H-Point Machine and Head Restraint Measurement Device Positioning Tools and Validation

Brian Walker†, Liliana Cowlam†, Jamie Dennis†, Simon Albery‡, Nicolas Leblanc‡

†- *Arup*

‡- *Futuris*

Abstract

It is essential for seat manufactures to be able to accurately predict the H-Point position of a seat during the design stage, i.e. before the seat is actually built. This can be estimated empirically but this method is usually not sufficient to accurately determine how the manikin's position is affected by subtle yet complex interactions within the seat and its trim. To aid this process, Arup have developed a positioning tool kit for use in conjunction with the Oasys PRIMER software [1]. The positioning tool kit calculates the H-Points of the automotive seats as well as the backset measurement thus providing the scores of the head restraint.

The benefit to the seat engineer of using the Oasys HPM positioning tool is increased confidence in the H-Point of a new seat design, and an opportunity to adjust the design to minimise H-point variation that may be measured in test. This improved understanding of the seat will allow more accurate predictions of whiplash performance and other crash test simulations where dummy positioning is critical.

HPM Positioning Tool is a JavaScript tool for prediction of the H-Point of a seat, based on the SAE J826 regulation [2], used in conjunction with Oasys PRIMER and LS-DYNA® [3]. All pre-simulation positioning of the HPM is completed automatically within Oasys PRIMER, and the output is a ready-to-run LS-DYNA model. Once LS-DYNA has calculated the settling of the manikin using the seat properties, Oasys PRIMER is used for interpretation of the results to report the H-point co-ordinates and back angle of the HPM.

• H-Point Machine and Head Restraint Measurement Device Positioning Tools and Validation

HRMD Positioning Tool is a JavaScript tool for prediction and assessment of seat and head restraint geometries according to the following procedures:

- *IIHS*
- *NHTSA*
- *EuroNCAP*
- *C-NCAP*

The HPM and HRMD Positioning Tools have been validated through comparison to physical measurements and tests based on Futuris seat data. The tools showed good correlation to physical HRMD drops conducted by Thatcham on a seat package. The prediction was shown to consistently lie in within the scatter of the available test data.

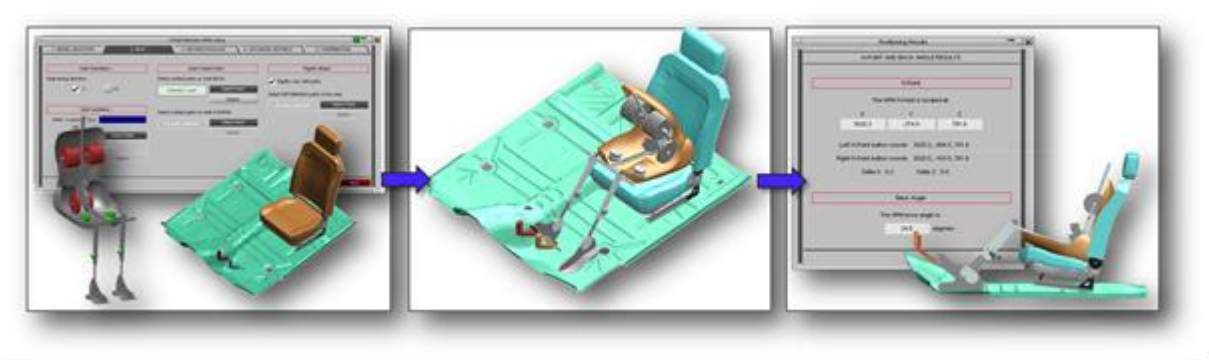


Fig. 1: H-Point Machine script

- **H-Point Machine and Head Restraint Measurement Device Positioning Tools and Validation**

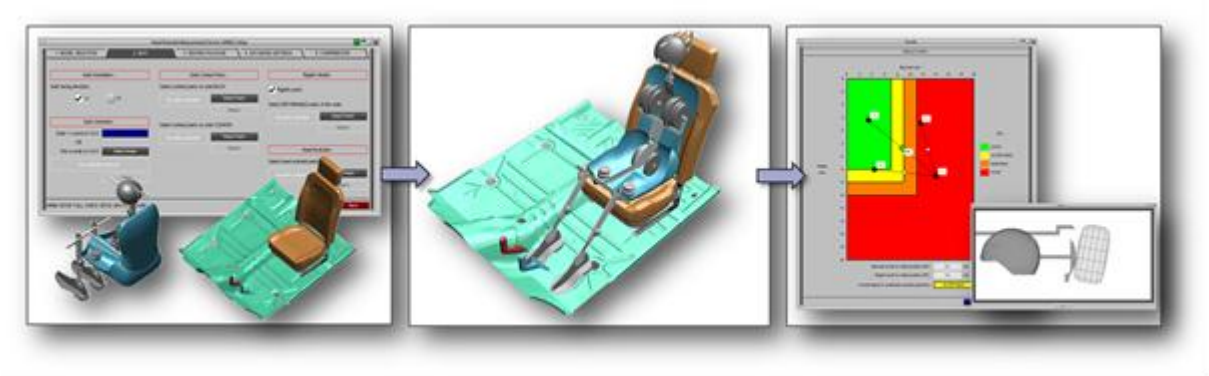


Fig. 2: Head Restraint Measuring Device script

[1] Oasys® PRIMER11.0 User Manual. Ove Arup& Partners Ltd: Solihull, UK, 2013.

[2] SAE International: "J826 NOV2008 Devices for Use in Defining and Measuring Vehicle Seating accommodation", Revised 2008-11.

[3] LS-DYNA® Keyword User's Manual, Version 971. Livermore Software Technology Corporation (LSTC): Livermore, CA 94551-5110, USA, May 2007

Contents

- Introduction
- Overview of the JavaScript Tools
  - HPM
  - HRMD
- Validation and Verification
- Summary and Conclusion

Introduction

- Accurate prediction of the H-Point of a seat is essential for seat manufacturers.
- Also important for dummy positioning in crash tests.
- Crucial to have this early, before the physical seat is built.
- Arup have developed a positioning tool kit to predict the H-Point and whiplash performance.
- The Tools work in conjunction with the Arup PRIMER and LS-DYNA.
- Some of the benefits are:
    - Increased confidence in the H-Point of a new seat design,
    - Opportunity to adjust the design,
    - Allow for more accurate predictions of whiplash performance and other crash test simulations where dummy positioning is critical.
- This presentation gives an overview of the Positioning Tools.

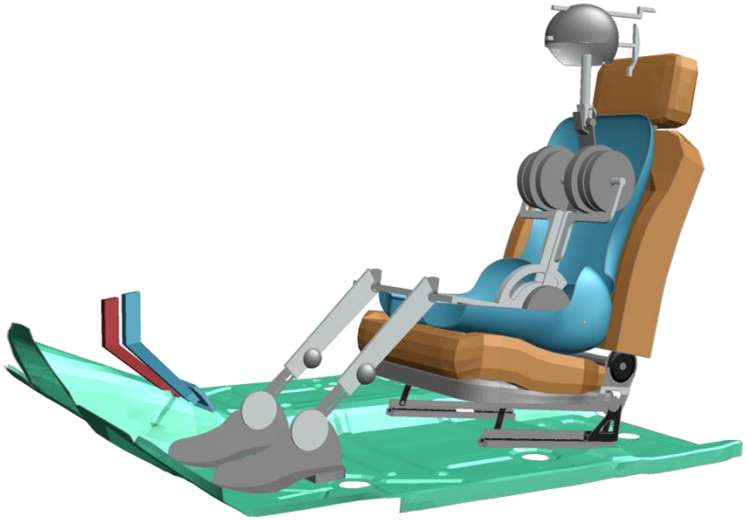
HPM Setup & HRMD Setup PRIMER Tools

HPM Setup

- **Determine seat H-Point**
- Uses model of industry standard H-Point Machine
- Outputs ready-to-run LS-DYNA® model
- Interprets results and reports H-Point

