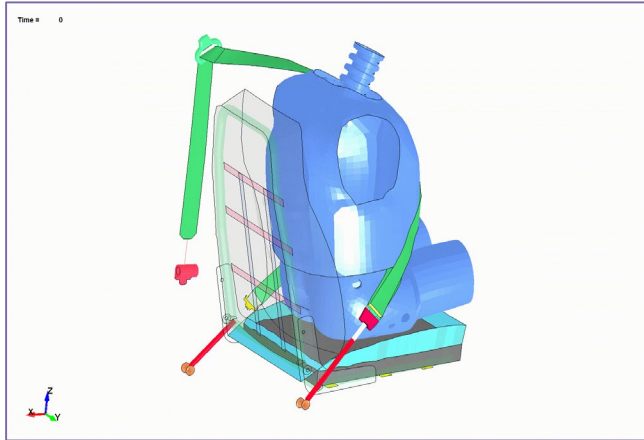
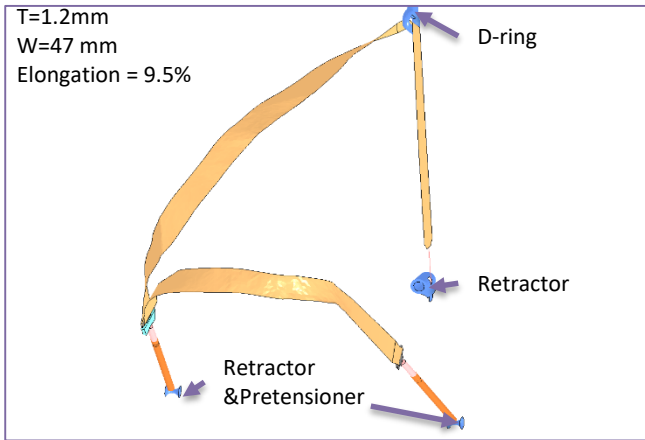
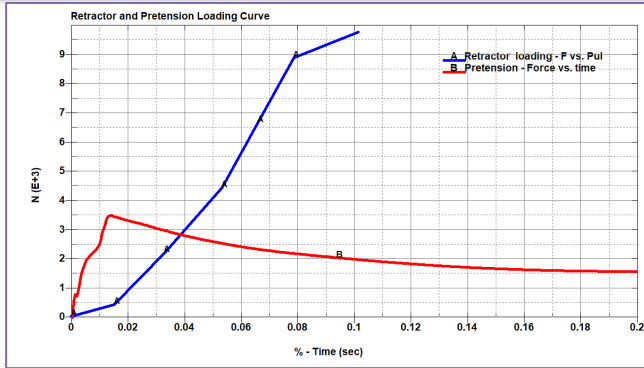
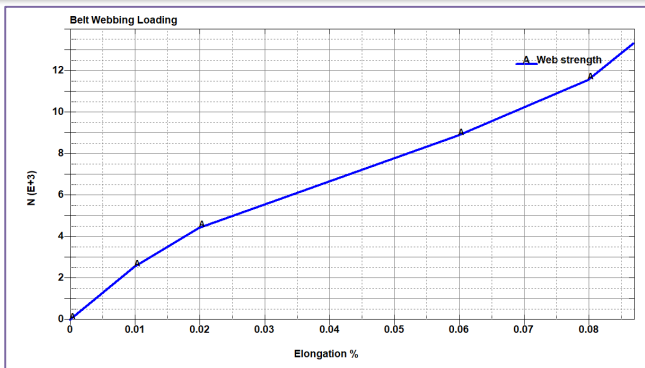


- Generated nodal motions for the ISF (right) model from FSM (left)
- Non structural masses such as occupants and restraints systems are integrated into the ISF model as ROMM



Ground Vehicle Rollover M&S

- Seatbelt restraints system models



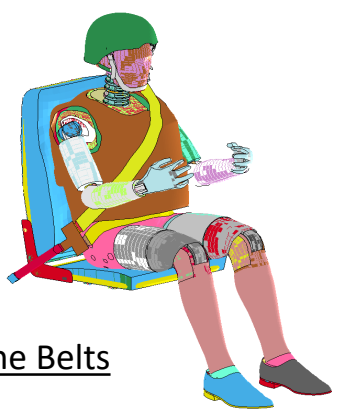
- ❑ Seatbelt, retractor and pretensioner in M&S model and their properties are shown in figure
- ❑ Pre-simulation performed for all occupants independently to eliminate slack



