Occupant Analysis in Rollover using Detailed Vehicle and THUMS Models

TRB ANB45-1 Rollover Crashworthiness Sub-Committee Winter 2014 meeting

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Acknowledgment

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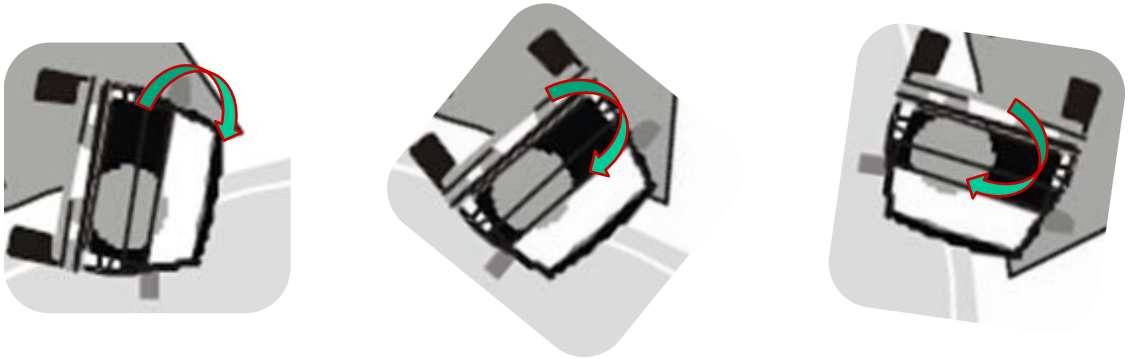
Required “time window”

Front-/ Side Impact

80-150ms



Roll over

>400ms

Rollover events require a much longer simulation “termination time” to capture the most relevant occupant kinematics and injury mechanisms