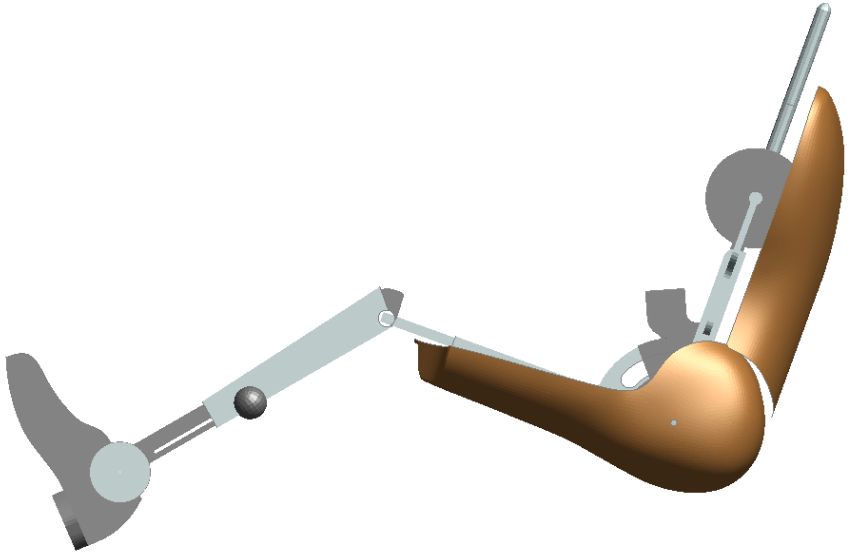
HRMD Setup

- **Assess head restraint geometry**
- Uses HPM model with HRMD extension
- Calculates static scoring for
  - EuroNCAP, IIHS, NHTSA & C-NCAP



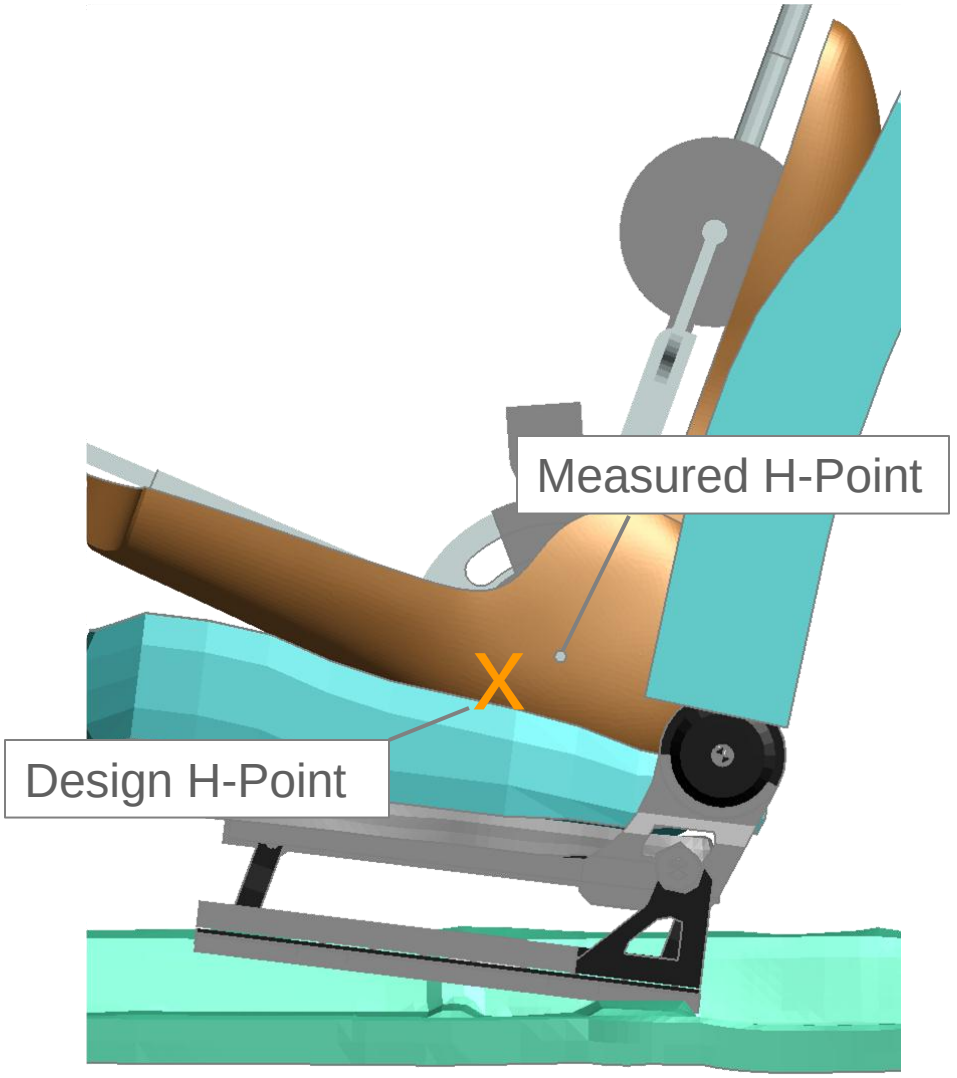
H-Point

- Theoretical position of seated occupant's hip
- Highly important reference point in vehicle/seat design for:
  - Comfort
  - Safety
  - Visibility
  - Ease of entry/exit
  - etc
- Used to position dummies in crash tests
- Measured using the H-Point Machine



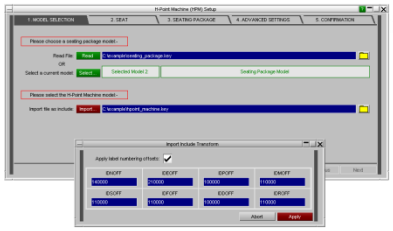
The Problem

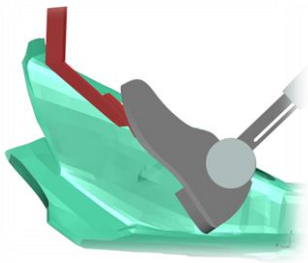
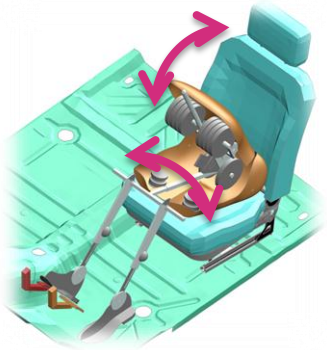
- H-Point difficult to predict from CAD data alone
- Sensitivity to seat parameters difficult to assess
- Actual H-Point often differs from design H-Point
  - Implications for ergonomic and safety design
- Improved prediction methods would prove valuable to manufacturers
  - Use LS-DYNA to simulate



Why use a script for HPM positioning?

- Positioning follows the procedures in SAE Document J826
  - Complex procedure containing multiple steps
- Often repeated multiple times
- Difficult and time consuming to simulate the procedure




