Oasys PRIMER
Model Checking & QA

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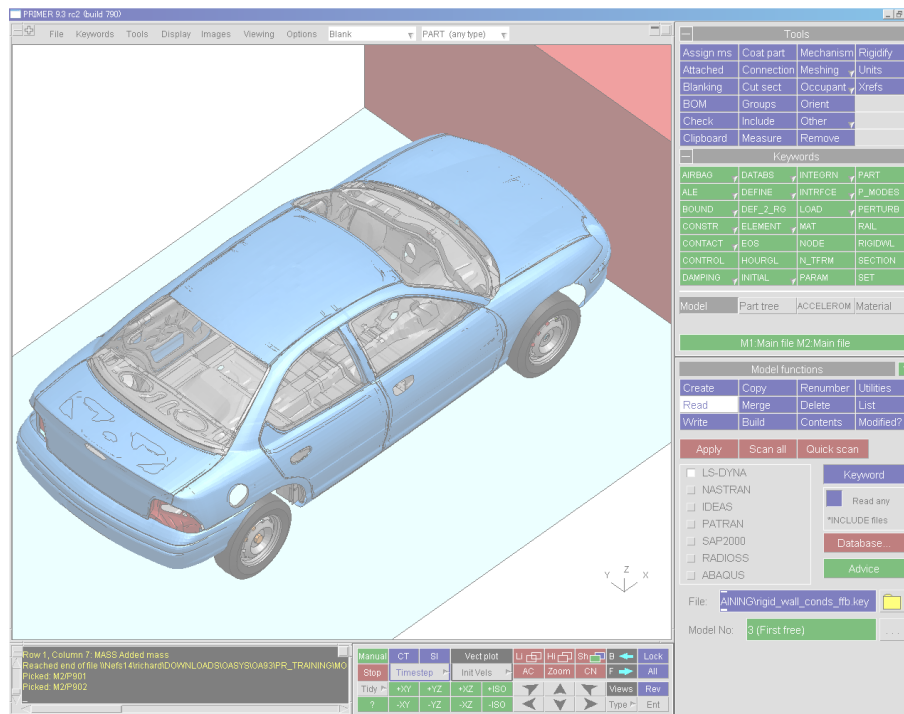
# Contents

- Introductions.

- Purpose & overview of Oasys PRIMER.

- Focus - Model Checking and QA.

    - Core model checking tools.

    - Other PRIMER tools used for checking models.

    - Tools which maintain the model integrity.

    - Customisation of checking.

    - PRIMER integrated with post-processing tools.

- Summary.

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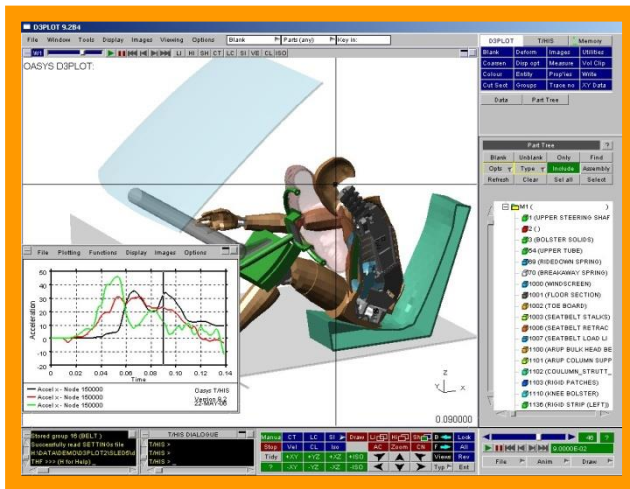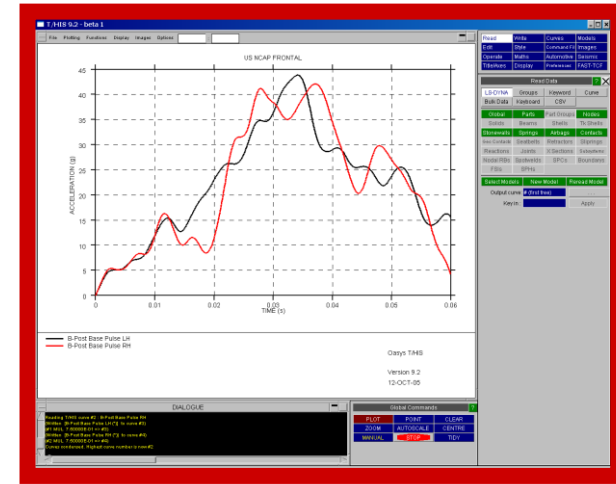The Software House of ARUP