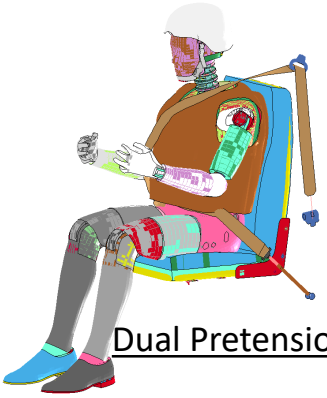
Ground Vehicle Rollover M&S

- Analysis of Different Seatbelt Systems

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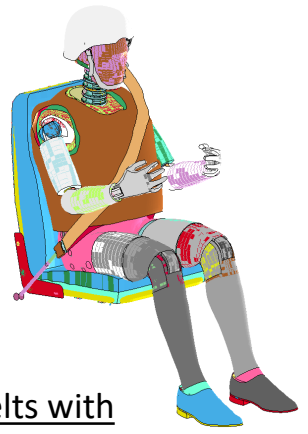
Baseline Belts



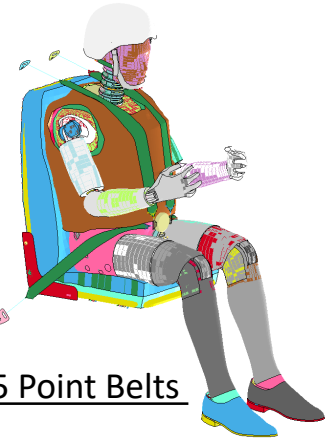
Dual Pretensioner



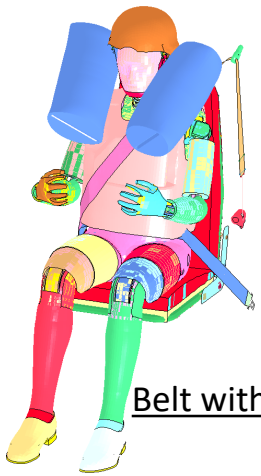
Stroking Seat concept



3 Point Belts with Buckle Pretensioner



5 Point Belts



Belt with Neck Airbag

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Ground Vehicle Rollover M&S - HMMWV ROMM Model

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Total no. of parts	1730
Total no. of elements	699,120
No. of CPU's	20
Termination time	2 seconds
Completion time	37 hours

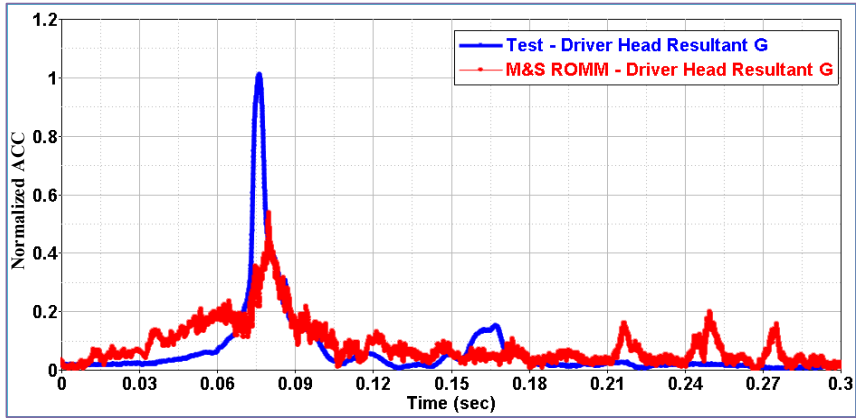
ROMM Model with occupants and seatbelt restraints system