HPM Setup

Identify Parts
Initial Positioning

Positioning Procedure
Completed

Retrieve H-Point
and
Back Angle

Model Setup

HPM Seatsquash Analysis

Results

Interactive Setup in PRIMER

Oasys PRIMER

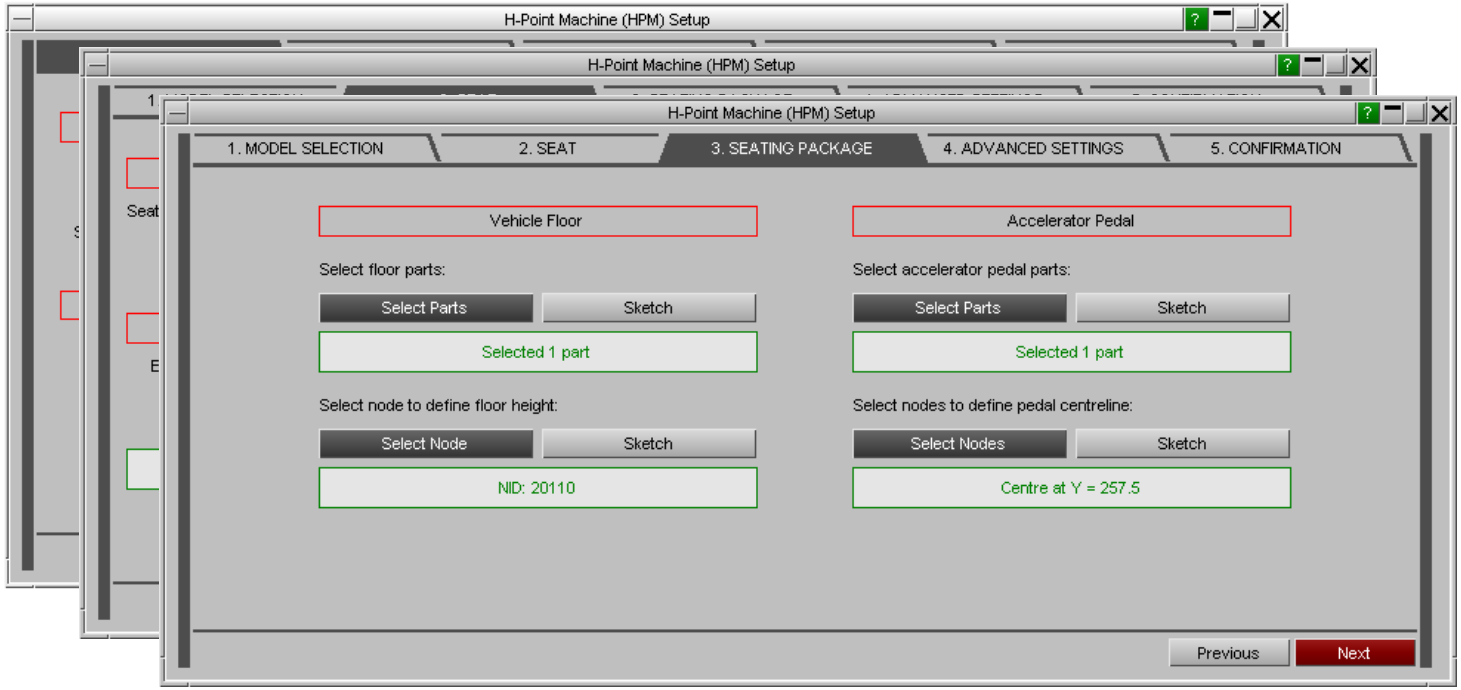
Identify Parts
Initial Positioning

LS-DYNA

Positioning Procedure Completed

Oasys PRIMER

Retrieve H-Point and Back Angle



- Clear and simple menus
- Read and merge models
- Select relevant parts of seat model
  - Cushions, floor, pedal etc
- PRIMER automatically configures contacts, sensors, loads and other boundary conditions