Feasibility

Detailed validated vehicle model

~ 700.000 elements

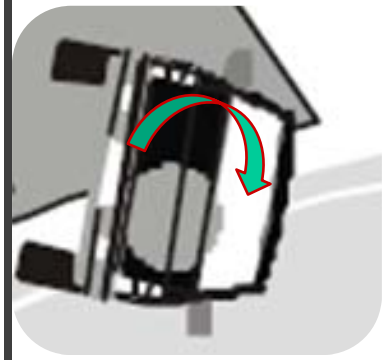
+

Detailed human model THUMS

~ 1.700.000 elements

+

“Long duration” roll over event

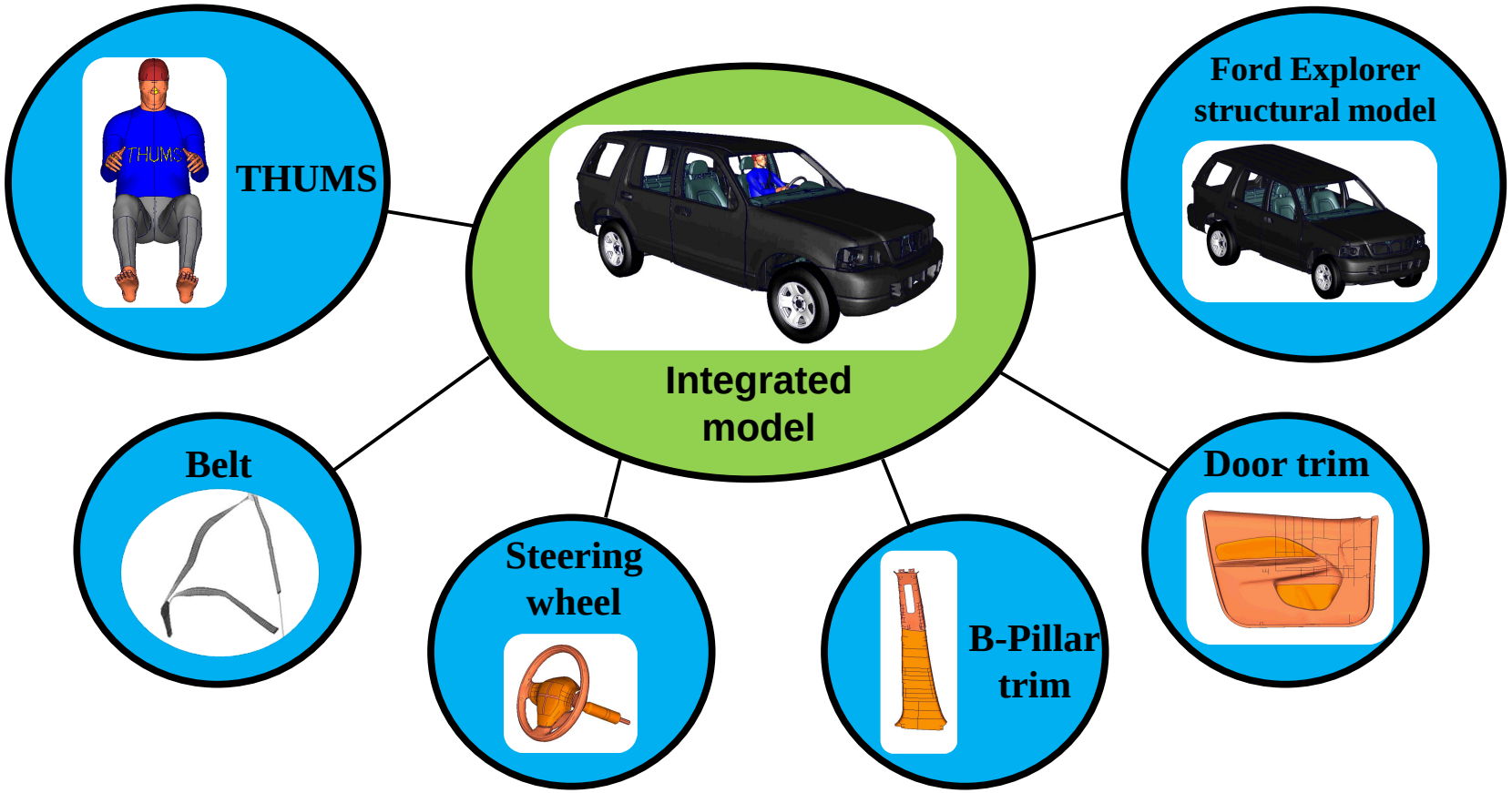


complex initial conditions

= ?

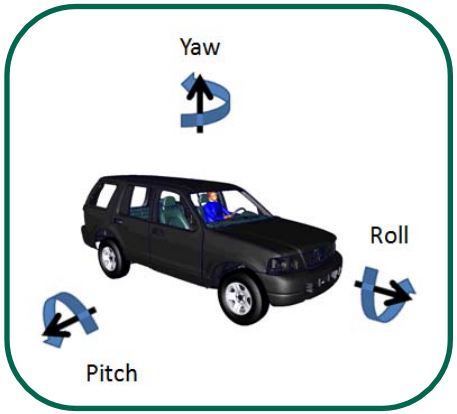
Is it possible to simulate complex rollover event with detailed vehicle and human finite element model?

Model description



Integrated occupant vehicle model consisting of Ford Explorer structural model, THUMS human occupant model, and generic restraint and interior components

Load Case



Model is prepositioned for the with the following initial conditions:

Yaw 10 degree	**Pitch 0 degree**	**Roll 125degree**
v(-y)=15mph	**roll rate= 190 o/s**	**Drop height: 100mm**

“Model preparations”

