Developments in Occupant and Seat Modelling with Primer 9.3

German LS-DYNA Conference 2006

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Abstract

- There is constant pressure to reduce the time needed to process design data into crash results (mesh, assemble, create different crash cases, check, run, post-process). The meshing step has been reduced by batch meshing technology, and progress has been made in several other areas such as automatic post-processing. Attention is now turning to the remaining bottlenecks, which include occupant and seat positioning. These steps require careful manual work and cannot currently be automated. The problem is magnified by the large number of seat position/dummy combinations.
- It is intended that Primer Version 9.3 will solve these problems, by providing fast methods of dummy positioning, seat positioning, seat foam compression, and belt fitting. The development work is not complete at this time; the paper gives a brief overview of work-in-progress and future direction.

Contents

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Motivation

- Crash model assembly:
  - 30-40 full vehicle crash cases, of which at least half include a dummy
  - Some crash cases must be analysed with several dummy and seat positions (front/mid/rear, highest/mid/lowest, etc)
  - Consider also analysis for restraints and interiors (cockpit/HYGE sled type), FMVSS 208, etc
- Total number of seat/dummy/belt/position combinations typically 20-40
  - When the design changes, some or all of these must be re-assembled
- Total man-time spent on dummy/seat model assembly tasks can be 1 to 4 weeks per design iteration
- This time has not reduced, while meshing and other tasks are now very much quicker
- We aim to cut this time by 5x or 10x.
- Even more benefit for preparing optimisation/stochastic analysis

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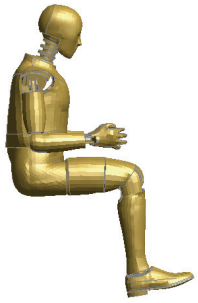
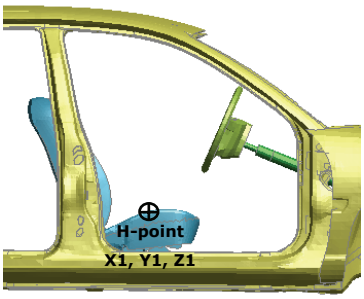
Motivation

Start with vehicle, seat, dummy, and required H-point





- H-point, interior
- Position seat
- Position dummy
- Seat foam
- Fit belt
- Write INCLUDE files

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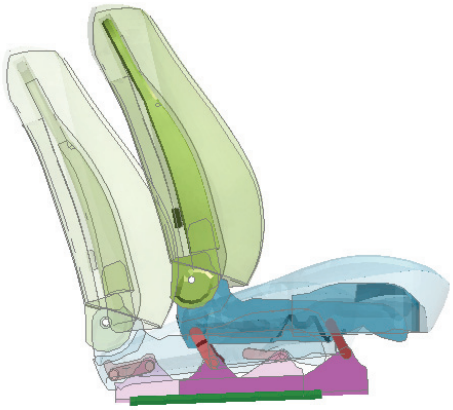
Motivation



Both the slides and the linkage must be set correctly to obtain the desired height and fore/aft position. The cushion angle depends on the mechanism action. This requires geometry from CAD, or tedious trial-and-error.

- H-point, interior
- Position seat
- Position dummy
- Seat foam
- Fit belt
- Write INCLUDE files

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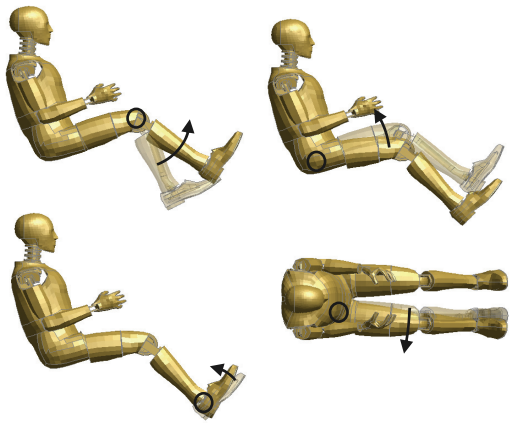
Motivation



The foot position is determined by the combined effect of 7 joint rotations. Rotating each joint in turn (the usual method), it is difficult to control the final position of the foot, e.g. to place the foot on the footrest. Similarly, the hand position is determined by 6 joint angles.

