HyperCrash

A highly-tuned modeling environment
for crash analysis and safety evaluation
in the HyperWorks simulation framework

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Summary:

HyperCrash is a new preprocessing environment for LS-Dyna that offers a comprehensive toolset for all crash and safety modeling needs.
With a modern and intuitive graphic user interface, HyperCrash provides functions for fast model handling, easy load case definition, automatic connection creation and numerous checks to create highest-quality models. Tools such as dummy positioning and seatbelt routing are offered for the setup of the most challenging safety applications.
HyperCrash meets the needs of modern crash analysis environments with its multiple solver support. Interfaces to LS-Dyna, Radioss and PamCrash and also provides a powerful automatic solver conversion.

Keywords:

Preprocessing, crash, safety, conversion, assembly

1   Introduction

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HyperCrash meets the needs of modern crash analysis environments with its multiple solver support. Interfaces to LS-Dyna, Radioss and PamCrash also provides a powerful automatic solver conversion.

HyperCrash is not a completely new software. It was commercialized in 1998 by the Mecalog Group under the name of MCrash. When Altair Engineering acquired the Radioss technology suite in 2006, HyperCrash became part of Altair's **HyperWorks**, the most competitive open environment solution for crash analysis. Fig. 1 shows the positioning of HyperCrash within the HyperWorks environment.
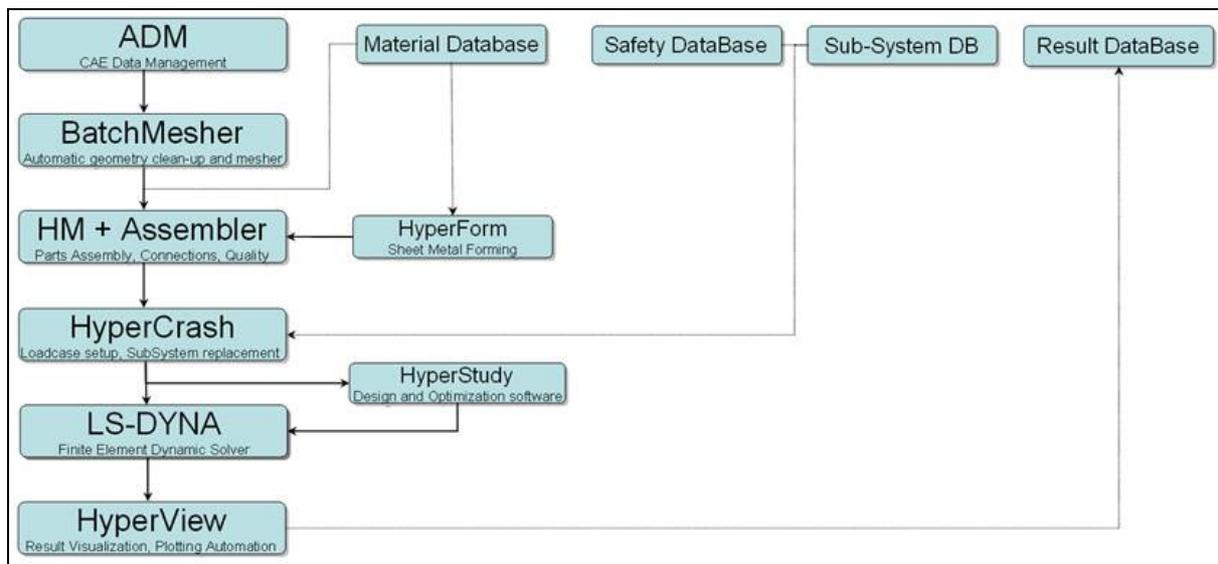

Fig. 1: Positioning and use of HyperCrash in the Altair HyperWorks environment.

2   Graphical user interface

The HyperCrash graphic user interface (GUI) provides intuitive and user-friendly features for efficient model manipulation and interrogation (see Fig. 2). Great attention has been placed to reduce mouse travel, decrease the number of clicks, and eliminate unnecessary validations. The toolbar gives easy access to the most frequently used functionalities like display control, masking, shading, etc. Furthermore, the bi-directional link between graphic display and Tree Browser assists with the display and organization of parts and subsets of the model.

2.1   The Tree Browser

The *Tree Browser* is the main control center where many essential functions are conducted, you can:
- assign material/property from a database (file system) to any part
- update the mesh of a part
- check the connectivity of the model
- export selected parts
- replace a part or a sub-system (see Section 2.4)