Positioning I

Positioning II

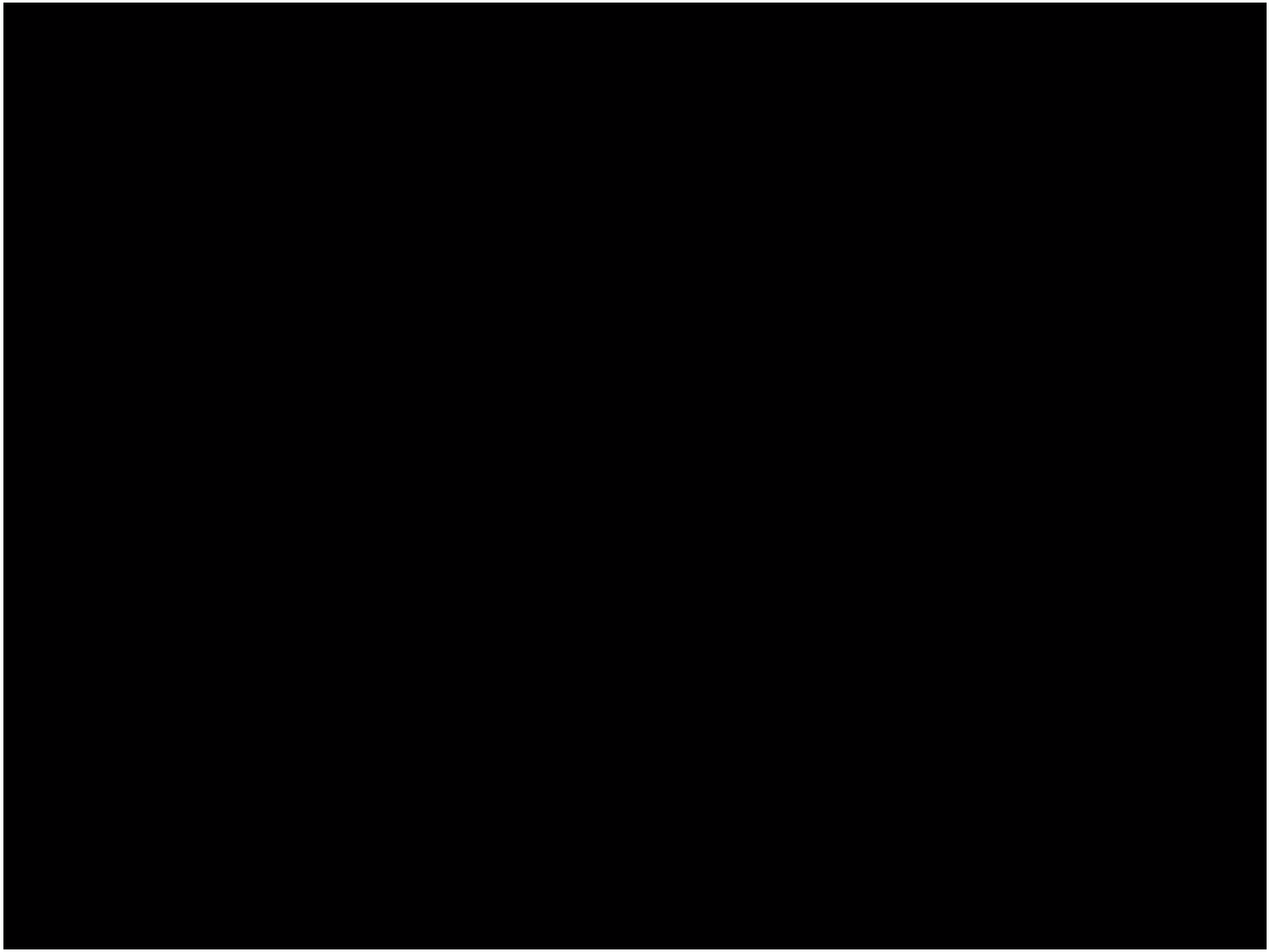
“Seat squash”

THUMS preparations for integrated simulation

“Belt fit”

Positioning of limbs

First Results - animation



Feasibility

Detailed validated vehicle model

~ 700.000 elements

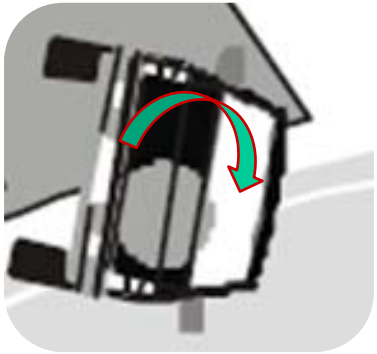
+

Detailed human model THUMS

~ 1.700.000 elements i.e. head i.e. liver

+

“Long duration” roll over event



complex initial conditions

=

It is possible!

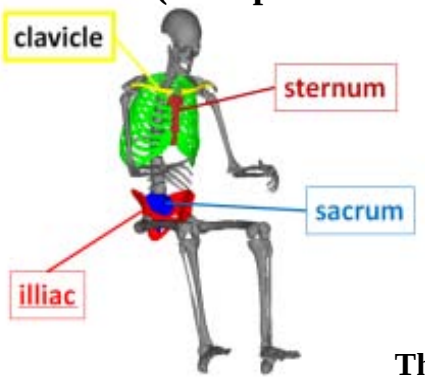
Evaluation Methodology

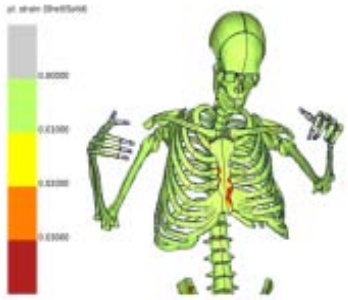
Overall occupant and vehicle kinematics

Occupant Risk Analysis

Location & timing of interaction with vehicle Structure and interior

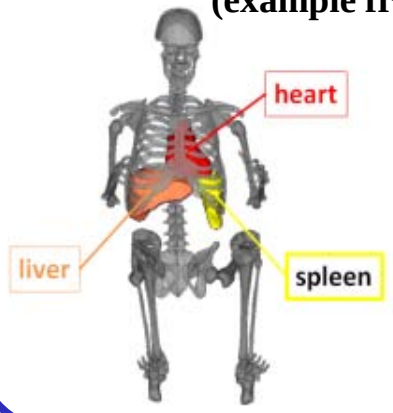
Loads to skeleton using plastic strain evaluation (example from a frontal impact)