LS-DYNA, Oasys and ARUP

- We distribute LS-DYNA in the UK, India and China, and have over 30 years experience of working with LS-DYNA and LSTC.

- We have access to the LS-DYNA code which allows us to develop our own functionality for use by ourselves and for our clients, as well as fully understanding all LS-DYNA keyword data.

- We provide LS-DYNA support to clients around the world which helps us develop a deep knowledge of LS-DYNA, and understand the trends in it's use, as well as trends in automotive CAE.
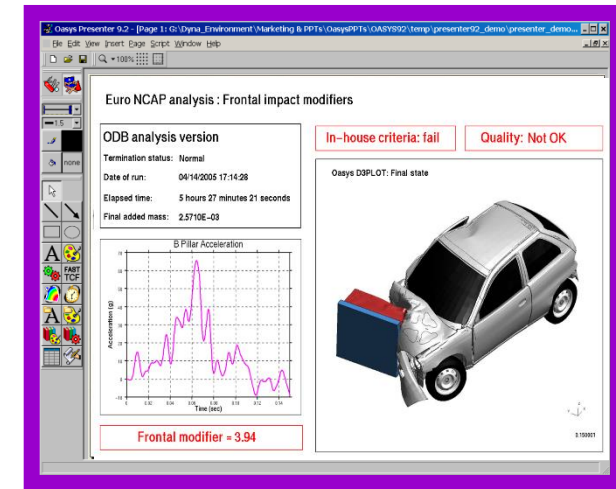
Oasys
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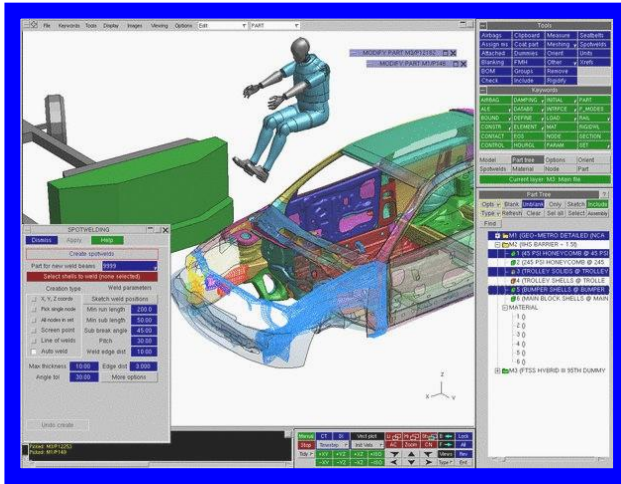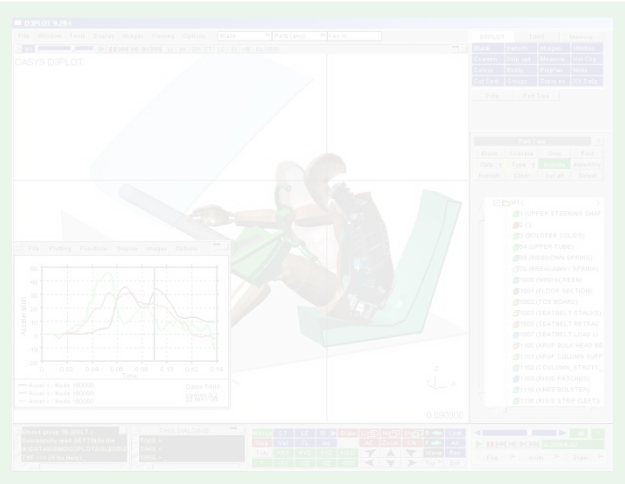
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Oasys PRIMER