Uniformity between HyperCrash and other HyperWorks applications enhances the user experience and allows a quick start even for completely inexperienced users.
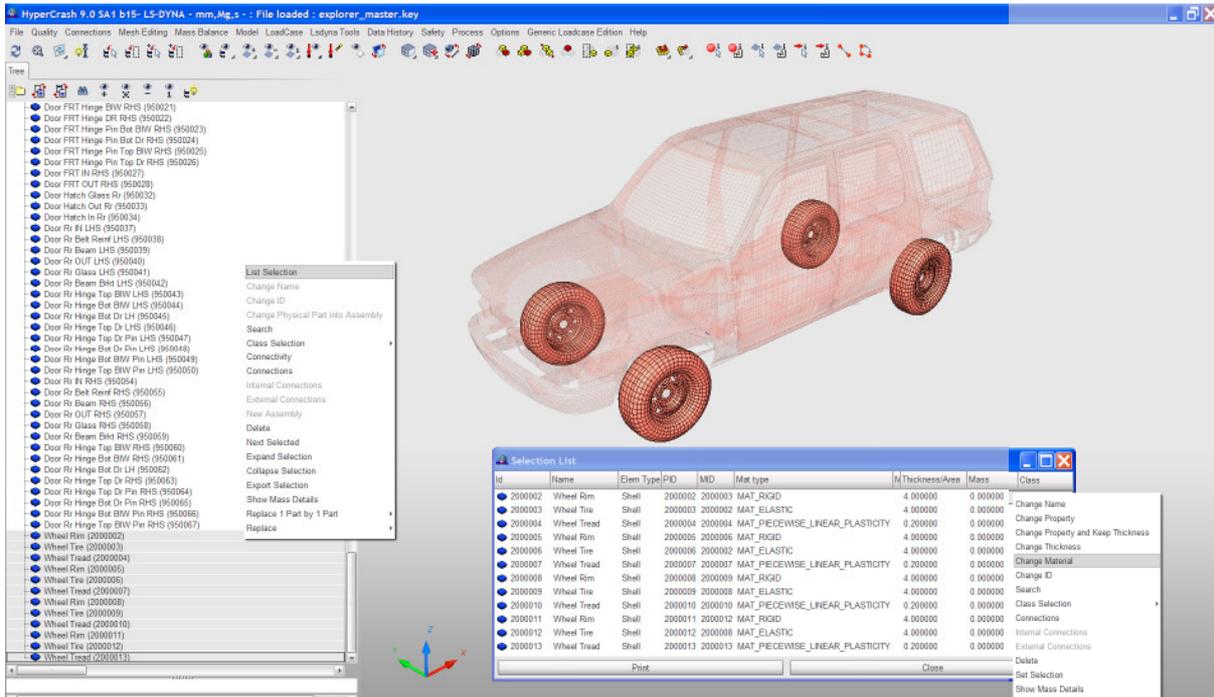
Fig. 2: HyperCrash GUI with Tree Browser and selection list.

2.2   Model and Include Browser

The Tree Browser describes only the parts and assemblies of a model; all the other CAE entities (materials, boundary conditions, contacts, include files, etc.) can be handled in the **Model Browser** (see Fig. 3).

The Model Browser has two viewing modes. The user has the option of viewing the entities as a flat list, or else the related include files can also be displayed. In this second mode, includes can easily be created and edited. Also, a cross-reference viewer can be invoked for each entity in either mode.
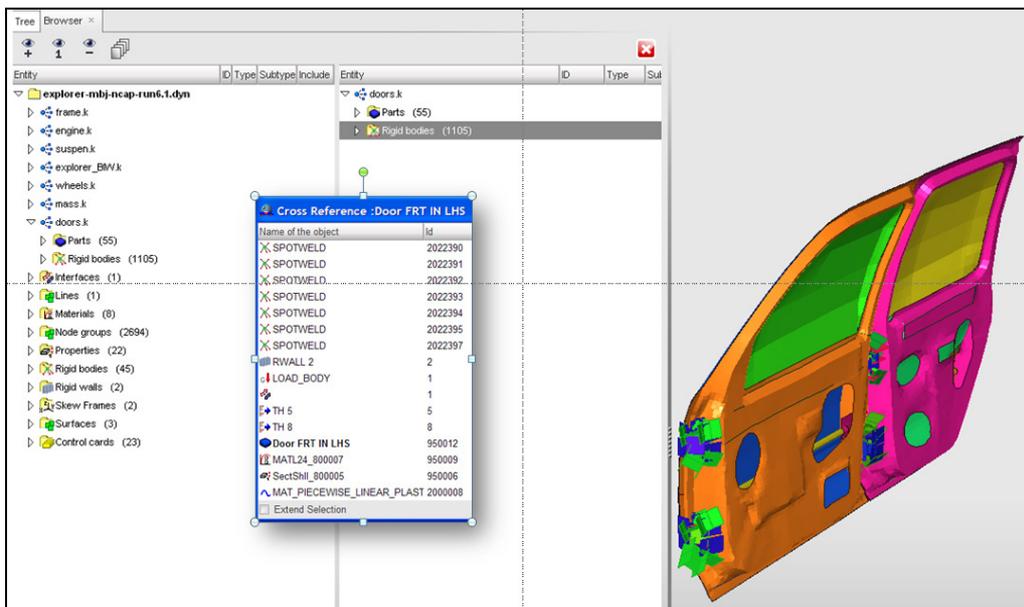

Fig. 3: Model Browser with include file management and cross-reference viewer display. The list shows material and property of part "Door FRT IN LHS" (bold) as well as all entities (spotwelds, time history sets, contact definition, rigid wall, gravity load) that have a reference to this part.