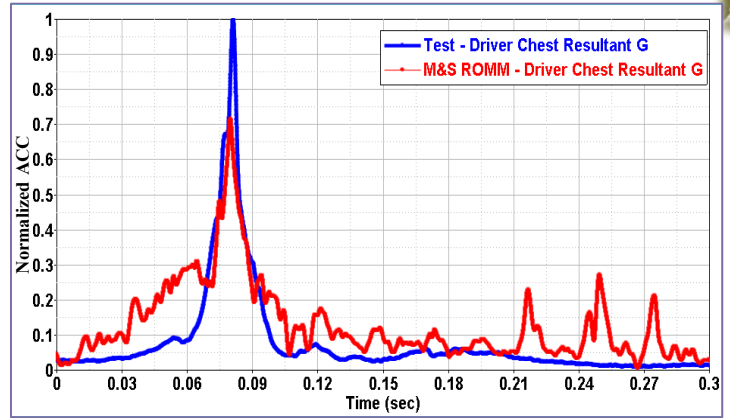
RESULTS

ROMM - Driver head, chest, pelvis accelerations

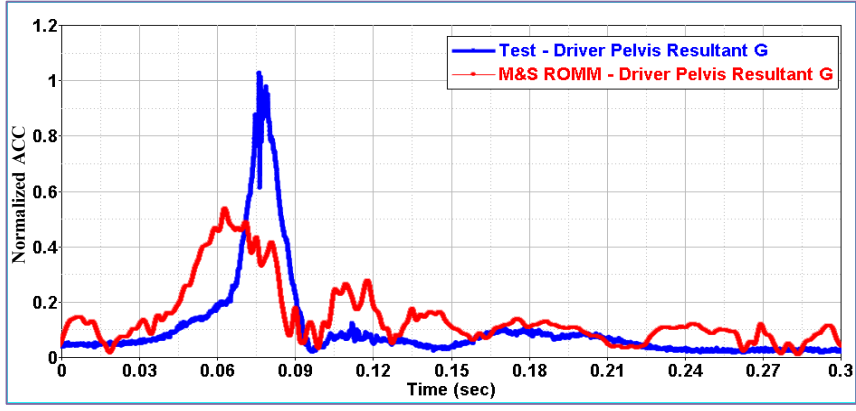
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Driver - Head Resultant Acceleration



Driver - Chest Resultant Acceleration



Driver - Pelvis Resultant Acceleration

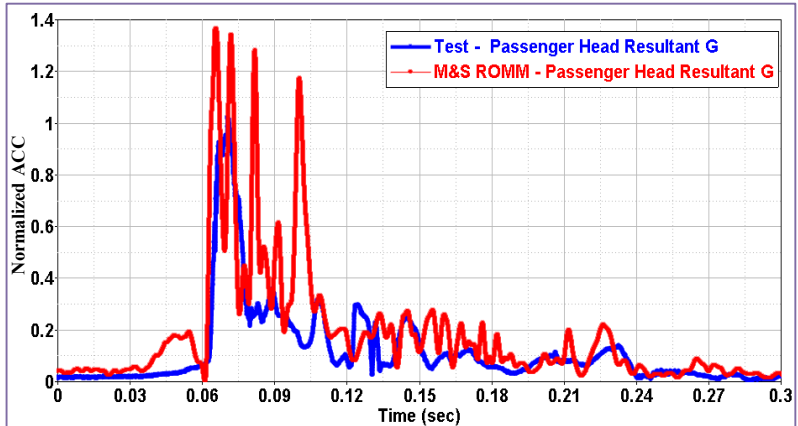
- Driver head, and chest resultant acceleration between test and M&S time history compares well.
- Pelvic acceleration signature deviates from that of the test
- All the responses are normalized to test peak