- H-point, interior
- Position seat
- **Position dummy**
- Seat foam
- Fit belt
- Write INCLUDE files

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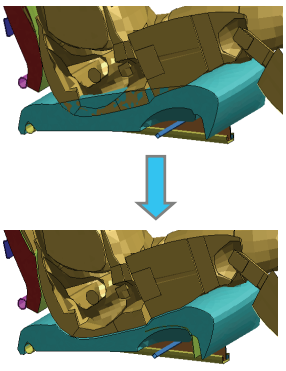
Motivation



- Make dummy rigid; lift dummy until no penetration
- Create Boundary Conditions to move dummy back to correct H-point
- Run LS-DYNA
- Cut deformed coords of foam nodes, paste into keyword file

- H-point, interior
- Position seat
- Position dummy
- **Seat foam**
- Fit belt
- Write INCLUDE files

This process can take 30mins-4hrs per dummy/seat combination

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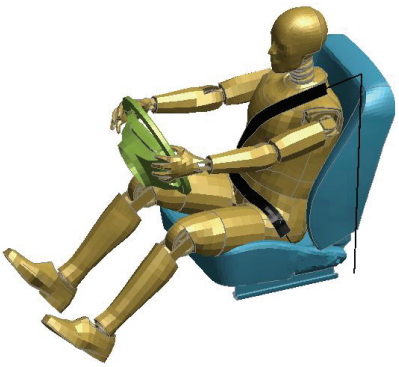
Motivation



Belt-fitting takes about 10-20mins but must be repeated for each dummy and each position

- H-point, interior
- Position seat
- Position dummy
- Seat foam
- **Fit belt**
- Write INCLUDE files

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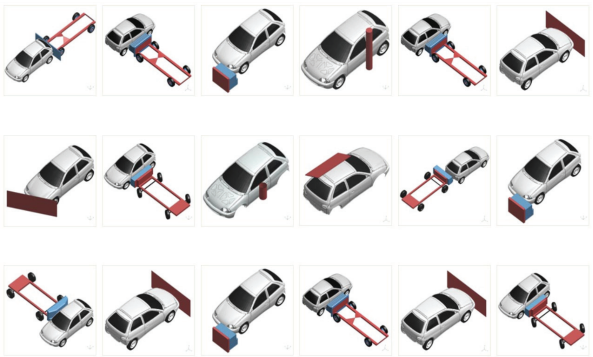
Motivation



We now have a data management exercise to ensure that every analysis uses the correct INCLUDE files.

- H-point, interior
- Position seat
- Position dummy
- Seat foam
- Fit belt
- **Write INCLUDE files**

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Contents

Motivation

New Primer features for seat and dummy – Slides & Demo

- **Seat positioning**
- **Dummy positioning**
- **Seat foam compression**
- **Model organisation**
- **IPP impact**

Conclusions

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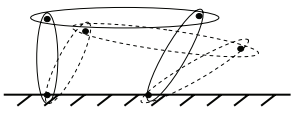
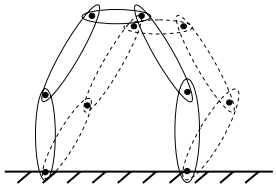
Mechanisms

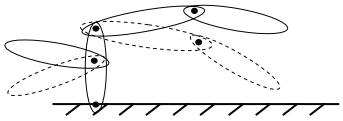
Determinate: 1 DoF



Indeterminate: >1 DoF



Tree: DoF = No. of joints



- Need to solve to find possible joint angles or part positions
- Matrix methods available from robot technology – well suited to determinate systems
- Iterative methods are more CPU-intensive but cope better with nonlinearities such as joint stop-angles, contact, etc.
- Primer now has an iterative mechanisms solver.

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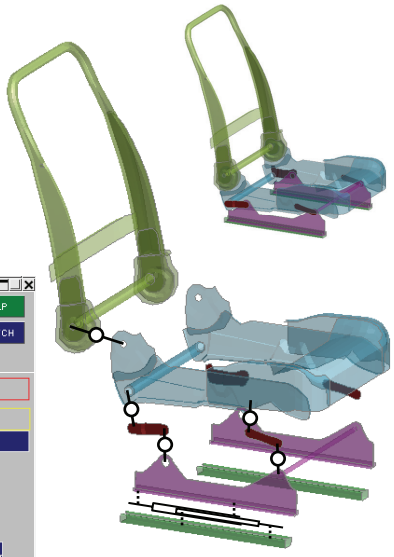
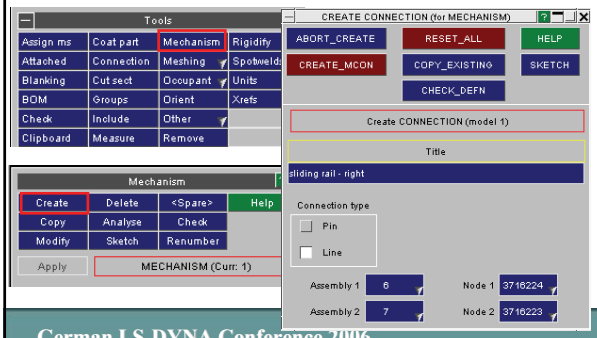
Mechanism definition