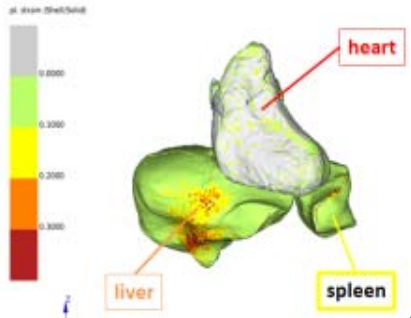




Threshold Burstein/McCalden

Loads to internal organs (example from a frontal impact)





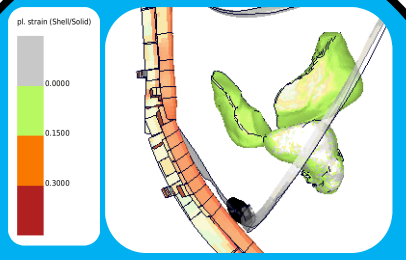
Threshold Melvin/Yamada

First results - evaluation

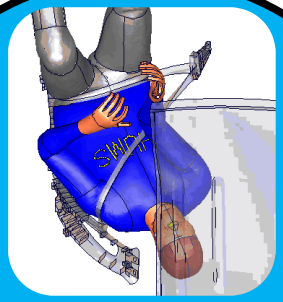
Evaluation of roof interaction

Integrated Simulation

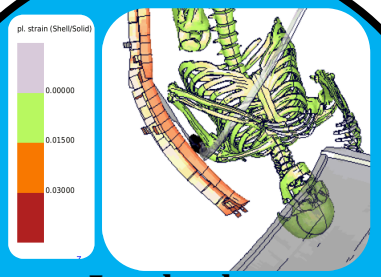
with reduced roof crush



Load to organs



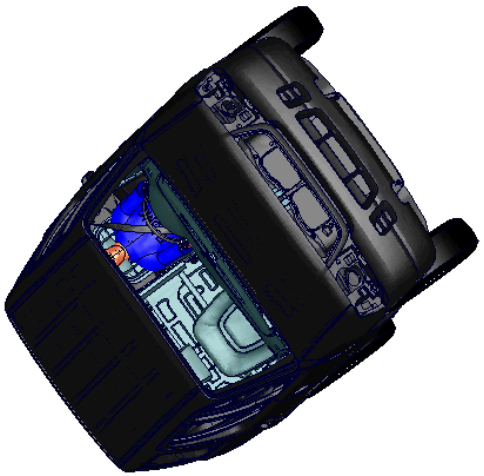
Evaluation of belt interaction



Load to bones

Simulation shows realistic occupant kinematics. Interactions include contact of the head with the roof, contact of the left shoulder with the b-pillar and d-ring, and contact with the belt. Loads to bones and internal organs in the chest did not exceed accepted thresholds.