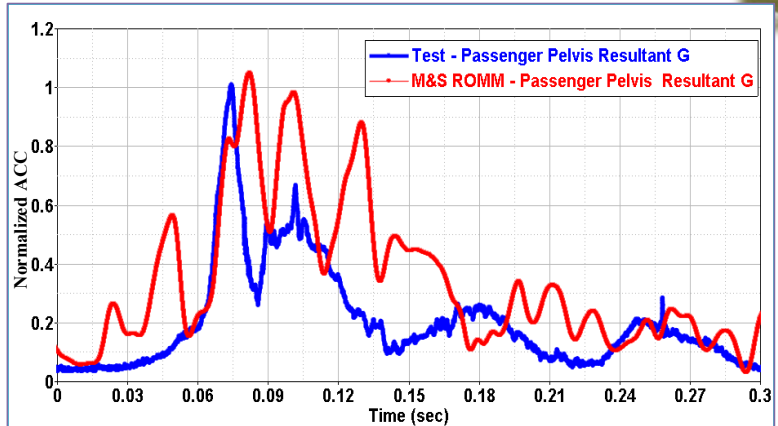
RESULTS

ROMM - Passenger head, chest, pelvis accelerations

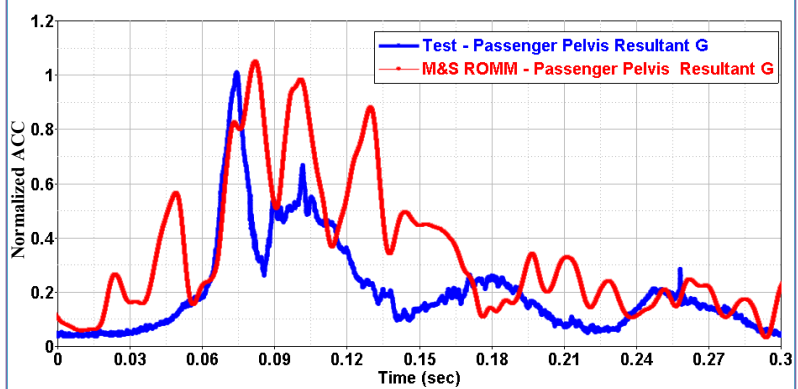
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Passenger - Head Resultant Acceleration



Driver - Chest Resultant Acceleration

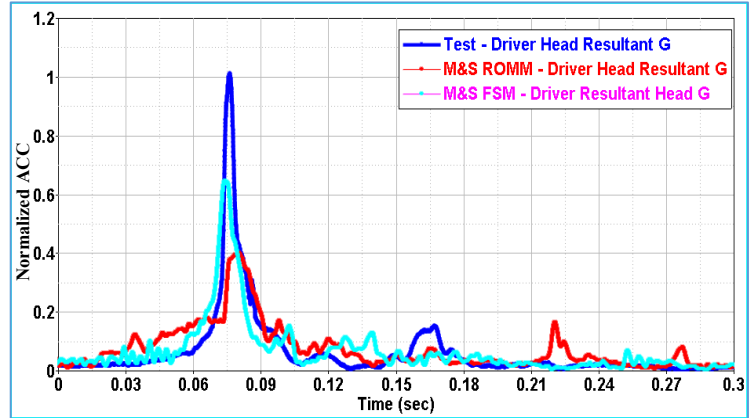


Driver - Pelvis Resultant Acceleration

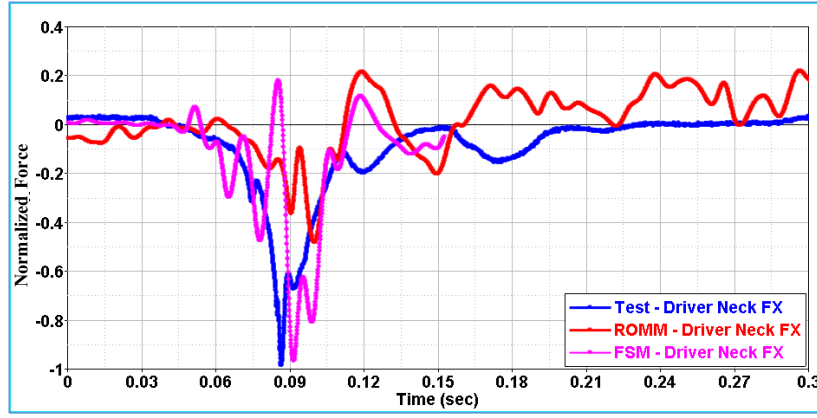
- Passenger head and chest resultant acceleration between test and M&S time history compares fairly well.
- Pelvic acceleration signature deviates from that of the test



Ground Vehicle Rollover M&S - FSM and ROMM Comparison

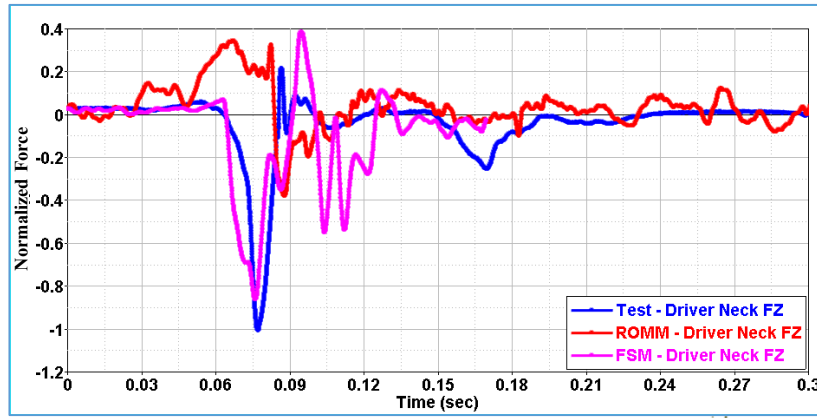


Driver – Head Resultant G



Driver – Neck FX

- ROMM and FSM responses are compared to the test responses for driver head resultant acceleration, and neck FX and FX loads
- FSM responses correlates better than the ROMM responses. Both FSM and ROMM signatures follows the test pattern