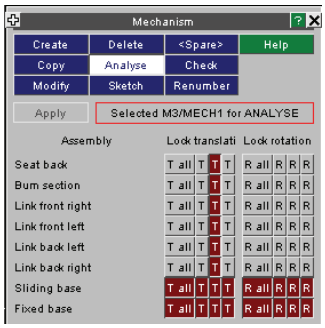
- New menu to create mechanisms – can also create dummy tree file
- Assemblies identified by Parts or Part Sets, e.g. back, squab, front and rear links, etc
- Joints defined at picked node – an LS-DYNA joint is not necessary
- Joint types: pin, hinge, sliding

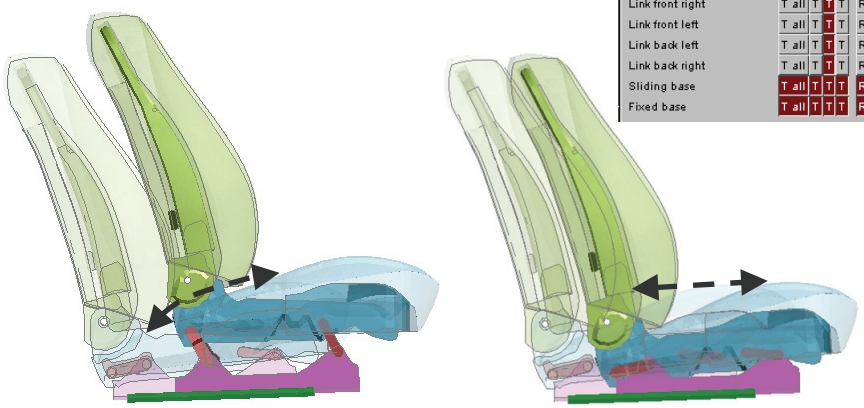




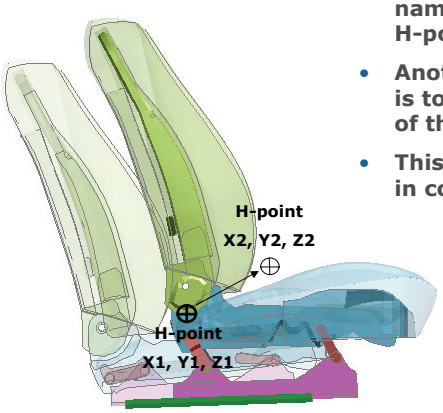
Application to seats

- "Analyse" function offers list of assemblies with translational and rotational restraints.
- Depending on restraints, we can drag just the slides, just the 4-bar linkage, or both.





Application to seats



- Mechanisms may contain named reference points (e.g. H-point)
- Another option for positioning is to type the new coordinates of the reference point
- This method will be available in command files

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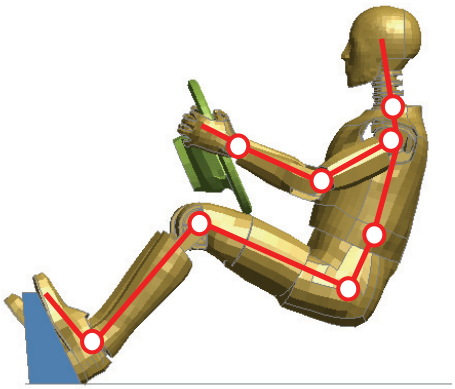
Application to dummies



- A dummy is also a mechanism.
- Typically it is under-constrained – several different configurations are possible for any given position of hand, foot, etc
- We may want to restrain different parts of the dummy; then it may become determinate, or over-constrained.
- Primer can use the dummy's tree file to enable the dummy to be treated like a mechanism.
- Joint stop-angles are important, and the user may want to opt to consider contact while dragging.