Parametric study - description



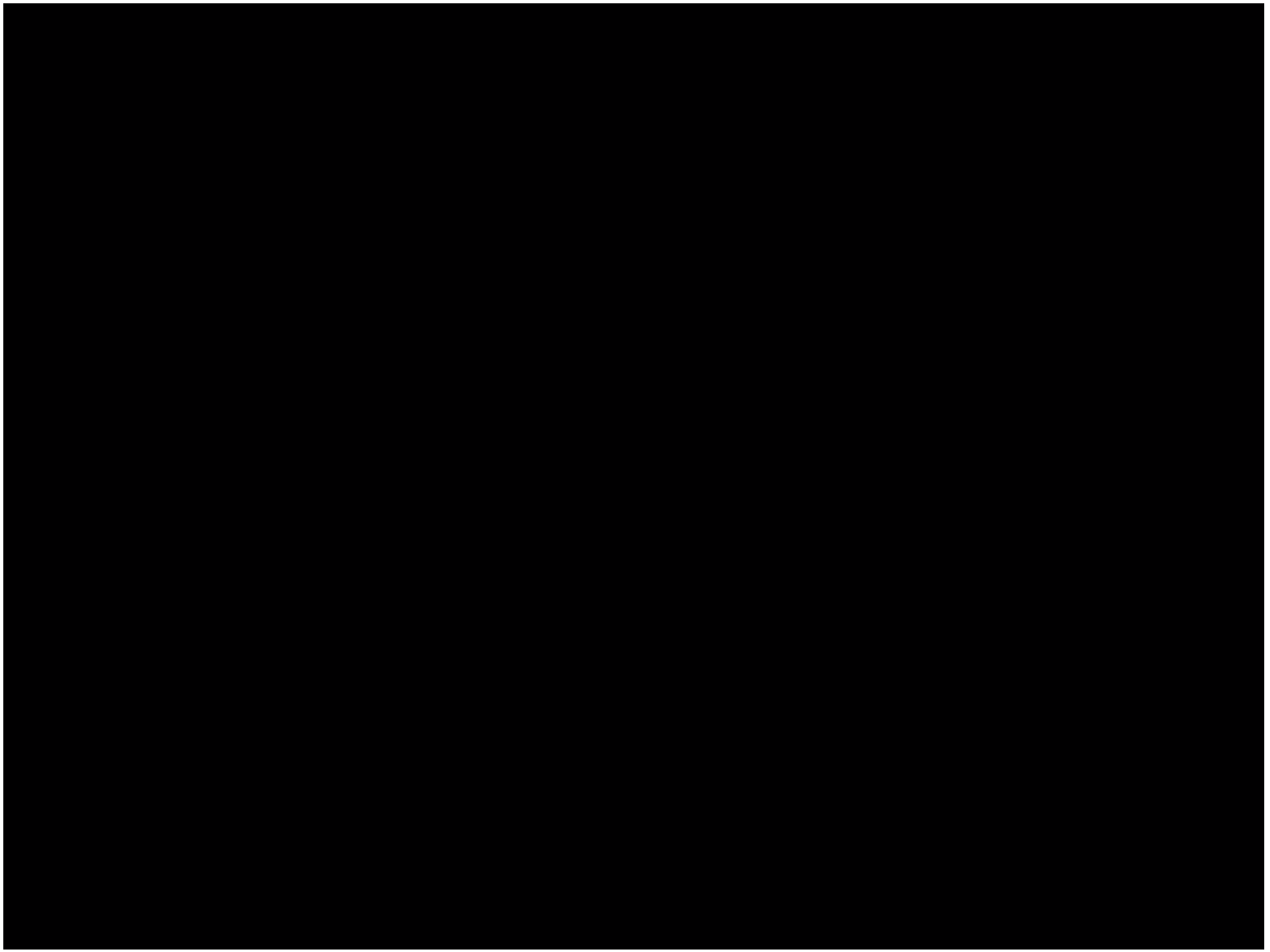
-10 pitch

0 pitch

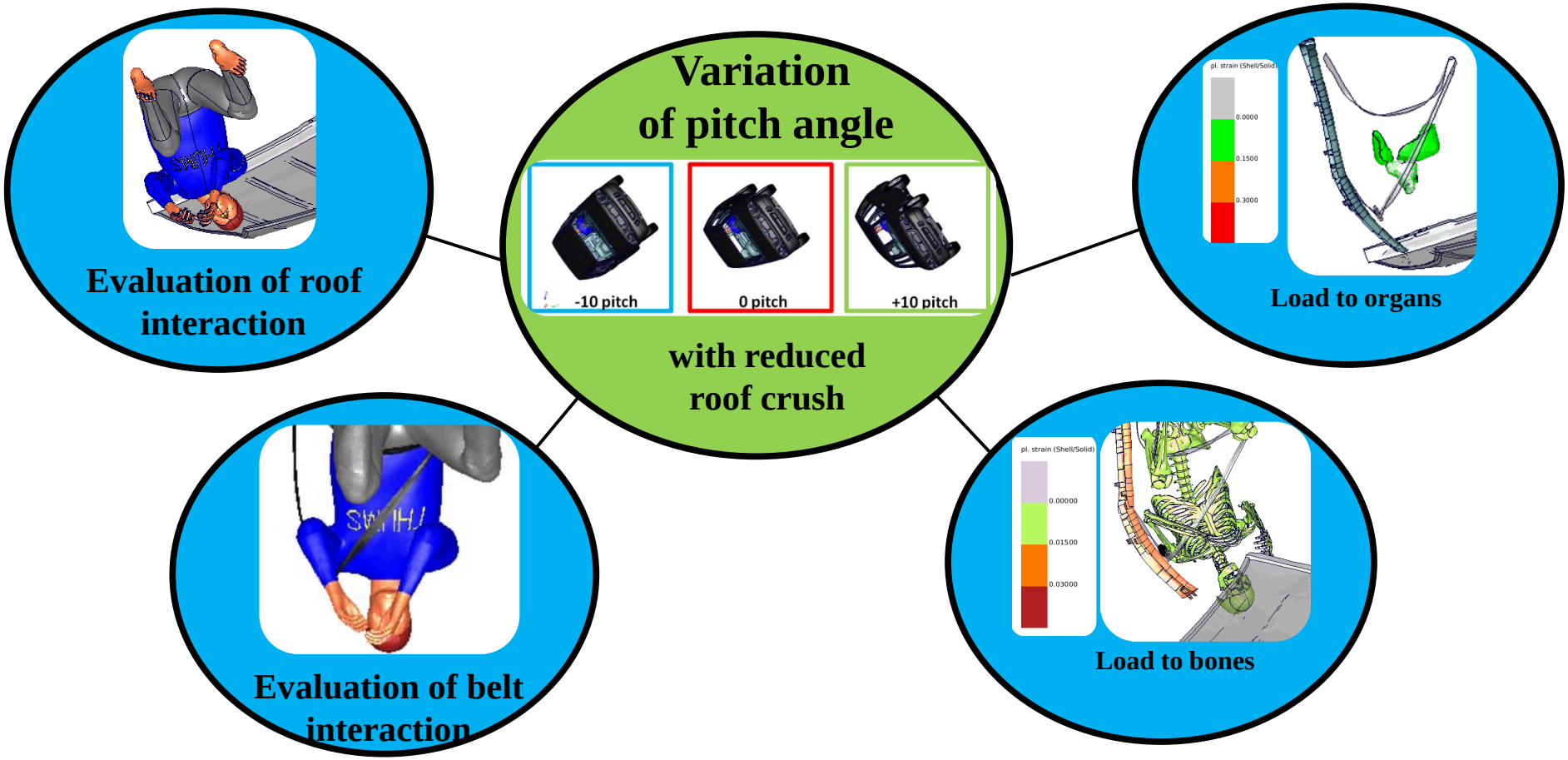
+10 pitch

The integrated THUMS occupant - vehicle model (with reduced roof crush) has been used to evaluate the effect of different initial pitch angle (while leaving all other boundary conditions the same)

Parametric study - animation