Initial Positioning in PRIMER

Oasys PRIMER

Identify Parts

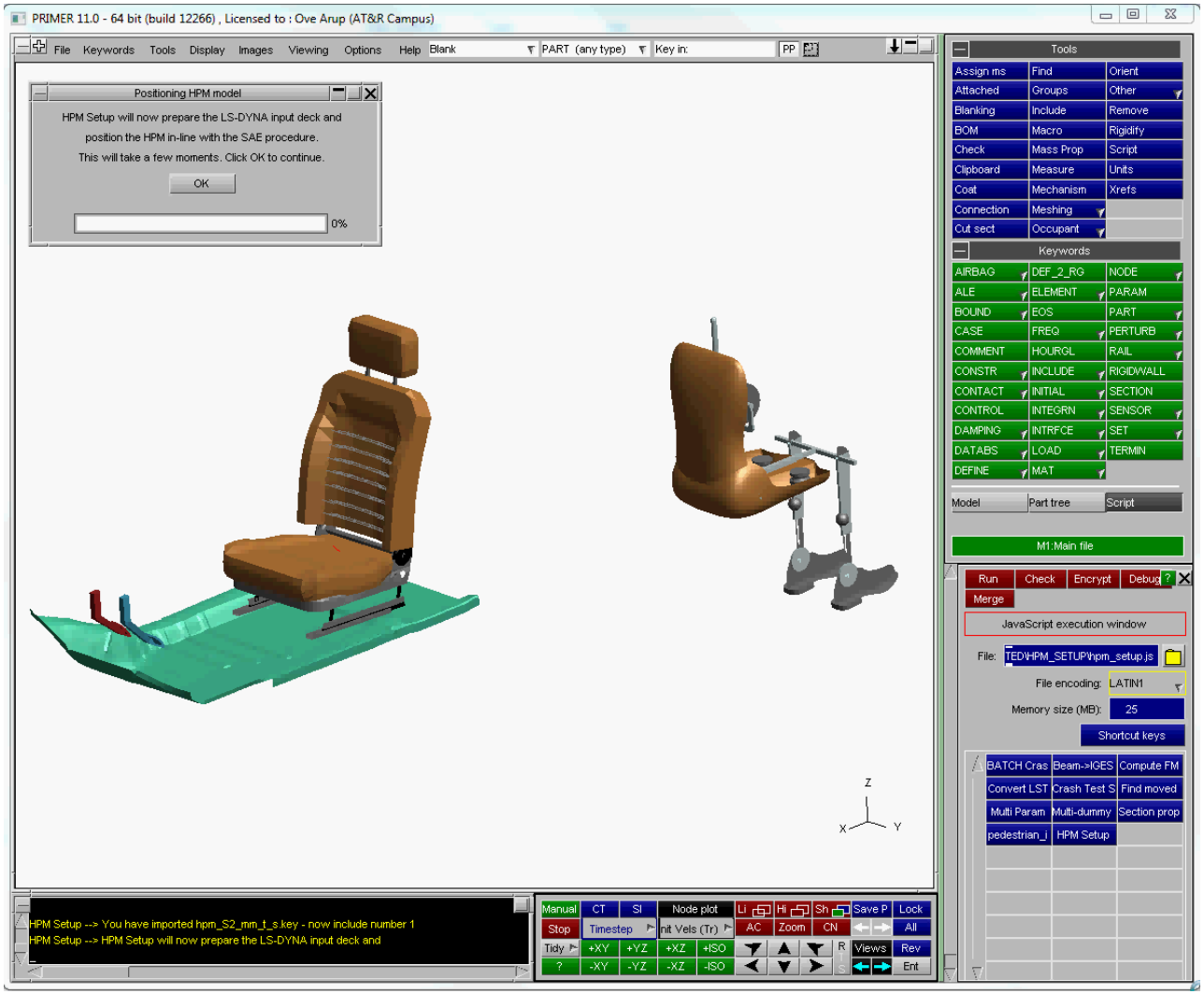
Initial Positioning

LS-DYNA

Positioning Procedure Completed

Oasys PRIMER

Retrieve H-Point and Back Angle



Positioning Completed in LS-DYNA

Oasys PRIMER

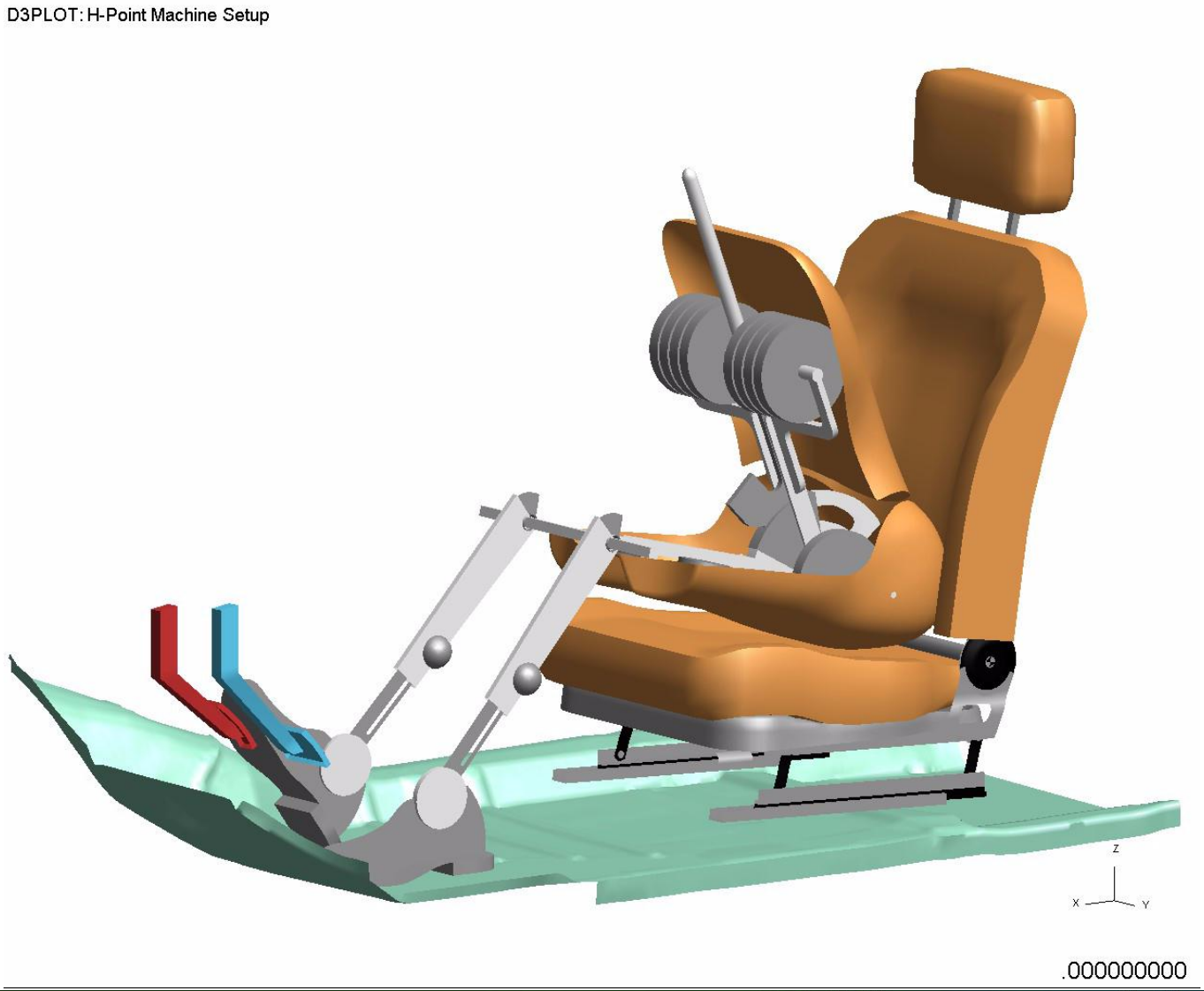
Identify Parts
Initial Positioning

LS-DYNA

Positioning Procedure
Completed

Oasys PRIMER

Retrieve H-Point
and
Back Angle



Positioning Completed in LS-DYNA

Oasys PRIMER

Identify Parts
Initial Positioning

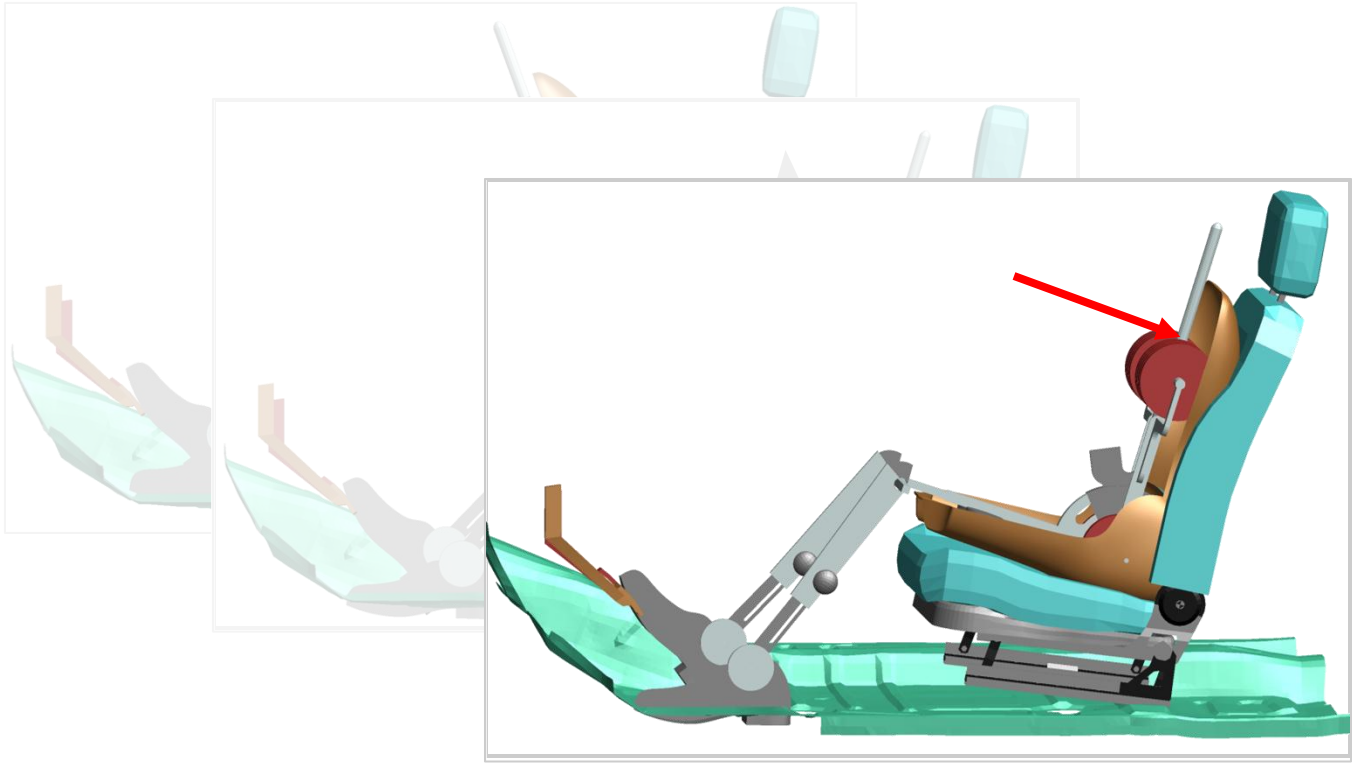
LS-DYNA

Positioning Procedure
Completed

Oasys PRIMER

Retrieve H-Point
and
Back Angle

- *SENSOR_... cards used to allow a multi step procedure to be simulated within a single LS-DYNA analysis
- *LOAD_GRAVITY_PART cards used to simulate the installation of various weights