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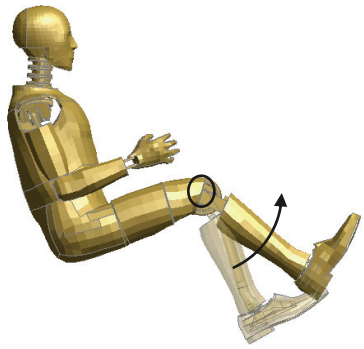
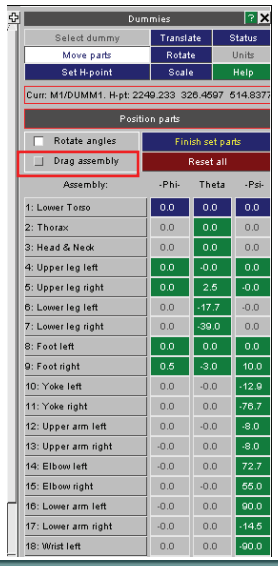
Application to dummies

- Primer's existing menu for rotating dummy's joints
- To use the new "mechanism" capability, simply switch to Drag Assembly. Primer generates the necessary data automatically using the dummy's tree file.





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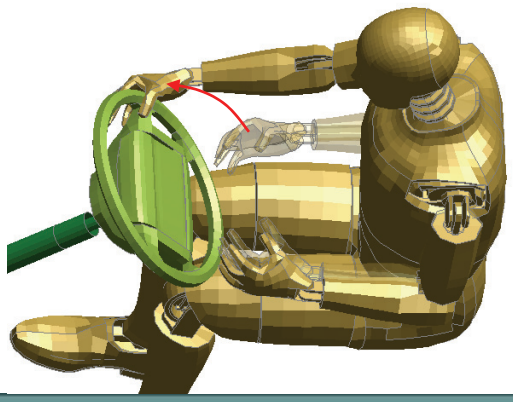
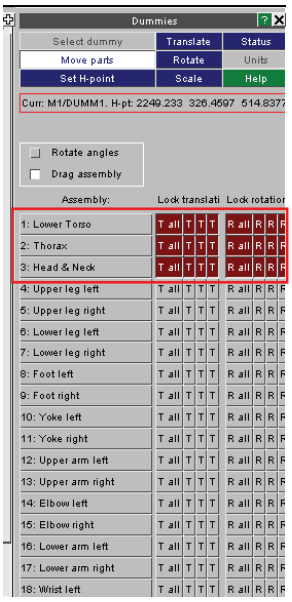
Application to dummies

- The Drag menu offers translational and rotational restraints for each assembly
- Use menu to restrain torso; drag hand onto steering wheel, drag foot onto footrest





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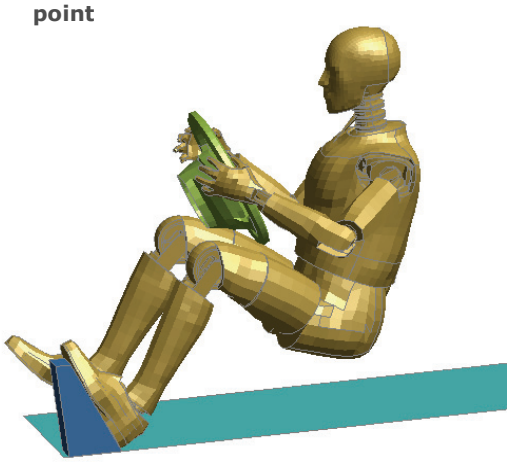
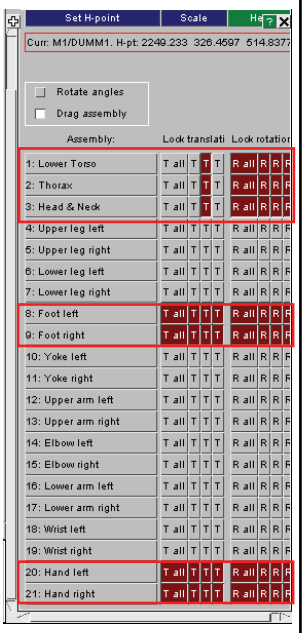
Application to dummies

- Use menu to restrain hands and feet, release X and Z translations of torso.
- Drag torso into new position, or type new H-point