Parametric study - Results

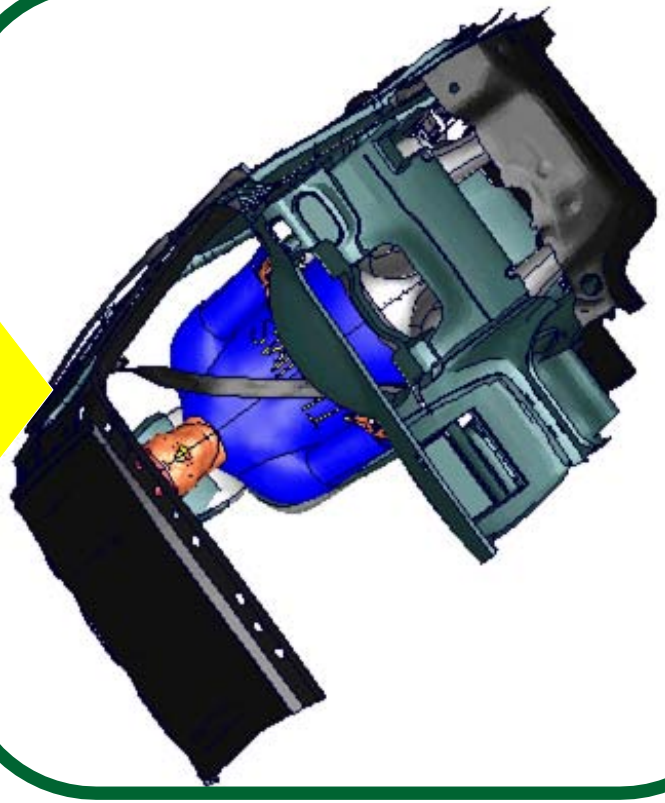


Differences in occupant kinematics, roof and belt contact could be observed for the different initial conditions. Loads to bones and internal organs in the chest did not exceed accepted thresholds

Extended simulation – load case

Vehicle model simulation
with original roof crush characteristics
without occupant