2.3   Transformations

The use of transformations in CAE crash analysis has emerged as common practice when dealing with modules such as barriers and dummies, kept in company-enforced databases and used for different crash simulations. The use of transformations allows keeping these modules unchanged in a "neutral" position by indirectly applying the target movement and ID offset to the FE entities with a transformation matrix. The transformation manager provides easy and intuitive functionalities to manage the individual positioning in these scenarios.
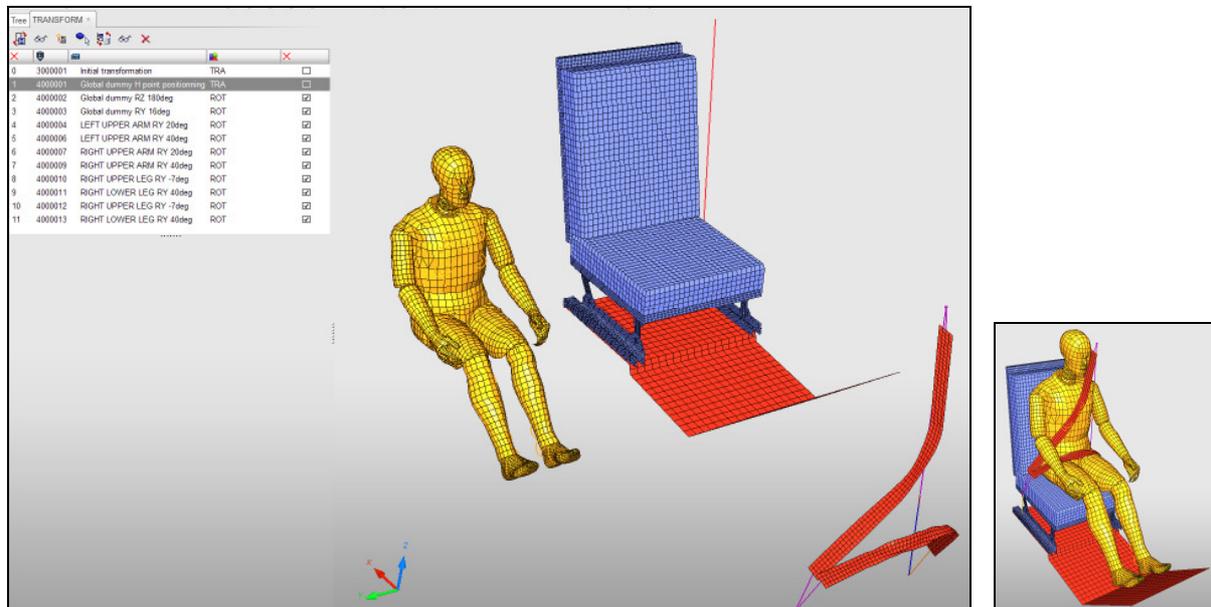

Fig. 4: The transformation manager provides a list of available transformations in the model. The positioning of the dummy and the belt system is deactivated in the left screenshot.

2.4   Replace parts/sub-systems

Single parts or complete sub-systems can be replaced automatically. All option sets will be recreated (with user validation and check, see Fig. 5):
  – connections (spotwelds and bolts)
  – interfaces involving the whole replaced system
  – added masses
  – boundary conditions
  – initial velocities
  – loads (imposed velocities and forces)
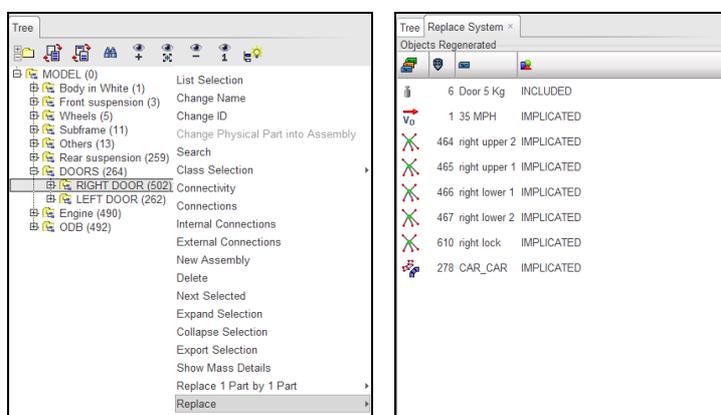 – connected rigid bodies and 1-D elements

Fig. 5: In the replace system window, the list of the features rebuilt by HyperCrash is displayed.