Oasys T/HIS

Oasys D3PLOT

Oasys REPORTER

Oasys PRIMER

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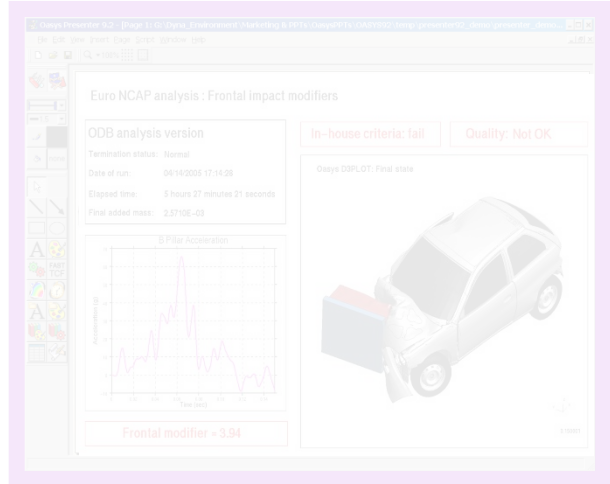
Oasys – The software house of Arup
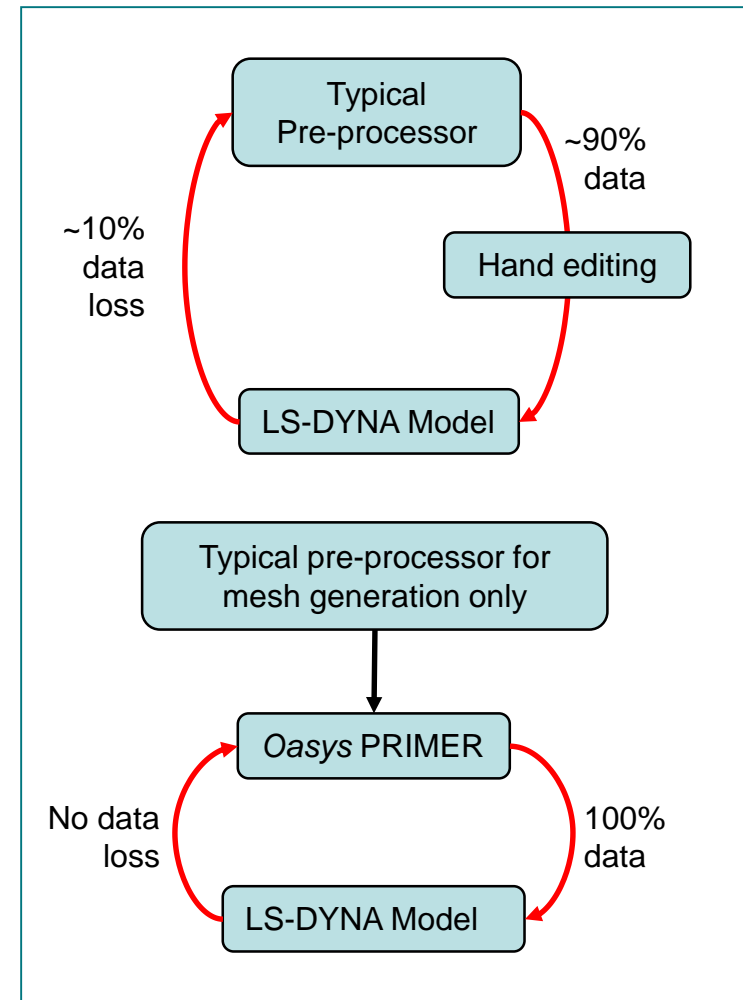