Sub model technique



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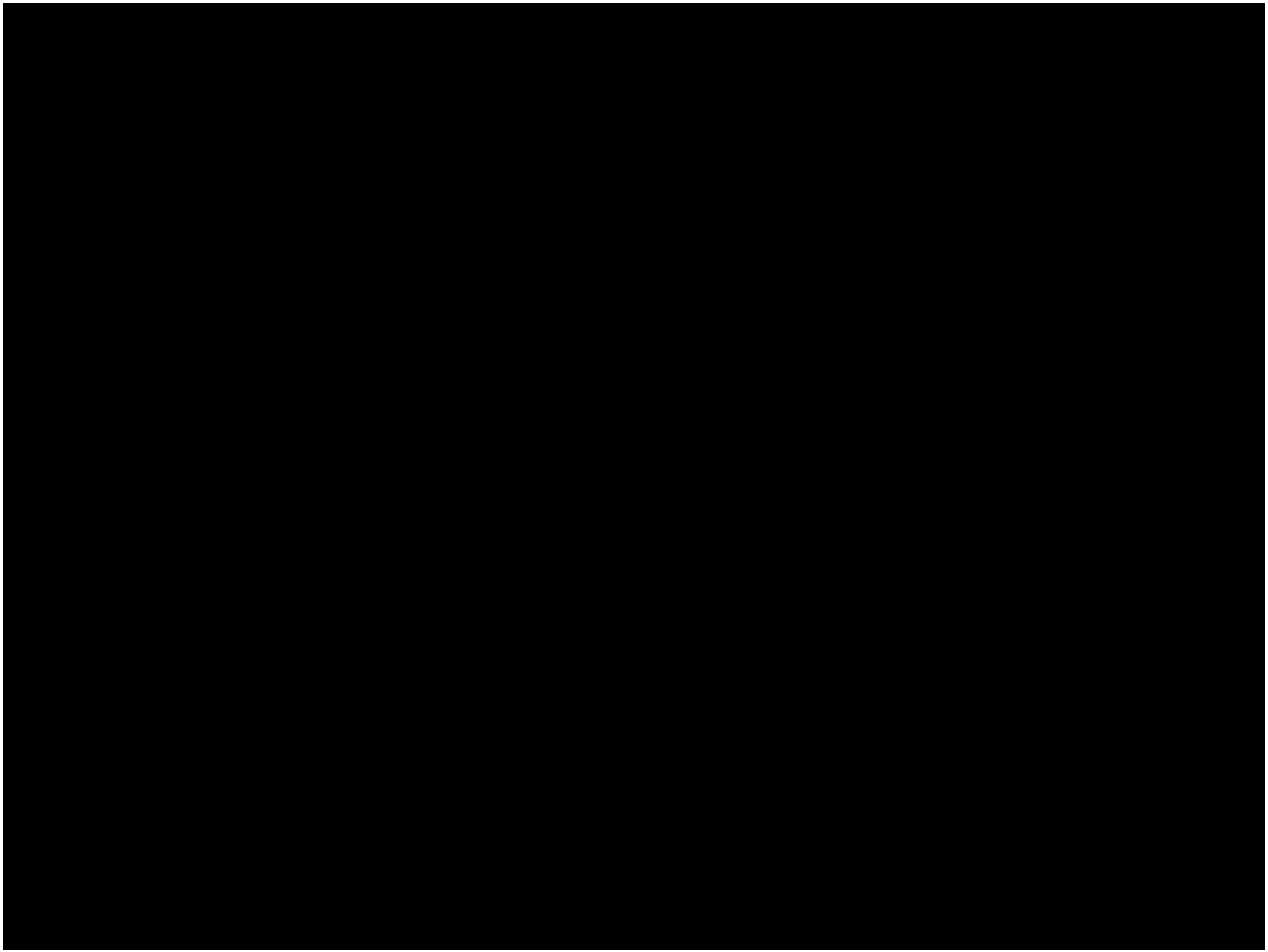
Extended simulation – animation



Extended simulation – results

Rollover event with detailed occupant model could be simulated till

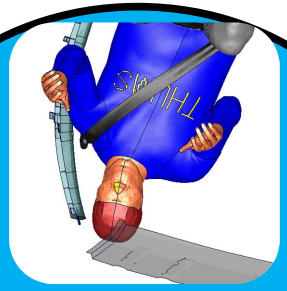
~ 1.400 ms!

capturing complete 3rd and 4th quarter turn

showing realistic occupant kinematics

Extended simulation – evaluation

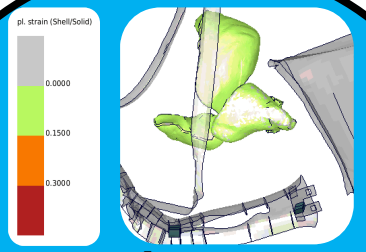
Evaluation of roof interaction



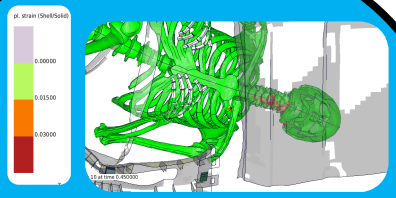
Evaluation of belt and interior interaction