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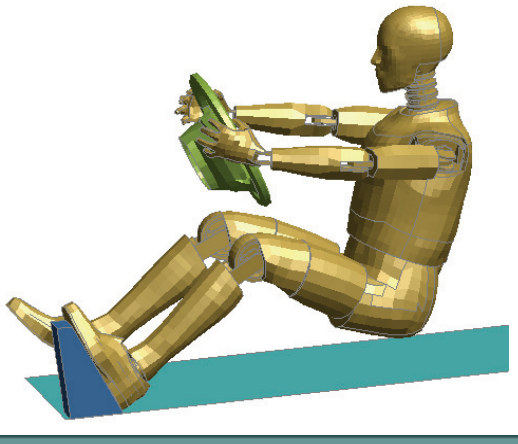

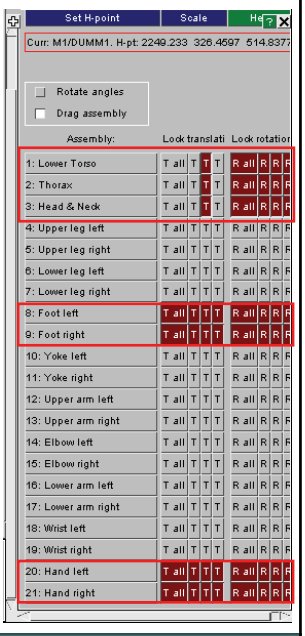

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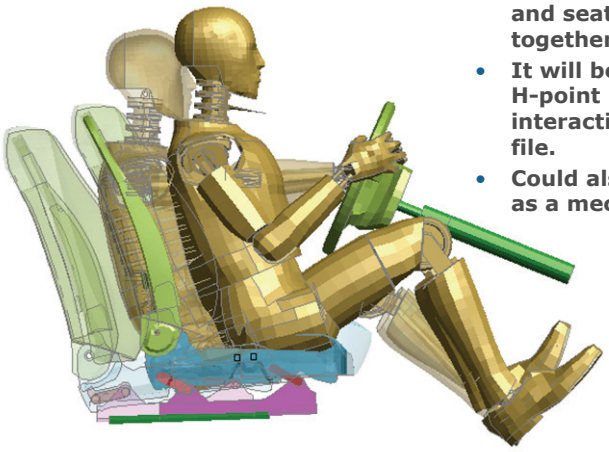
Combined mechanisms



- One mechanism may be linked to another, e.g. seat squab to dummy pelvis. Then the dummy and seat can be dragged together in a single action.
- It will be possible to set a new H-point position simply, interactively or in a command file.
- Could also add steering column as a mechanism

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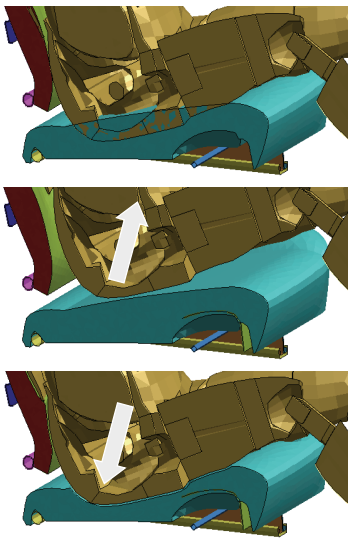
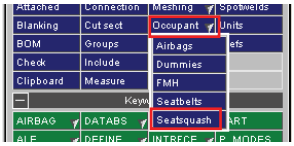
Seat foam compression





New feature in Primer:

- Dummy has been positioned, penetrating the foam
- User invokes Seat Squash feature, selects the dummy/seat contact and the top and bottom surfaces of the foam.
- Primer raises dummy until there are no penetrations.
- Primer pushes the dummy back down, compressing the foam evenly to prevent penetrations.
- Option for output of *INITIAL_FOAM_REFERENCE_GEOMETRY

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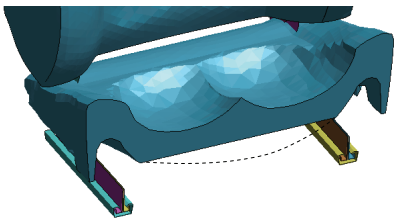
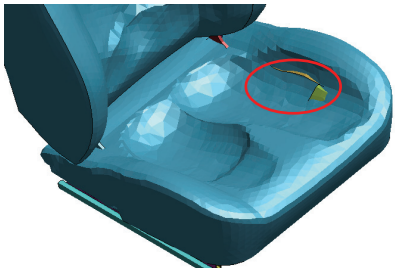
Foam compression - remaining issues