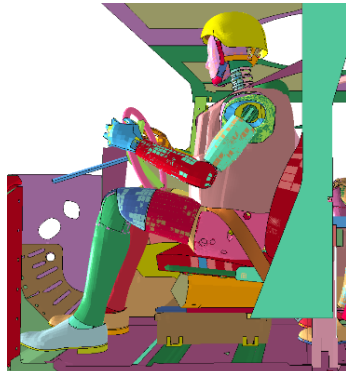
Driver – Neck Fz



Ground Vehicle Rollover M&S

- HMMWV Pre-test positions

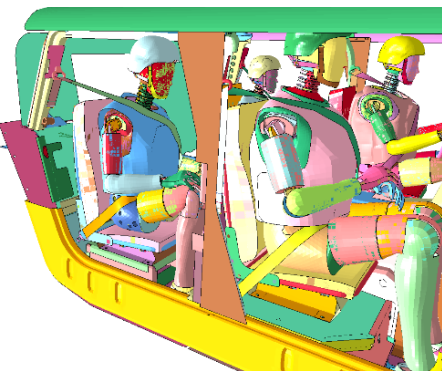
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Driver
Pre-test position



Driver-rear
Pre-test position



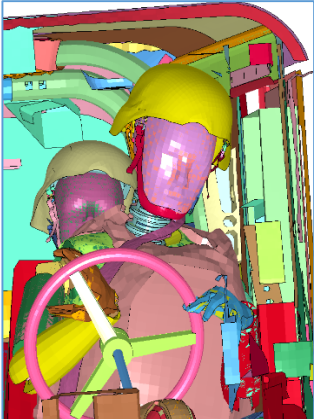
Passenger side
Pre-test position

➤ Occupants are positioned very close to the test conditions with the information available



Ground Vehicle Rollover M&S - HMMWV Post-test positions

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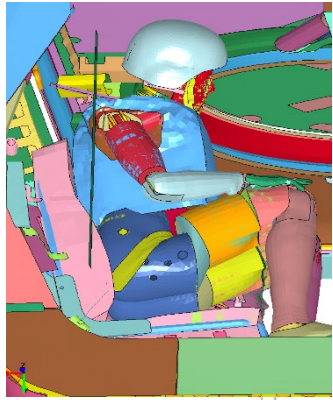
Driver - Post-test position



Passenger- Post-test position

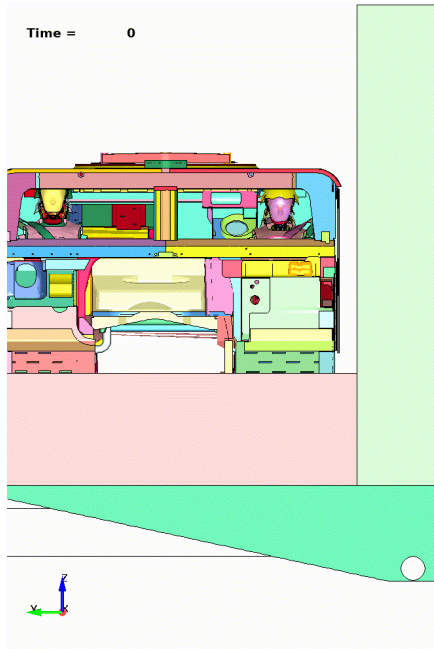
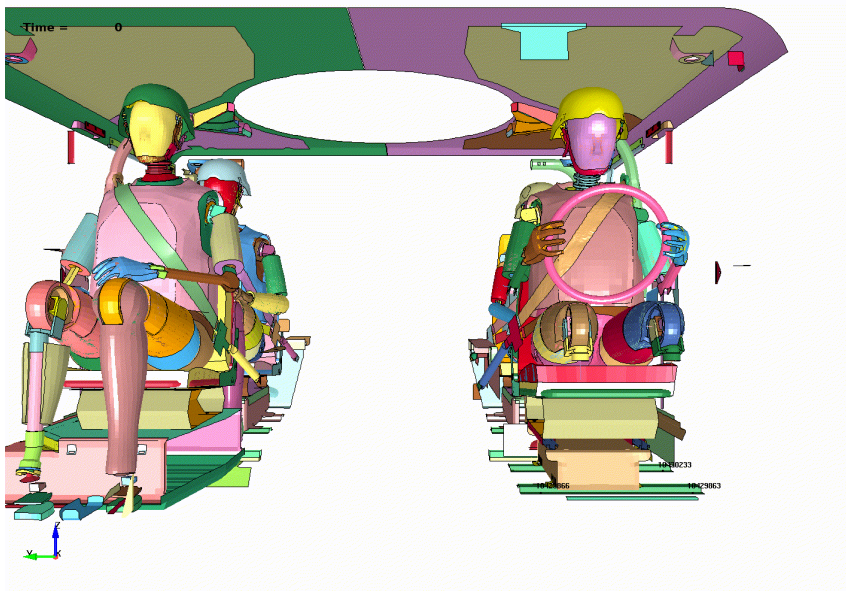