Oasys PRIMER
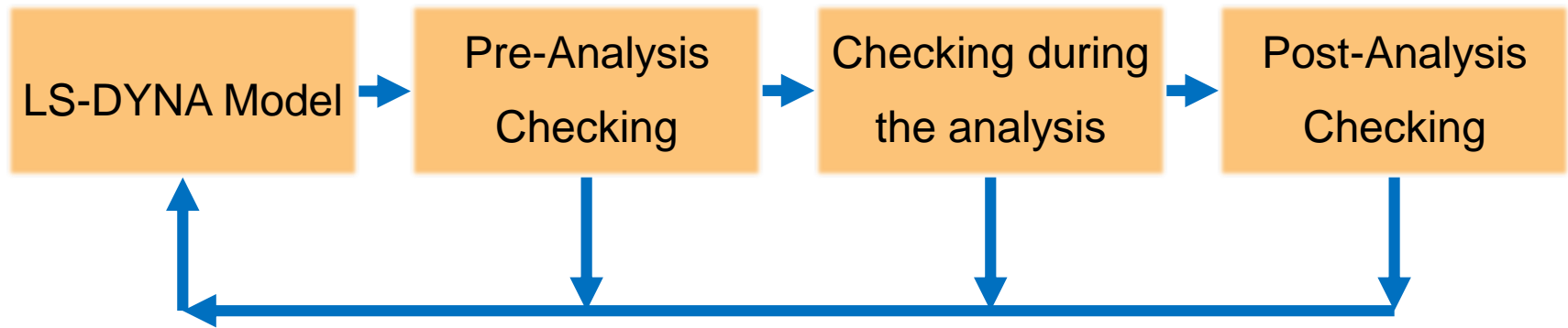
Oasys T/HIS

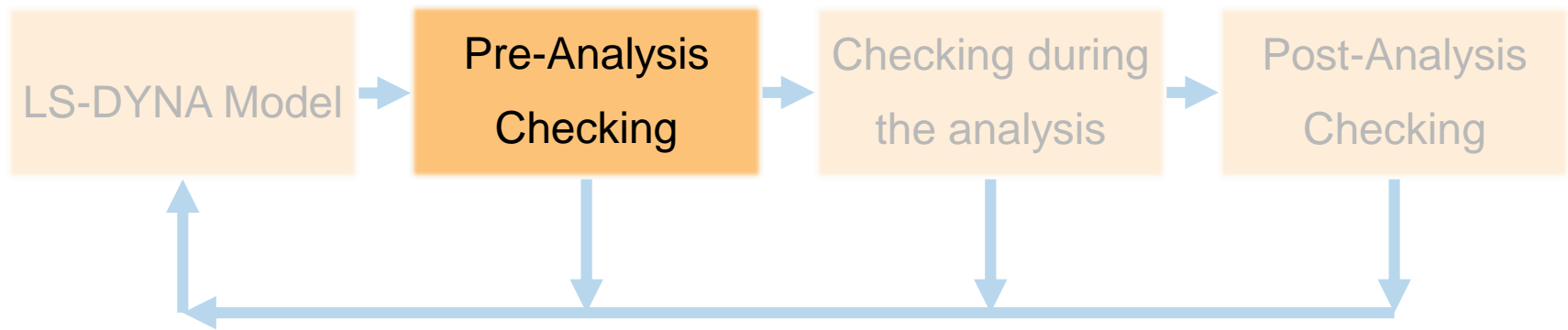Oasys D3PLOT

Oasys REPORTER

Purpose of Oasys PRIMER

- *Oasys* PRIMER is a specialised pre-processor used only for LS-DYNA models.

- PRIMER's modeling tools and comprehensive error checking can reduce preparation and debugging time.

- PRIMER is fully compatible with the latest version of LS-DYNA, so no information is lost when reading, or writing out model data.