- **Element quality checks and prevention of excessive deformation**
- **Detecting when the requested occupant position penetrates the seat structure**
- **Effects of precompression on material properties: some of the crush is used up**
- **How to allow suspension to deform?**
- **Initial stress considerations:**
  - Option to use *INITIAL_FOAM_REF_GEOM
  - Actual strain distribution should depend on material properties
  - For equilibrium, we should also precompress the dummy and use gravity
  - To perform precompression properly will require LS-DYNA run

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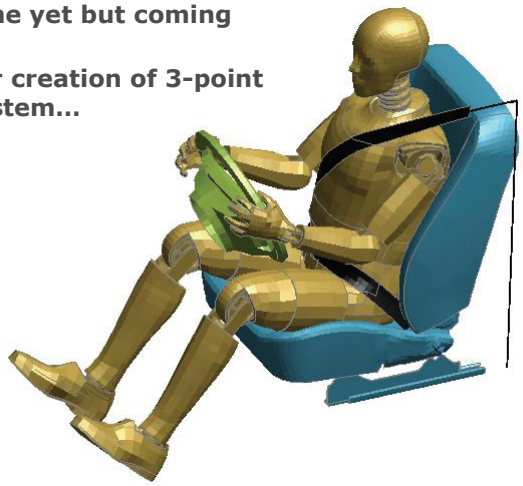
Belt fit & re-fit

- **Not done yet but coming soon:**
- **Quicker creation of 3-point belt system...**



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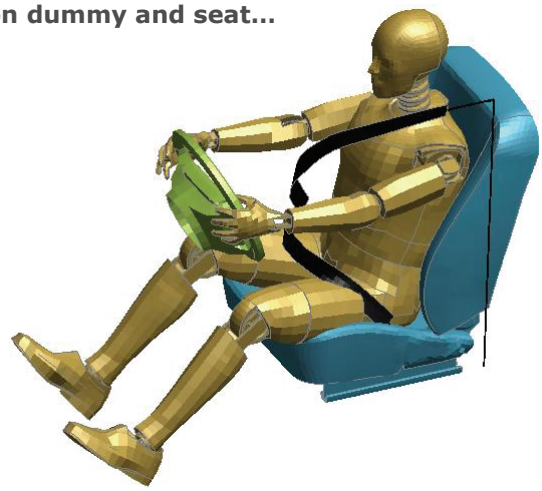
Belt fit & re-fit

- Reposition dummy and seat...



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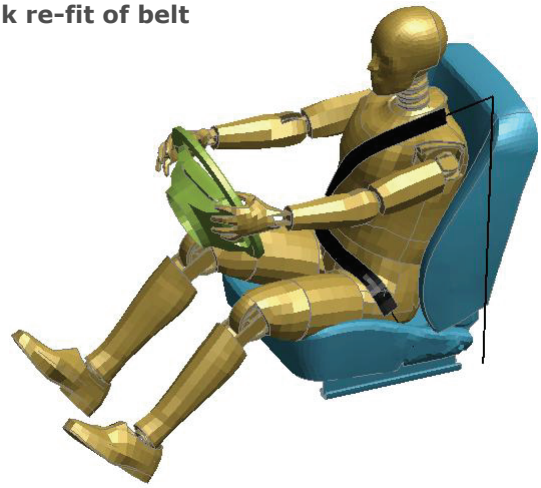
Belt fit & re-fit