Passenger- Post-test position



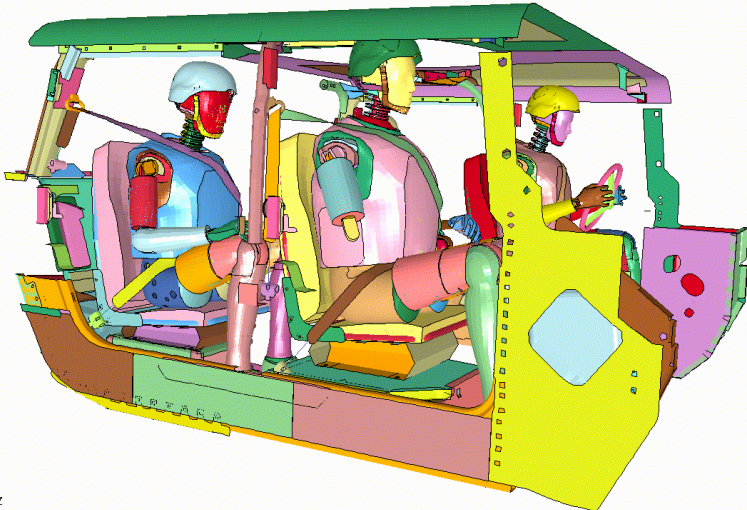
Passenger-rear - Post-test position



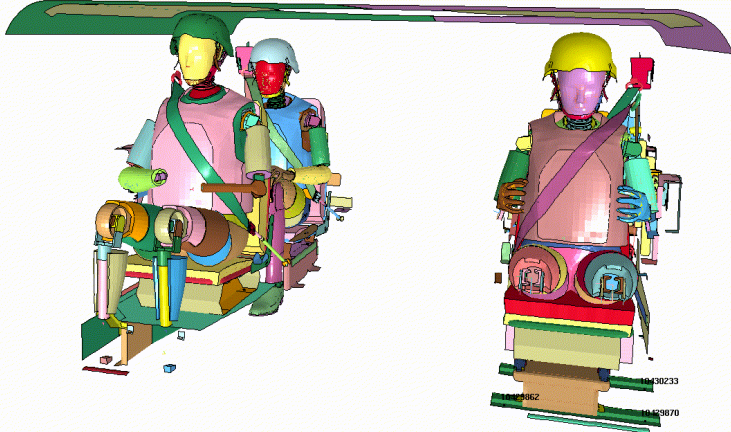




Time = 0



Time = 0



Baseline Seatbelt System

Buckle PT Seatbelt System





- IMMI conducted two HMMWV rollover tests
 - Baseline seatbelt restraints system (lap and shoulder belt)*
 - 3 point seatbelt with buckle side pretensioner*
- GVSC Analytics developed a reduced order model method (ROMM) and simulated these two tests with the IMMI and PM LTV provided data and also with full system models (FSM)
- M&S models correlated both the test responses and the results were comparable to both the IMMI test responses
 - *Occupant kinematics, and all the injuries captured*
 - *Head, chest and pelvis accelerations and neck FX and FZ loads are captured and shown in slides 14-20*
- ROMM run time 37 hours Vs. FSM run time 79 hours, 53% faster than the FSM with high fidelity responses.
- With this correlated model, 4 other design concepts are evaluated successfully
 - This will help PM LTV in identifying the best solution with very minimal cost and saves significant development time**