2.5   Solver conversion

HyperCrash provides interfaces to several different crash solvers and a powerful conversion framework that can be used to convert models between different solver formats. The tool is based on engineering know-how to convert most of the model definitions, material cards and solver parameters.
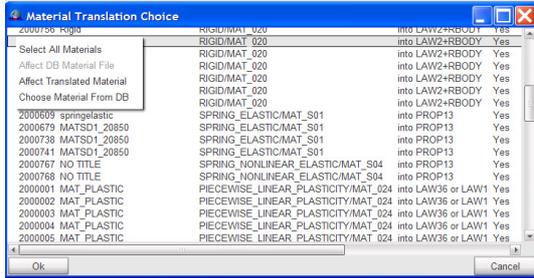

Fig. 6: Material conversion between LS-Dyna and Radioss.

3   Model checks

The **Quality Module** offers the following model checks (see Fig. 7):
– element quality
– check and automatic removal of intersections
– check and automatic removal of penetrations according to the true gap between parts (defined with thickness) or according to the defined gap in the interface
– check of the connectivity between parts

A global model check with several automatic fix tools helps to avoid modeling errors such as incompatible kinetic conditions, unlinked elements, unused entities, etc.
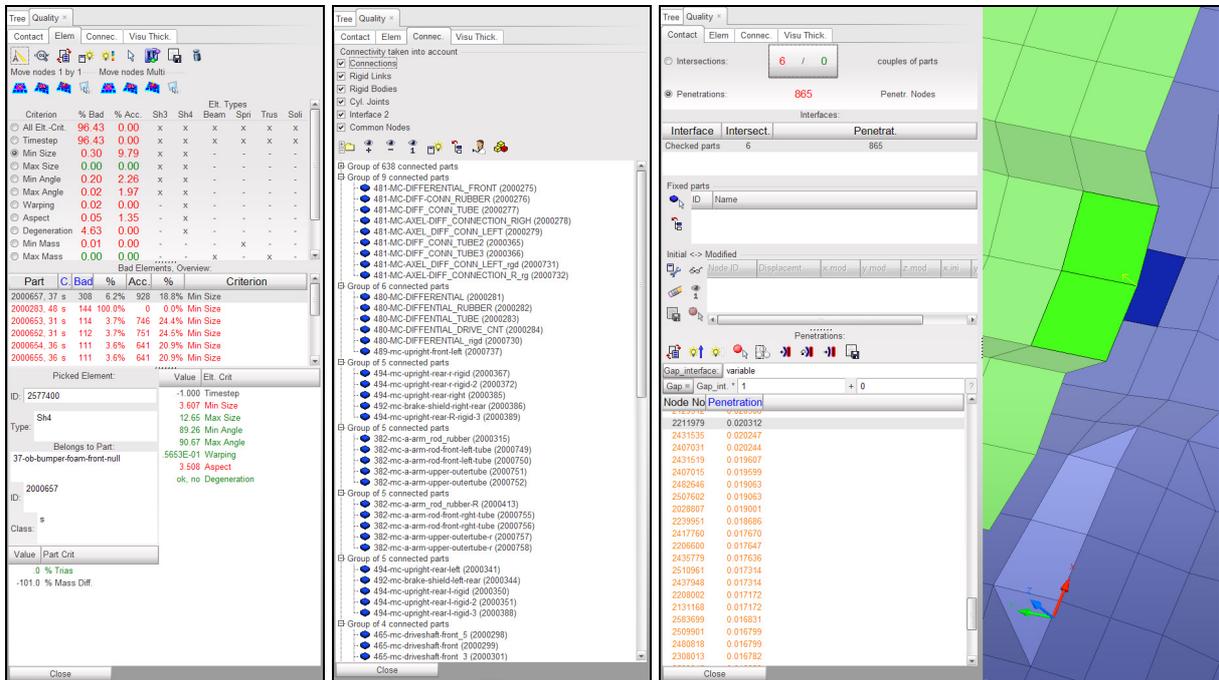

Fig. 7: Examples for element quality check, part connection check and intersection/penetration check.

4   Connections

Meshless spotweld connections can be handled in the **Connection Module** (see Fig. 8). HyperCrash will create the connection according to the output format and the parameters set in the environment

files. The connection information is always saved with the model, so HyperCrash is able to automatically rebuild the connection in case of part/component replacement, material/property modification or mesh modification (translation, element deletion, etc.). Import/export of the connection information is also available with different text file formats.
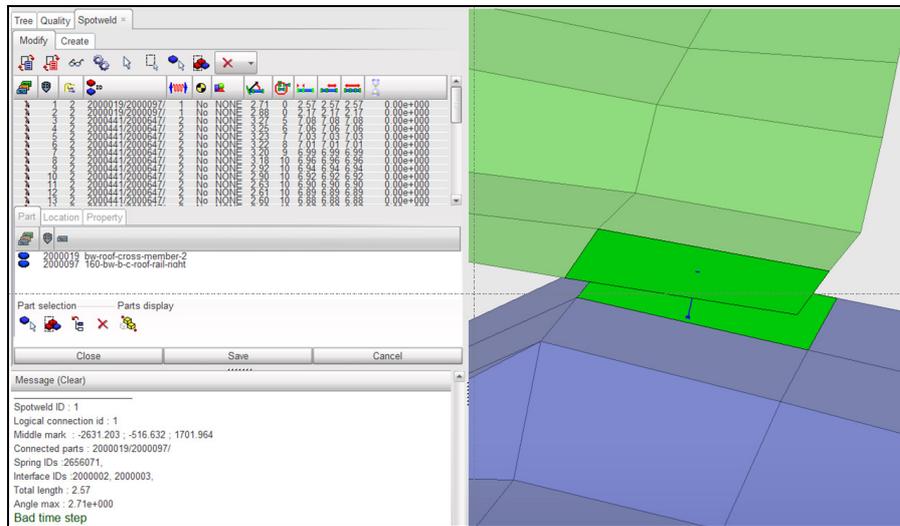