- Very quick re-fit of belt



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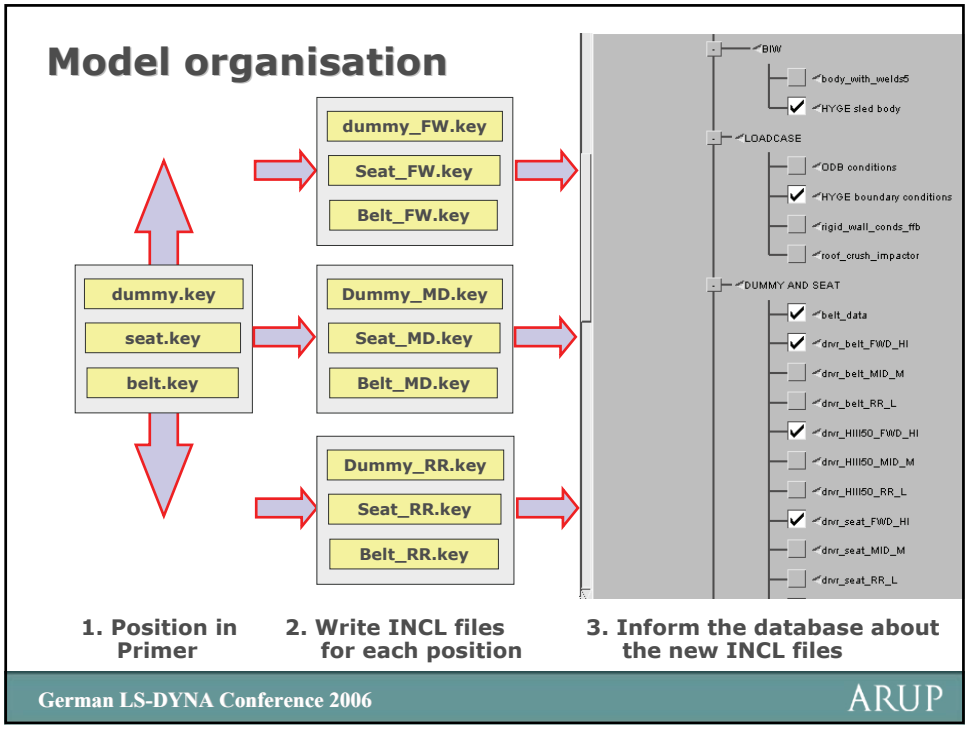
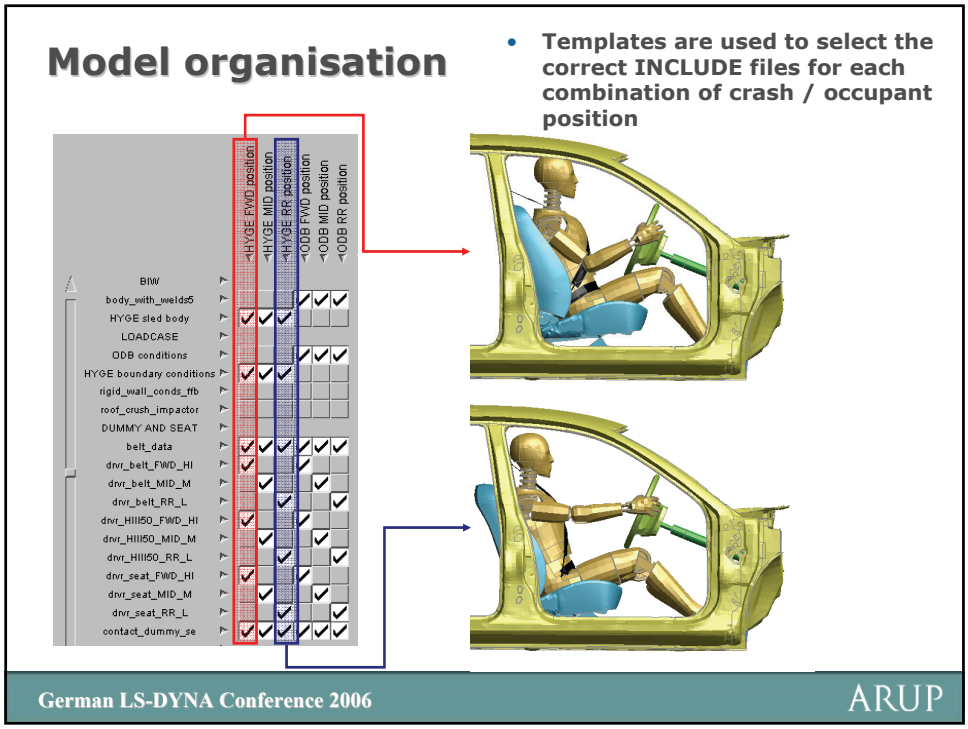
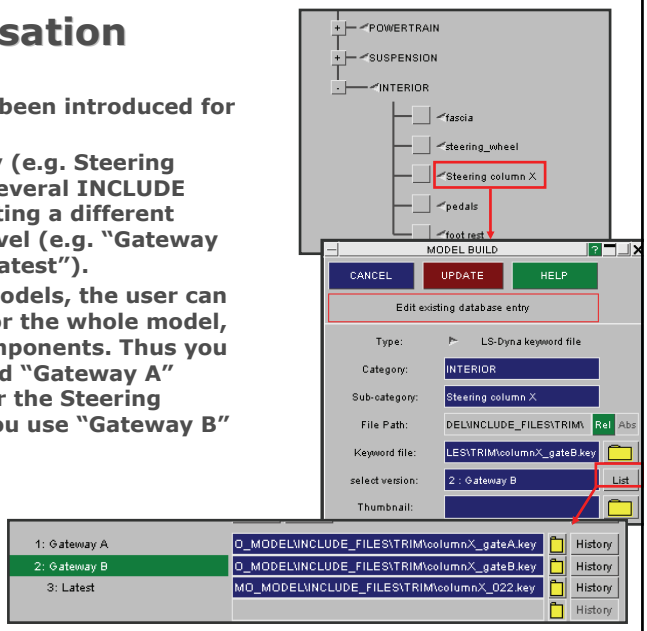