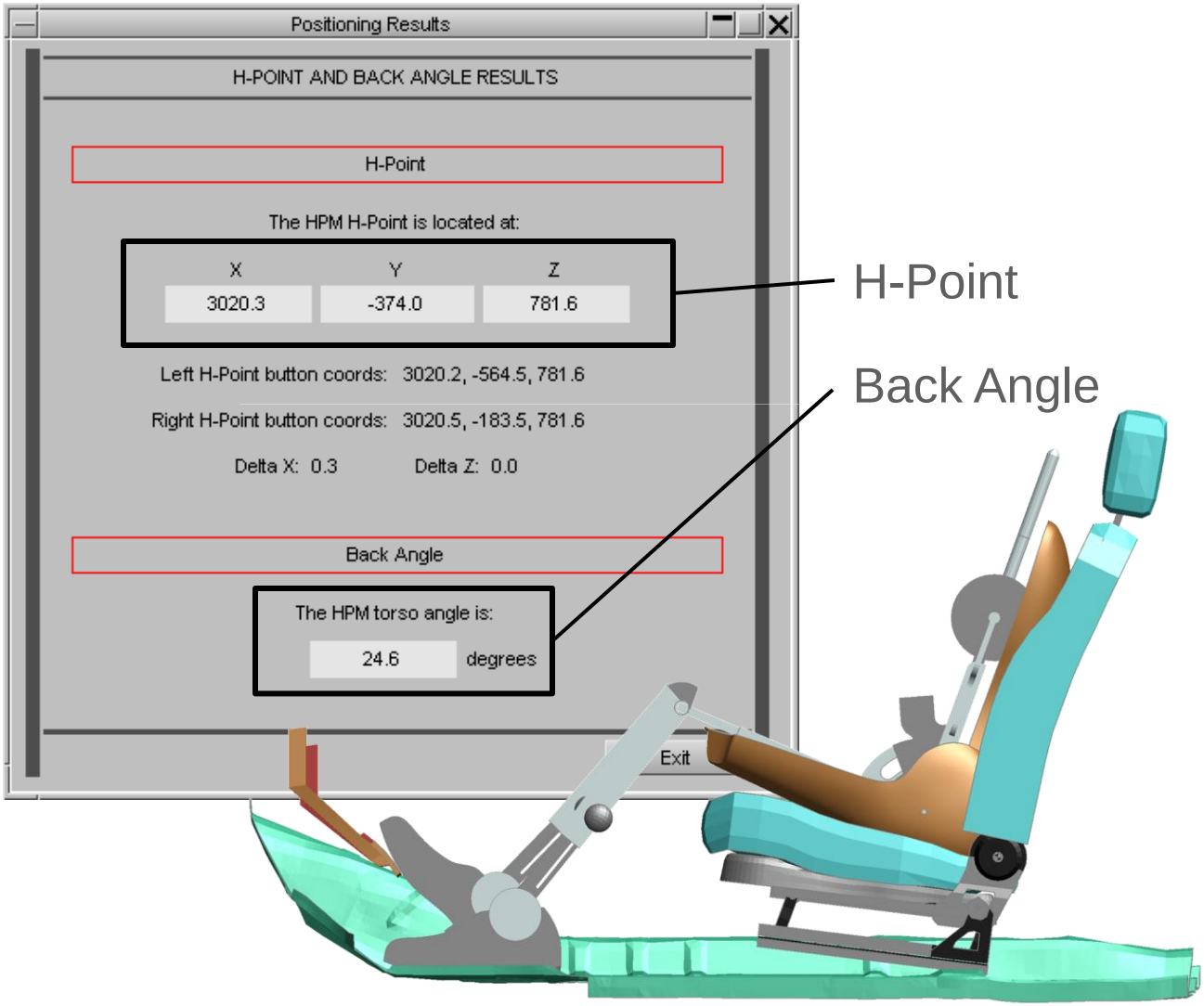
Results Presented in PRIMER

Identify Parts
Initial Positioning

LS-DYNA

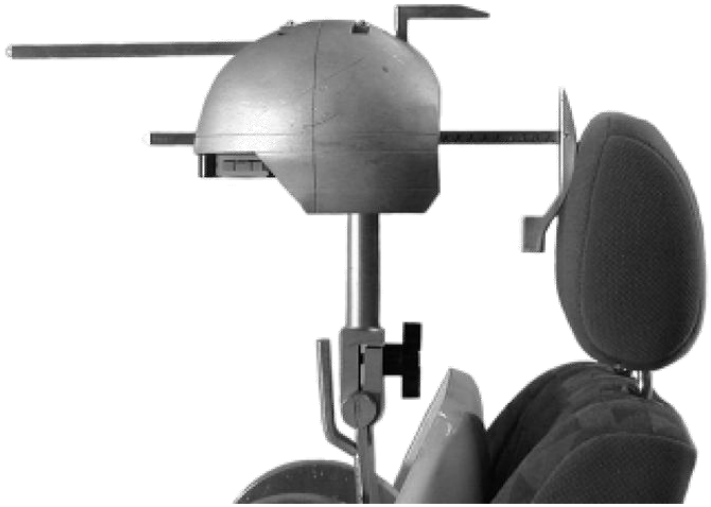
Positioning Procedure
Completed

Retrieve H-Point
and
Back Angle



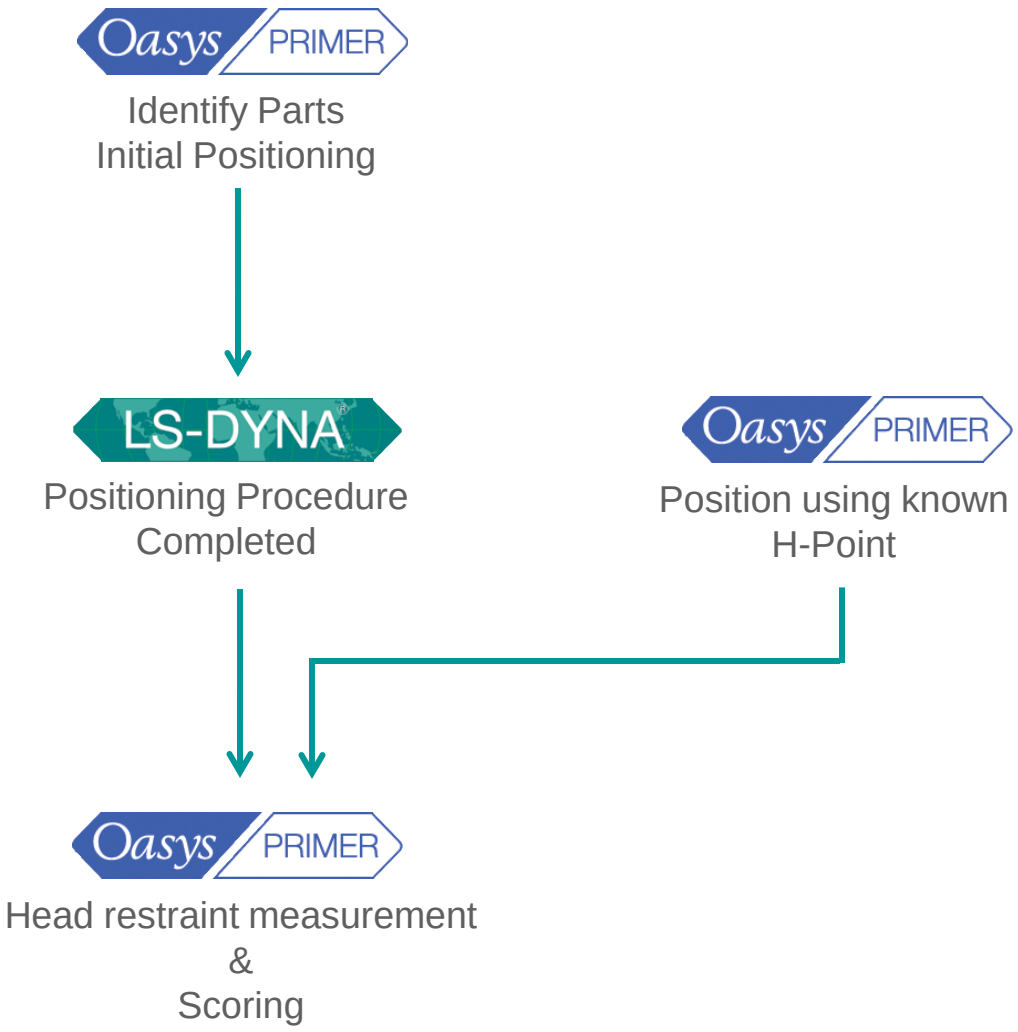
Head Restraint Static Assessment

- Position of head restraint relative to head influences likelihood of whiplash injury
- Position measured using H-Point Machine with Head Restraint Measurement Device (HRMD) attached
- Scoring is better if the head restraint is closer to the head



From: *RCAR: Issue 3, March 2008*

HRMD Setup


Oasys PRIMER
Identify Parts
Initial Positioning
LS-DYNA
Positioning Procedure
Completed
Oasys PRIMER
Position using known
H-Point
Oasys PRIMER
Head restraint measurement
&
Scoring