Fig. 8: Connector information can be imported from file. Connected parts, location of the spotweld and properties can be checked/modified in the Spotweld Browser.

5   Mesh Editing

The **Mesh Editing Module** offers the following options (see Fig. 9):
- create nodes by coordinates, between nodes or by duplicating existing nodes
- create beams, springs, trusses, shells and solid elements
- move nodes (translation, rotation, scaling, mirror)
- create, modify and check rigid bodies
- modify parts (split, merge, create stiffener)
- renumber the model or selected entities
- clean the model (i.e. remove all entities that are not used)

Note that this collection of tools is intended to perform simple modifications on the model. In the near future, some of the strong mesh editing features currently available in **HyperMesh** will be added to HyperCrash.
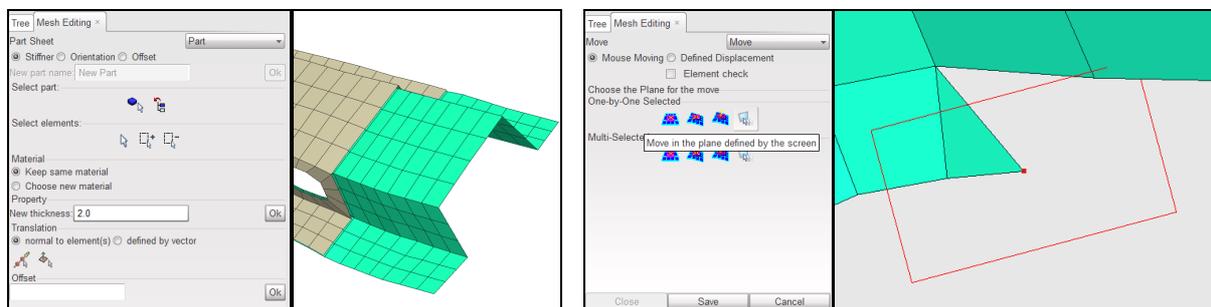

Fig. 9: Example of useful mesh editing tools, part stiffeners can be created automatically and nodes can be moved in plane defined by the screen.

6   Material and property definition

Material parameters and property definitions can be managed with a collection of powerful browser functionalities in HyperCrash, see Fig. 10. All material/property information can be found for selected

parts from the graphic display or Tree Browser. Conversely, all parts with selected material/property definition can be displayed. Material curves can be reviewed/edited in a separate function window and values can also be imported from file. Furthermore, access to "public" and/or "personal" material/property databases (file system) is possible.
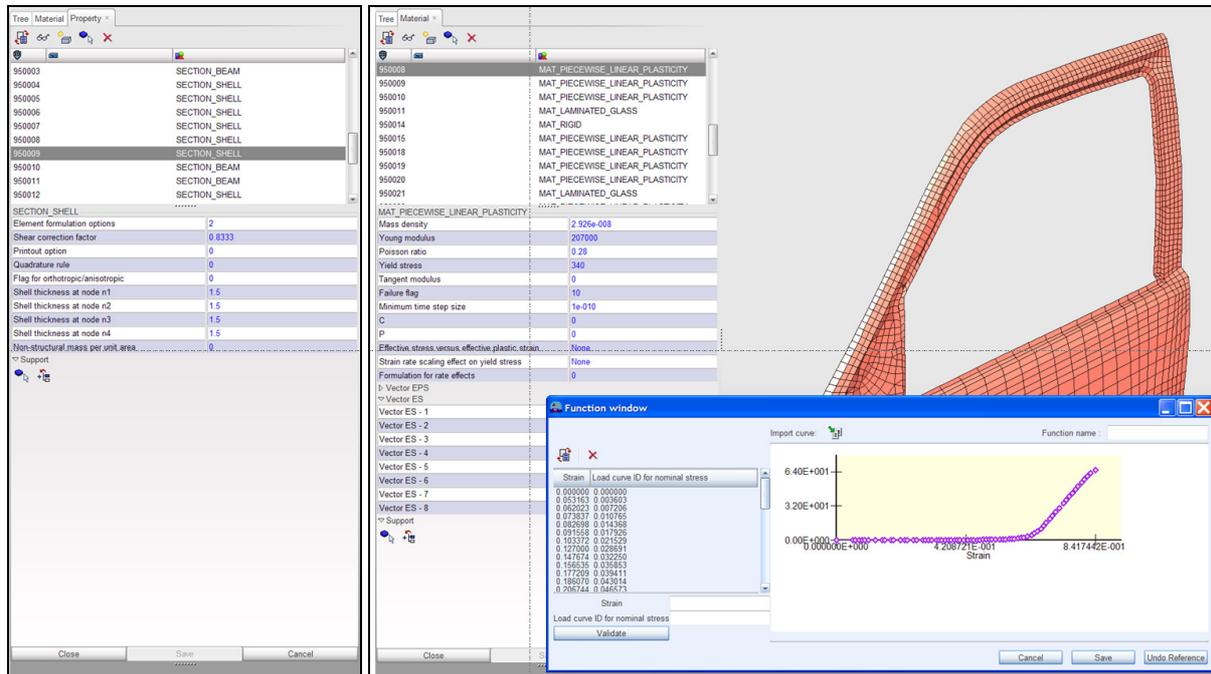