Model organisation

- Version control has been introduced for Primer 9.3.
- Each database entry (e.g. Steering Column) can have several INCLUDE files, each representing a different version or design level (e.g. "Gateway A", "Gateway B", "Latest").
- When assembling models, the user can select the version for the whole model, or for individual components. Thus you could choose to build "Gateway A" condition, except for the Steering Column for which you use "Gateway B"



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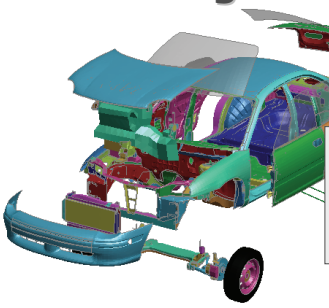
Model organisation

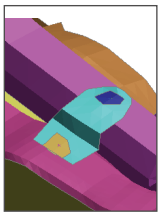


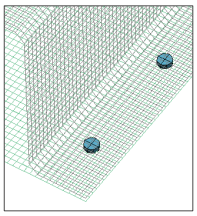
Unconnected parts

Connections file:
-Spotwelds
- Bolts
- Other types…

Assembled, connected and checked model

Primer's Database/Template system of model assembly has been extended to accept connection files. This method allows connections to be created during model assembly.





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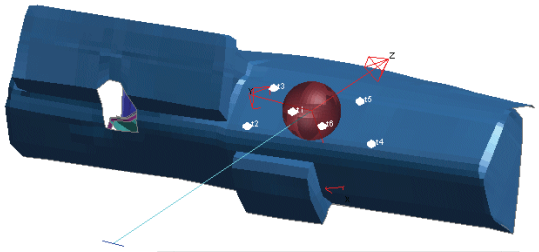
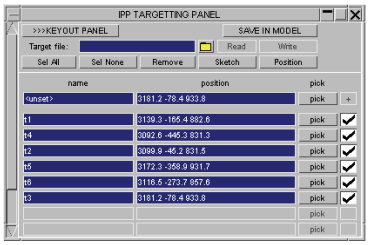
Instrument Panel Pendulum Impact



New feature – "IPP" model setup

- Target point definition & storage in model
- Position & depenetrate any impact point
- Batch process and multi-point auto-process



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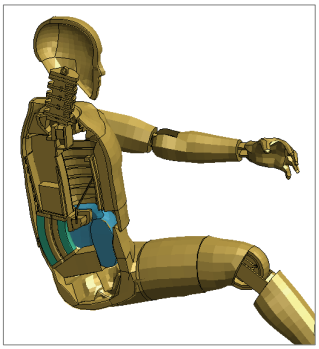
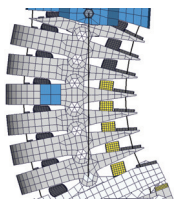
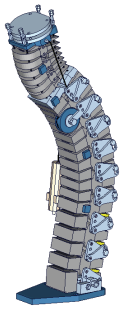
Future: Positioning deformable dummies?

- In future we want to position deformable parts of dummies
  - Bend lumbar spine
  - Compress foam
- Consider also human models and complex dummies such as BioRID
- Problem 1: positioning Problem 2: prestress







BioRID spine Courtesy of Dynamore

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Conclusions

- **Time taken to assemble and position occupant models will be greatly reduced by Primer 9.3**
  - Dummy positioning by dragging, while fixing selected parts
  - Seat mechanism definition and positioning by dragging or input of XYZ
  - Linked motion of mechanisms, e.g. dummy/seat/steering column
  - Seat foam compression
  - Belt re-fitting
  - Assembly of many crash cases including version control
  - Pendulum impact on IP
- **A beta version including most of the above will be available late 2006**
- **Come and talk to us at our booth!**

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Developments in Occupant and Seat Modelling with Primer 9.3

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