Quick and Easy Measurement

Oasys PRIMER

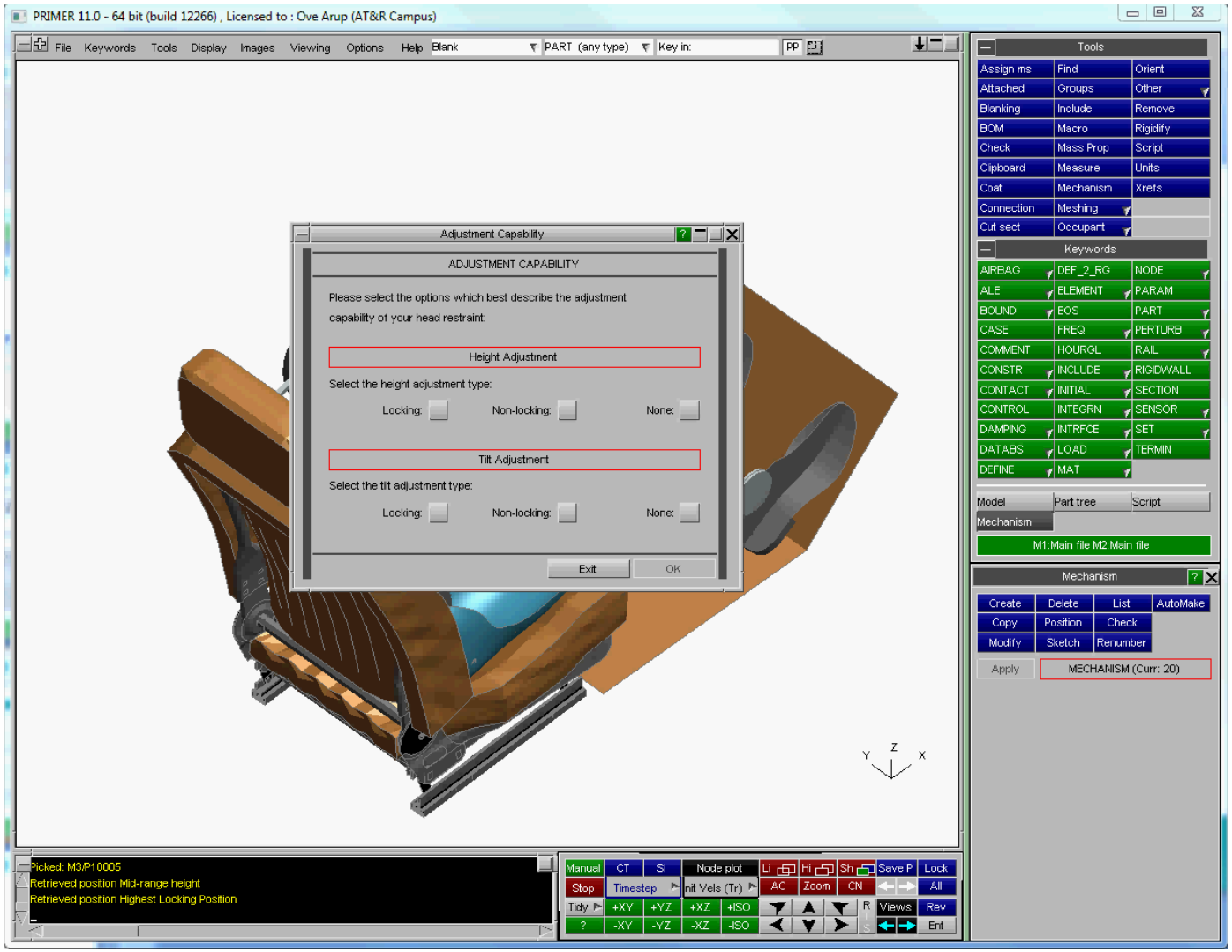
Identify Parts
Initial Positioning

LS-DYNA

Positioning Procedure
Completed

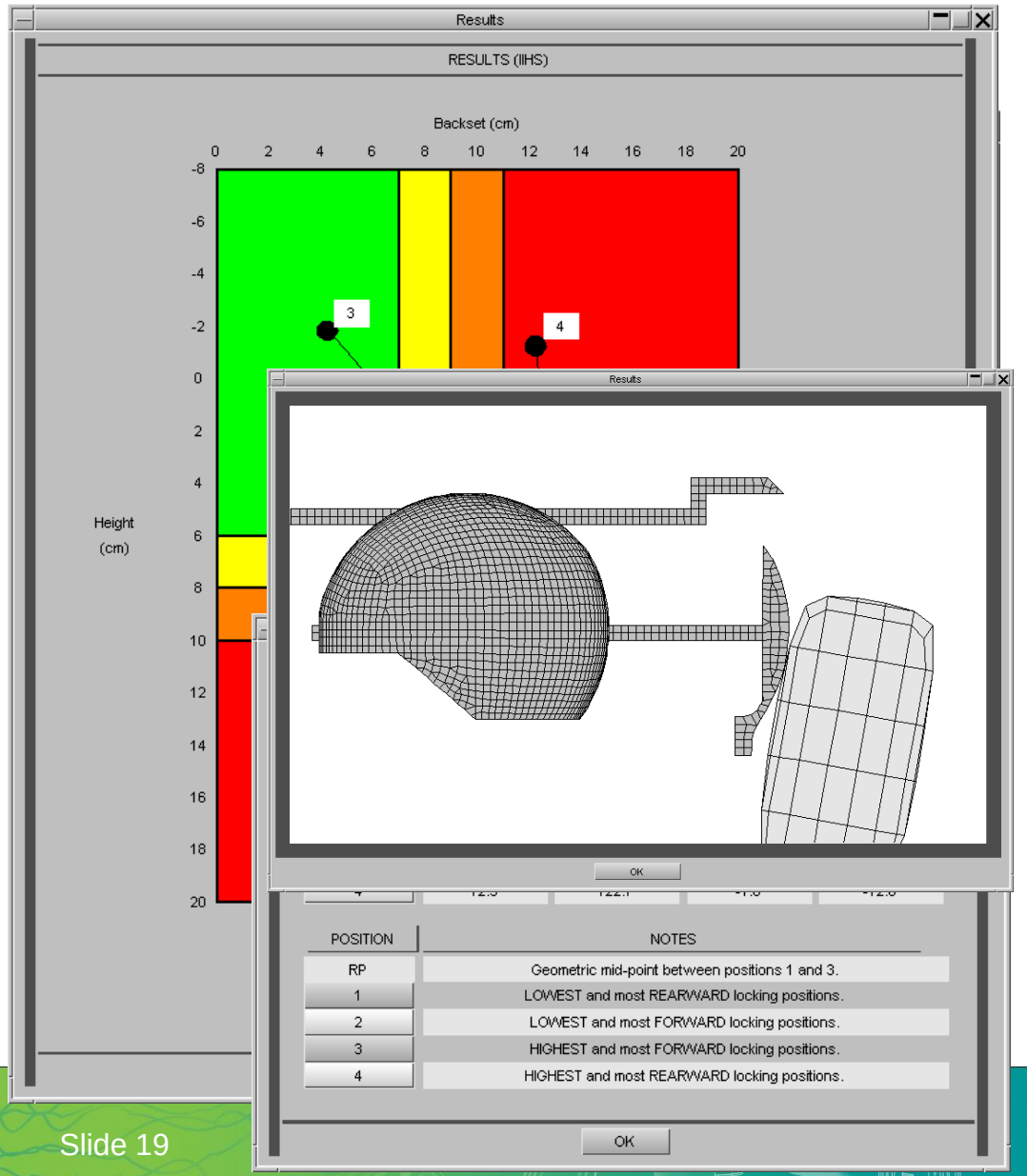
Oasys PRIMER

Head restraint measurement
&
Scoring



Displaying Results

- Results displayed simply and clearly
- Formatted in style relevant to chosen assessing body
- Score automatically calculated
- Images of head restraint and HRMD in each position can be reviewed



Details Taken Care of Automatically

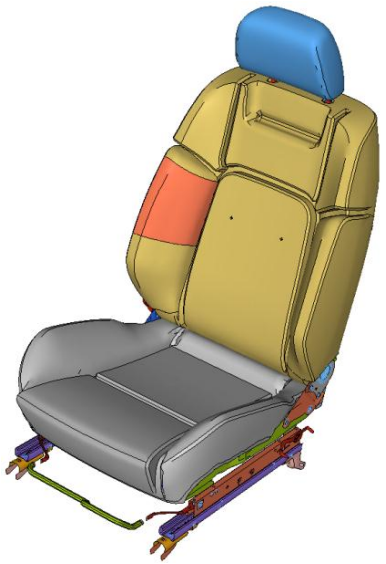
- HRMD Setup automatically accounts for differences in protocols

	IIHS	NHTSA	EuroNCAP / C-NCAP
Seat position	Rearmost, lowest	Mid fore/aft, lowest	Mid, MId
Upper leg length	407.7 mm (10th %ile)	401 mm	407.7 mm (10th %ile)
Lower leg length	417.1 mm (50th %ile)	414 mm	417.1 mm (50th %ile)
Feet position	Both feet rest on vehicle floor. Heels on floor, toes on floor/toe board.	Heels rest on vehicle floor. Ball of right foot against accelerator pedal, ball of left on floor/toe board.	Both feet rest on dedicated floor plane. Heels on horizontal section, toes on inclined section between 230 mm and 270 mm lines.
Height measurement	Made using height probe of HRMD	Made using HPM head-room probe	Made using height probe of HRMD
HPM back angle	25° ± 1°	Manufacturer's designed back angle	25° ± 1°
Loading order	HRMD torso weight setup used whilst seating HPM.	Standard HPM torso weight setup used whilst seating HPM. Replaced with HRMD torso weight setup as HRMD is added.	HRMD torso weight setup used whilst seating HPM.
No. of HR positions measuresd	Max. 4	1	Max. 2

Validation

- The HPM and HRMD tools have been validated through studies done in collaboration with *Futuris*, a global company specializing in the design and manufacturing of seating and interior solutions, with products renowned amongst the best in the world.
- The validation work focused on the HPM Tool for H-point prediction (SAE-J826) and on the HRMD Tool for backset prediction (Euro-NCAP).