Fig. 10: Property and material browsers with separate function window for curve review.

7   Load case definitions and boundary conditions

The ***Load Case Module*** contains all necessary functions to set the load cases on a crash model, e.g. initial velocity, rigid wall, monitored volume, contact interfaces, etc. The panels provide all necessary functions to select nodes, elements or parts. All available parameters can be set and check routines are included. An intuitive visualization allows a clear and comprehensive review of the model.
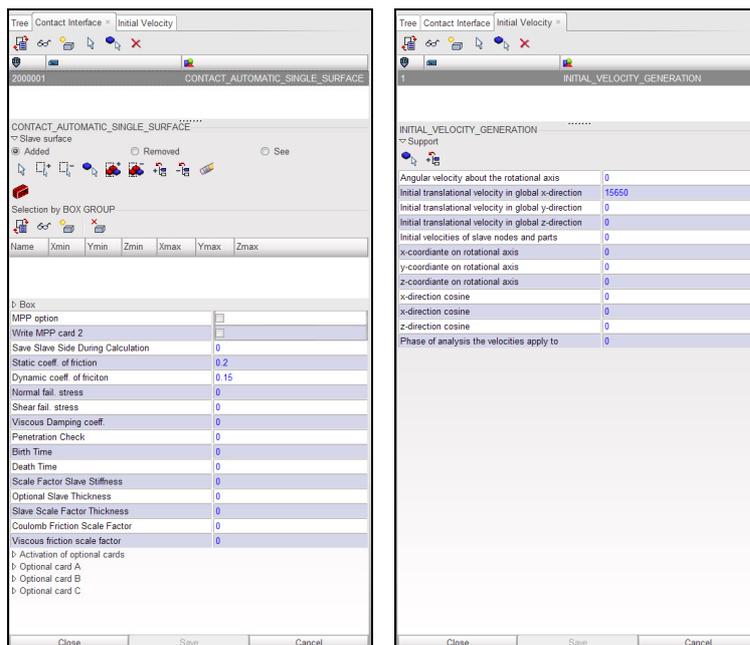

Fig. 11: Definition of LS-Dyna cards *CONTACT and *INITIAL_VELOCITY.

8   Solver control cards

All global model parameters and solver control cards can be managed in the ***Control Card Module***, see Fig. 12. Extended descriptions taken from the LS-Dyna manual and default values help to navigate through the huge list of possible solver settings.
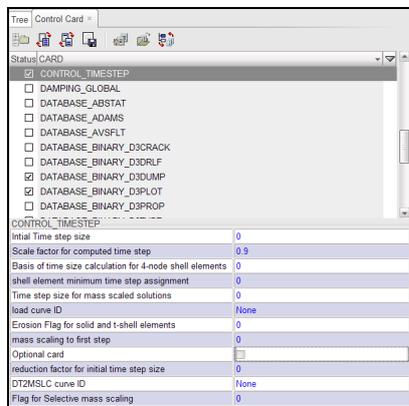

Fig. 12: Solver control card module, the example shows the definition of timestep control parameters.

9   Mass balance

The total mass, center of mass location and inertia of the model or a single part can be checked in this module. In the first step, HyperCrash automatically fits the mass of each part according to the prescribed mass (e.g. from CAD system). Added mass will be created.