Sub model

Integrated simulation till 1380ms



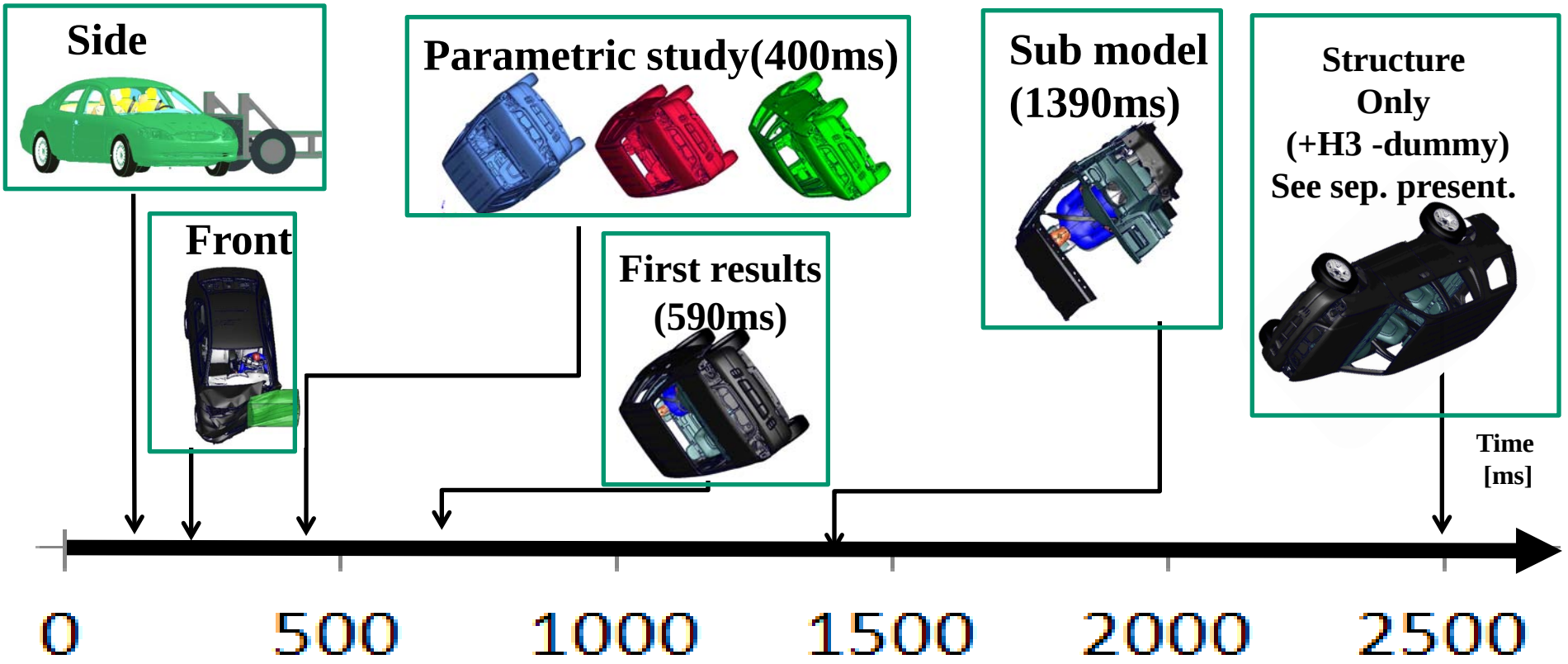
Load to organs



Load to bones

Occupant interactions include contact of 1) left shoulder with b-pillar/ d-ring, 2) head with roof, 3) right lower torso with middle console and 4)contact with the belt. Loads to bones locally exceeded accepted thresholds at the time of the roof crush. The evaluated internal organs did not exceed accepted thresholds.

Overview – termination times



Roll over events require much longer simulation times than front or side impact to capture important occupant kinematics and injury mechanisms

Conclusion

Groundbreaking research has been conducted, showing that it is possible to use detailed integrated occupant vehicle simulation with a complex human model to analyze kinematics and injury mechanisms in a long duration roll over crash event.

A tool has been developed that allows further investigation of complex roll over events using either anthropomorphic test devices or human models

Outlook

Possible further research includes:

injury risk assessment

countermeasures

vehicle models / types

initial conditions

occupant kinematics

which dummy model is most suitable

full scale or component test devices

dummy vs. human models

restraint systems

seating position

body regions e.g. lung injuries

Thank you!

Questions?