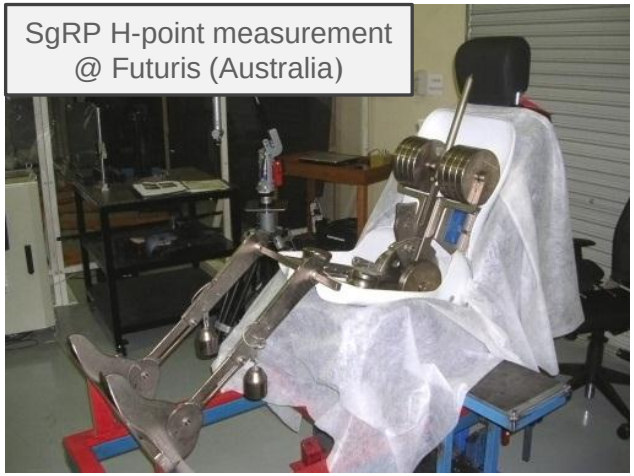
- The seat model used for this validation was correlated to multiple load cases: high speed front and rear impacts, low speed rear impact, quasi-static loading in multiple directions.
- The foam and trim were correlated in isolation as well as part of the complete seat system



Validation - HPM tool (SAE-J826)

Seat base and seatback set to “Design” (SgRP)

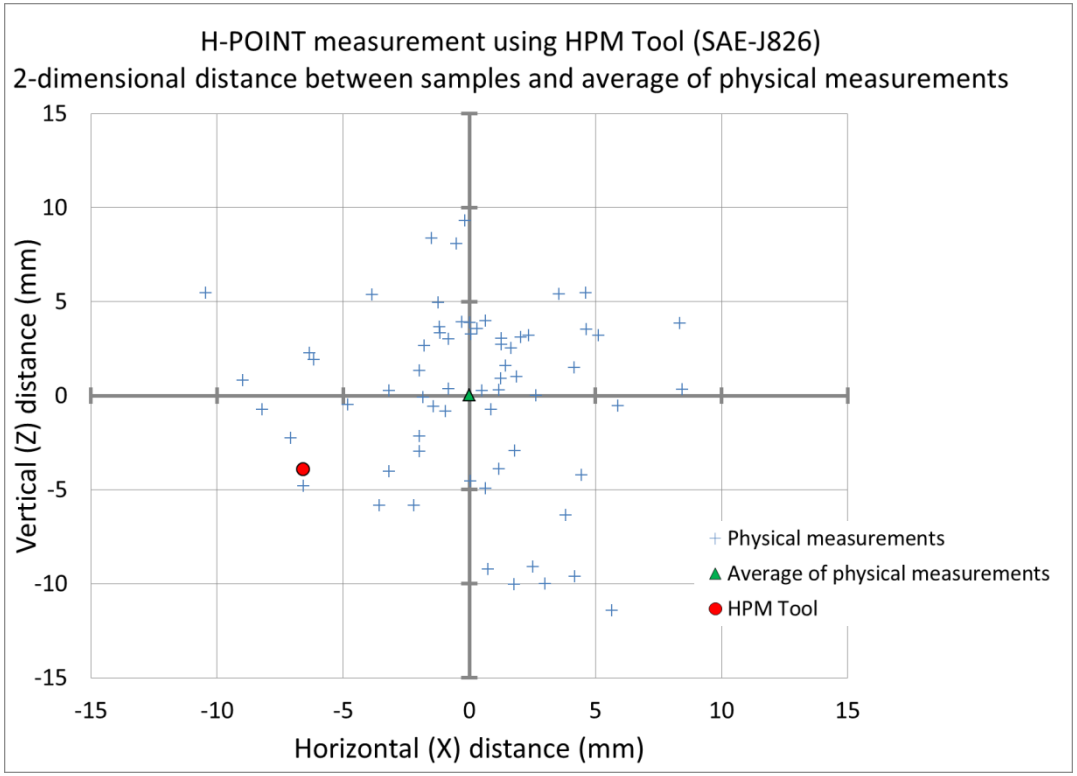
SgRP H-point measurement @ Futuris (Australia)



CAE simulation – final position

Red seat = “Design” position (SAE-J826)

Blue seat = Mid / 25° torso (EuroNCAP)

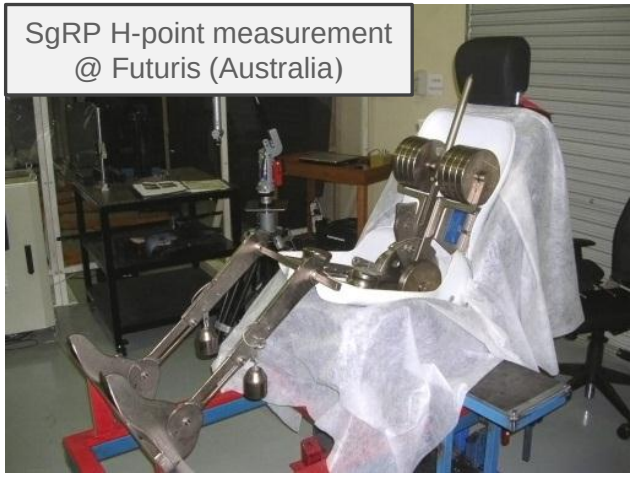


Validation - HPM tool (SAE-J826)

FUTURiS

Seat base and seatback set to “Design” (SgRP)

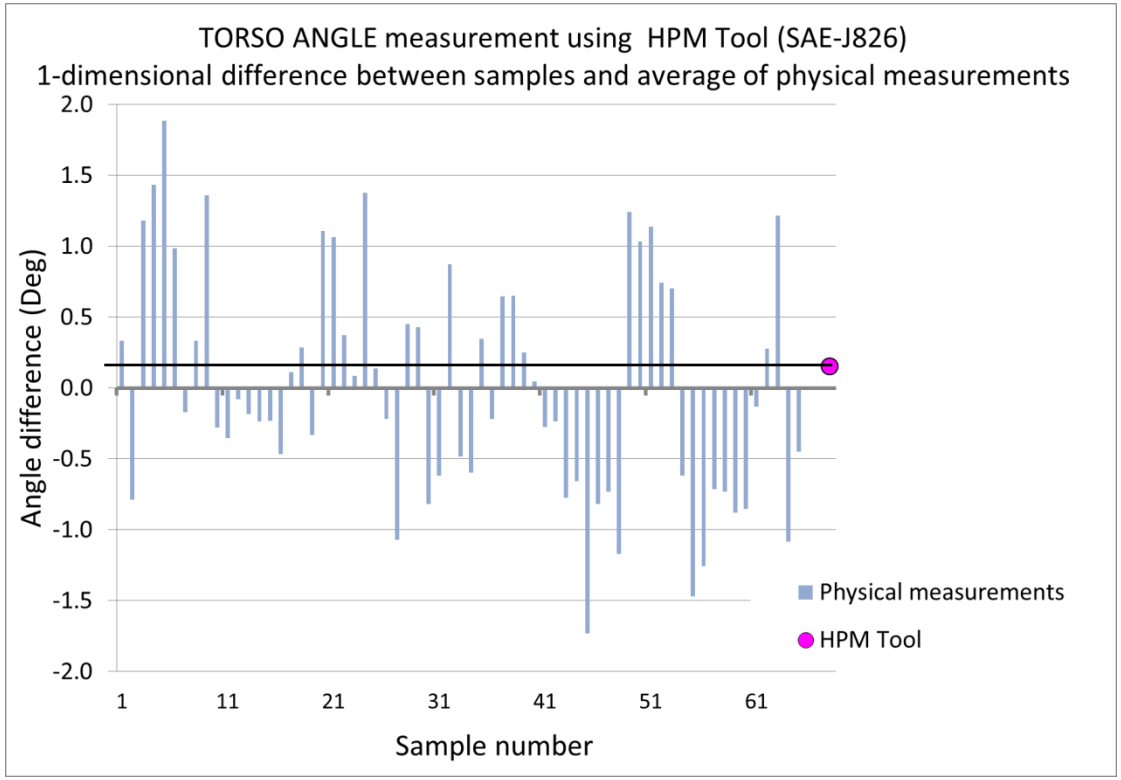
SgRP H-point measurement @ Futuris (Australia)



CAE simulation – final position

Red seat = “Design” position (SAE-J826)

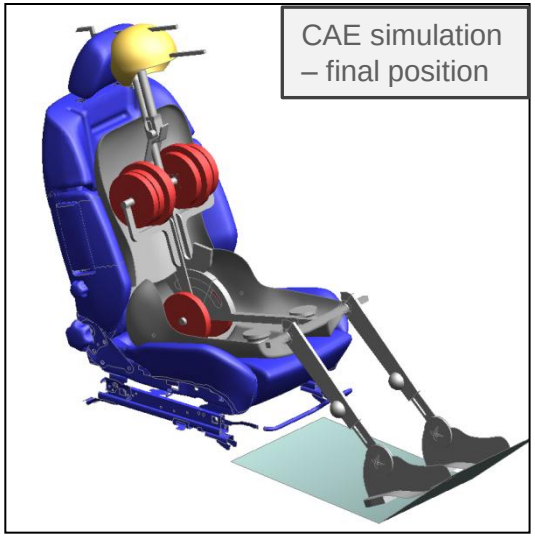
Blue seat = Mid / 25° torso (EuroNCAP)



Validation - HRMD tool (EuroNCAP)