Once the mass of all single parts is set, the total mass of the car can be balanced automatically according to a prescribed mass on the front and rear tires of the car (e.g. from an existing prototype, see Fig. 13). The existing added mass defined in the model will be modified according to defined rules in the software.
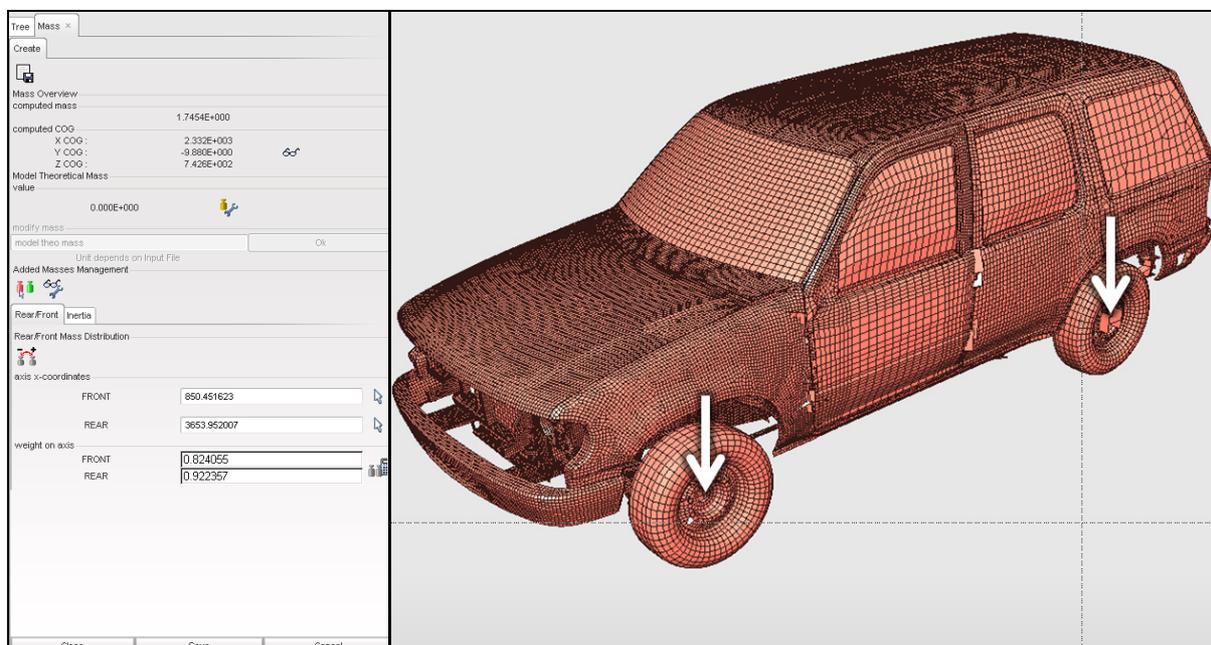

Fig. 13: Automatic mass balance with prescribed weight on the front/rear tires.

10   Safety tools

HyperCrash provides a complete toolbox to manage all features of modern safety models:

  - Dummy positioning tool
  - Seat belt editor
  - Seat deformer (morphing, geometrical deformation)
  - Airbag folder (geometrical folding followed by automatic meshing)

10.1 Dummy positioning and seatbelt routing

Dummy positioning in HyperCrash is based on a tree structure of the body. HyperCrash can interpret industry-standard tree structure definitions and review/position limbs of multiple dummies. Positioning can be performed with defined values or graphically. HyperCrash is able to create 1-D and 2-D seatbelts automatically. Guiding nodes and parameters like gap, width, material, etc. have to be prescribed. The information about the dummy positioning and the seatbelt creation are stored in a file, so it is possible to modify the position of the dummy and automatically update the seatbelt mesh.
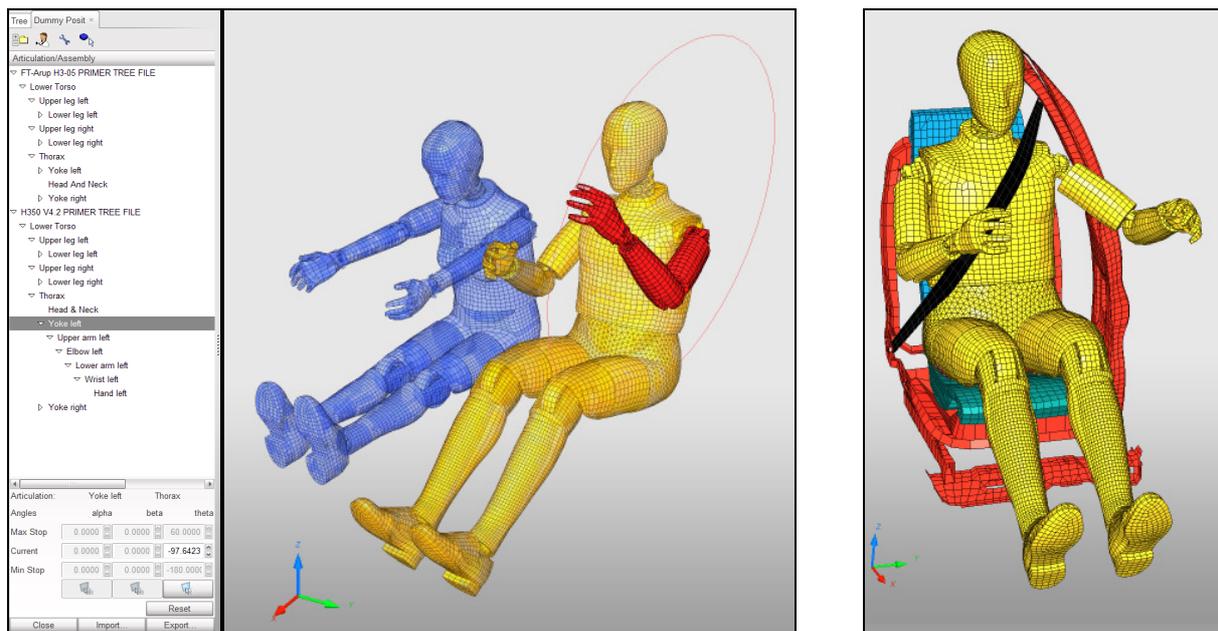

Fig. 14: Dummy positioning tool and seatbelt generator. The example shows the positioning of two Hybrid III 5% and 50% dummies with tree view in parallel.

10.2 Seat deformer

The seat foam can be deformed according to the intersection with the dummy model. The deformation will be smoothly spread on each layer of the solid foam. This geometrical deformation eliminates the need for a separate simulation to find the initial shape of the foam.
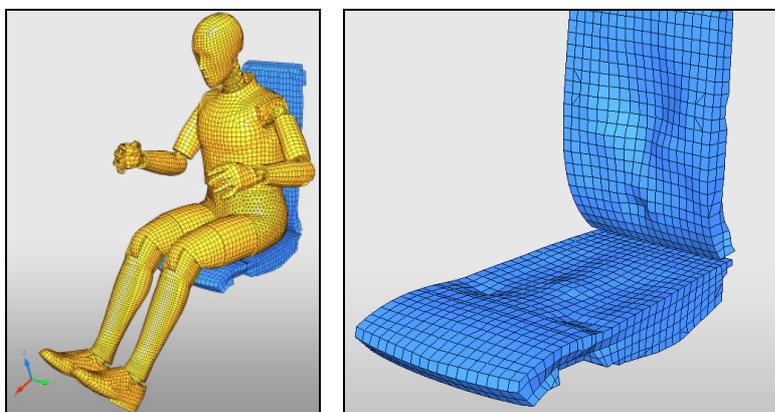

Fig. 15: Result of the deformed seat using the seat deformer.

10.3   Airbag folder

The airbag folder in HyperCrash is based on a geometric representation of a flattened airbag. All folding operations (zigzag, tuck, roll, etc.) are performed on the geometry. The folded airbag geometry will be meshed automatically and a reference mesh is provided.
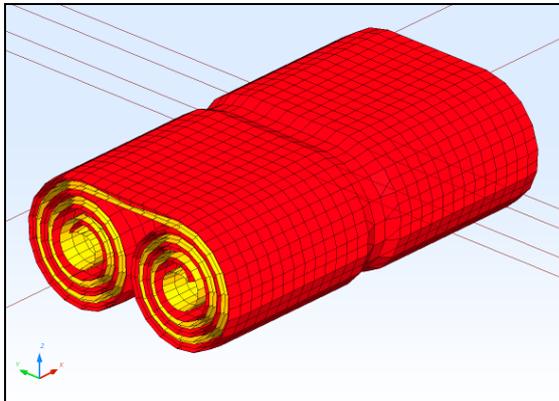

Fig. 16: Result of a folded and rolled circular airbag after automatic mesh generation.

11   Summary

HyperCrash is a new preprocessing environment for LS-Dyna that offers a comprehensive toolset for all crash and safety modeling needs. A modern and intuitive graphic user interface helps to navigate through the model and control the visualization. Parts and subsets are organized in the Tree Browser, while all other model entities are managed in the Model Browser. Both browsers contain powerful functions to replace parts, handle include files and transformations, review cross-references, etc. Material and property definitions are organized in separate browsers, material curves can be plotted/edited and all necessary parameters can be set. Several model checks like intersection/penetration, element quality and part connection are included and a global model check detects general modeling errors. HyperCrash contains basic mesh editing tools and several macros allow automatic mesh modifications (e.g. to create part stiffners). Connections (spotwelds, bolts, etc.) can be defined from coordinate lists and a browser helps to manage, visualize and edit the single entities. Similar browsers help to define loads, boundary conditions and solver control cards. All necessary parameters can be set and the model definitions can be reviewed fast and easily. For given weights on front/rear axis, HyperCrash is able to fit the total model mass by extra masses applied to a prescribed set of parts. Finally, powerful safety tools like dummy positioning, belt routing, seat deformer and airbag folder are included in HyperCrash.

Supported platforms: HyperCrash is available for 32bit and 64bit Windows PC, 32bit and 64 bit Linux PC and HP-UX Unix workstations.

For further information on HyperCrash and all other HyperWorks applications please contact

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