Seat base in Mid, seatback to 25°torso angle

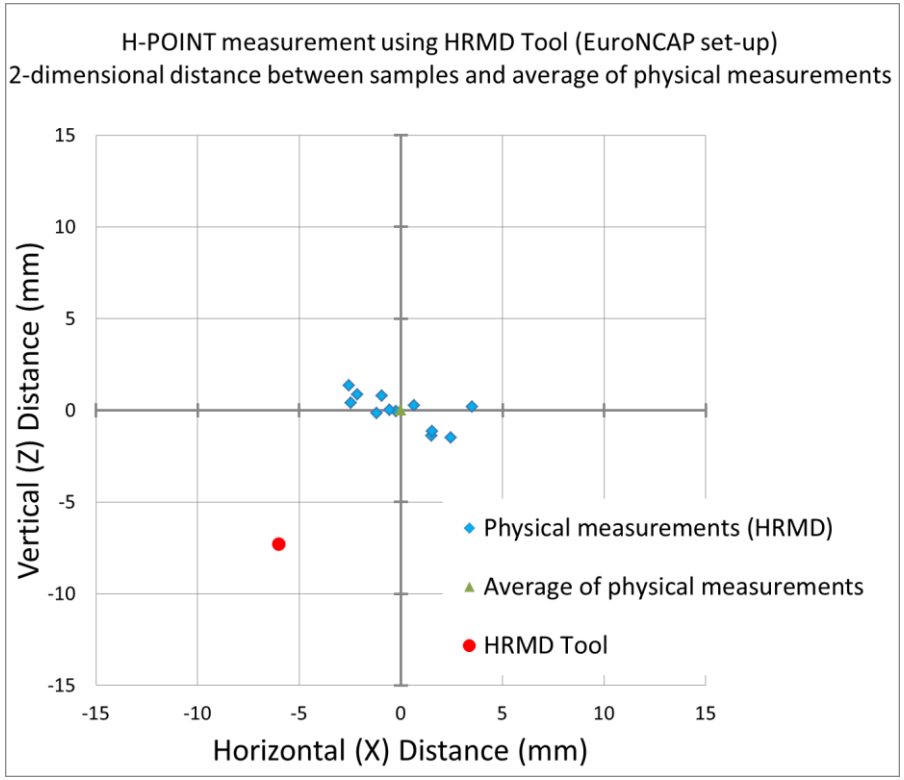
EuroNCAP backset measurement @ Thatcham (UK)



CAE simulation – final position

Red seat = "Design" position (SAE-J826)

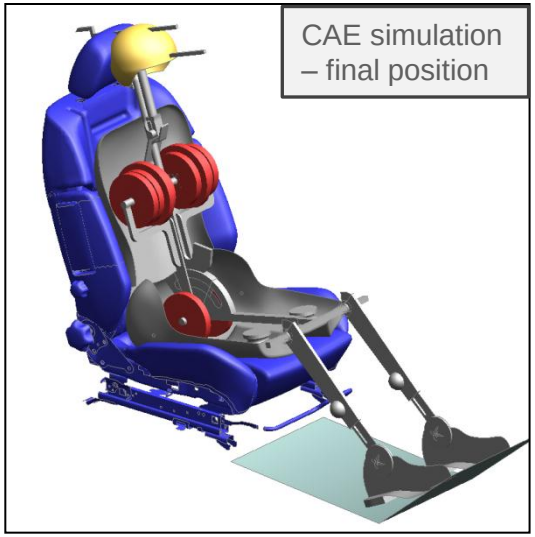
Blue seat = Mid / 25° torso (EuroNCAP)



Validation - HRMD tool (EuroNCAP)

Seat base in Mid, seatback to 25°torso angle

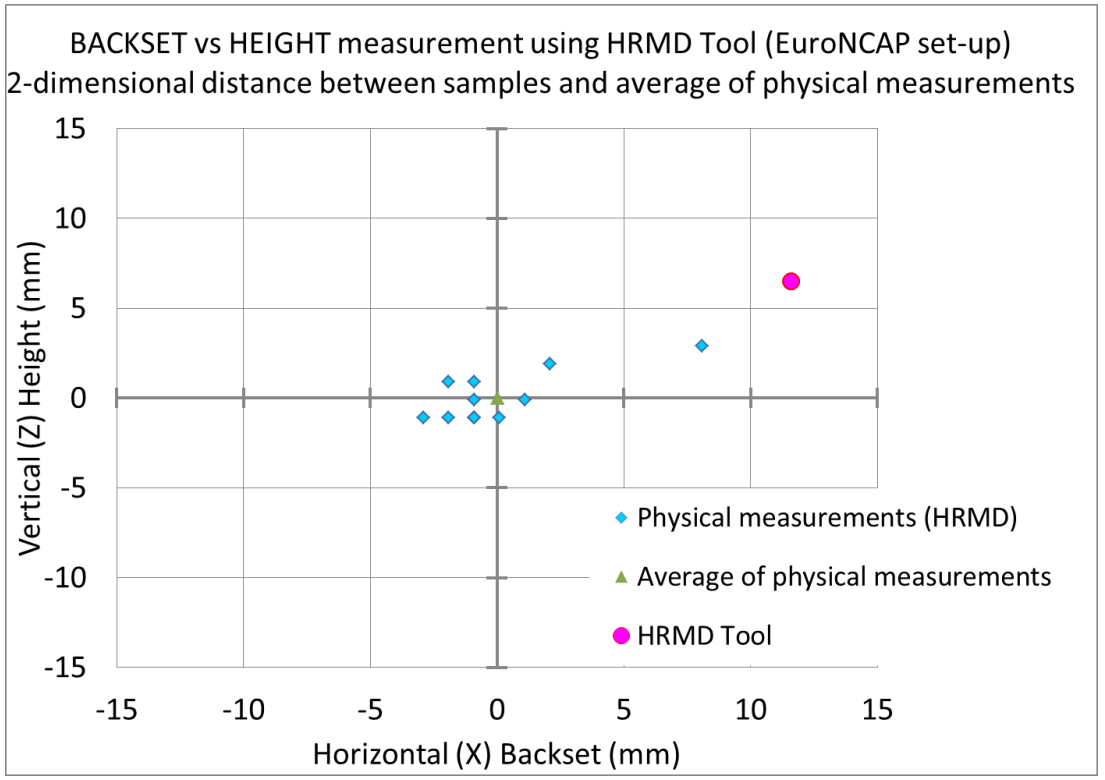
EuroNCAP backset measurement @ Thatcham (UK)



CAE simulation – final position

Red seat = "Design" position (SAE-J826)

Blue seat = Mid / 25° torso (EuroNCAP)



Validation

- With the seat base and seatback in “Design” as per SAE-J826, the HPM tool predicted:
  - H-point less than 6.6mm (X) and 3.9mm (Z) from average of 65 physical samples
  - Torso angle less than 0.1° from average of 65 physical samples
- With the seat base in Mid and the seatback set to 25° torso angle, the HRMD tool predicted:
  - H-point less than 6.0mm (X) and 7.3mm (Z) from average of 12 physical samples
  - Horizontal backset less than 11.6mm, head vertical height less than 6.5mm from average of 12 physical samples
- Considering the tolerance of physical samples (usually H-point ± 10mm), the tools showed very good correlation to physical samples.
- Extensive verification studies were also undertaken, as summarized on next page.

Verification

- Extensive verification studies were undertaken, where sensitivity to several variables was monitored, such as: versions of LS-DYNA, units, single versus double precision, SMP versus MPP.
- LS-DYNA version R7.0.0 was generally used. However, a comparison was done using 971 R6.1.1 and this showed no significant difference in results. Please note that the models require LS-DYNA 971 R6.0.0 or more recent versions.
- The conclusions of the studies are per below:
  - The variation in CAE results for the HRMD tool was in the same order of magnitude as the test variation;
  - Units [m, s, kg], [mm, s, t] and [mm, ms, kg] (s1, s2 and s3) were tested. The study showed that the units have no impact on results.
  - Double precision gives more consistent results and dummy settles sooner (~3.5-4sec for this particular seat package) when compared to single precision. Based on this, the recommendation is to run double precision. The graph shows the results from the study.

Benefits of HPM and HRMD Analysis

- More confidence in Design H-Point,
- Understanding variability of H-Point position to seat parameters,
- More confidence for dummy positioning in safety loadcases, e.g. Front impact, Side impact, Whiplash analysis,
- Automated tool for predicting the static score for seat head restraint Euro-NCAP, C-NCAP, IIHS & NHTSA,
- Opportunity to adjust the seat/package design.

Thank You

Questions?