- PRIMER's model management tools allow the CAE team to work in parallel on different components of the same model.

- Because of PRIMER's robustness and depth of understanding of the LS-DYNA data, users trust PRIMER to work on their complex models without corrupting or losing any data.

Typical
Pre-processor

~90% data

~10% data loss

Hand editing

LS-DYNA Model

Typical pre-processor for mesh generation only

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No data loss

100% data

LS-DYNA Model

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Model Checking + Ensuring the Integrity and Quality of Your Model
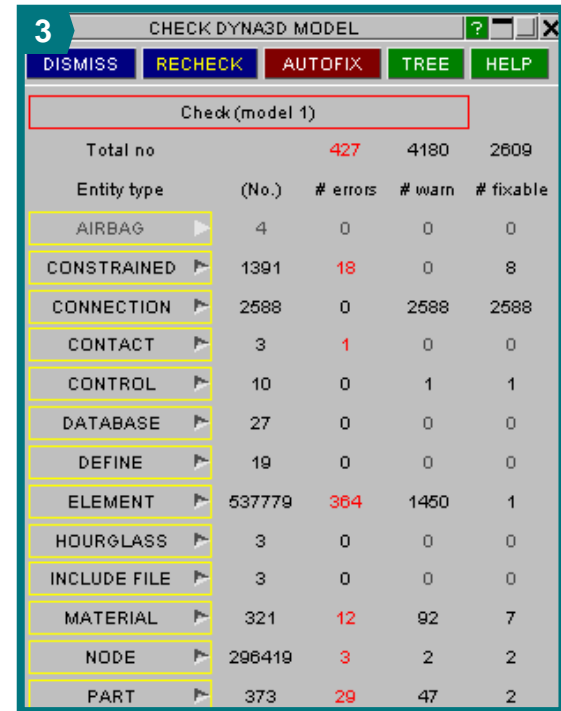
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LS-DYNA Model → Pre-Analysis Checking → Checking during the analysis → Post-Analysis Checking

LS-DYNA Model Checking

LS-DYNA Model → Pre-Analysis Checking → Checking during the analysis → Post-Analysis Checking

Core Checking Features

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Checking Models

PRIMER has over 7000 individual checks

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Checking Models

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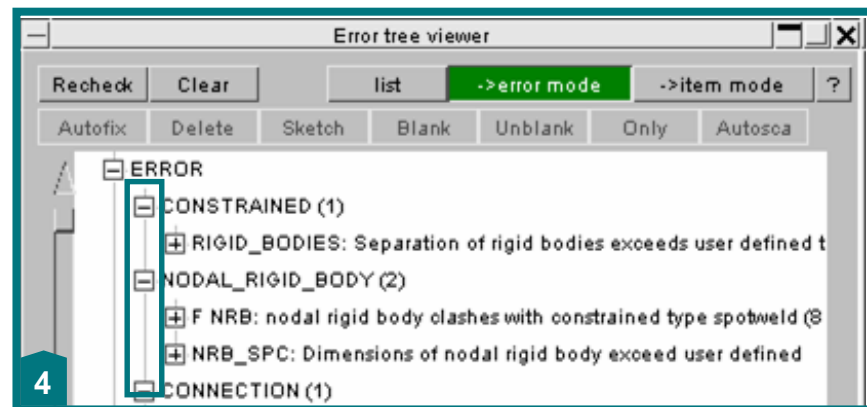
Checking Models

Recheck | Clear | show tags | list | ->error mode | ->item m

Autofix | Delete | Sketch | Blank | Unblank | Only | Autosca

ERROR

WARNING

CONTROL (1)

F SHELL: Sorting flag for degenerate quads <itrist/esort> is not = 1 (1) **Recommended parameter is not the default**

BEAM (3)

(spotweld) beam length is greater than maximum allowed size (1014)

Beam is part of a spotweld which is longer than maximum allowed length (361) **(Spotweld beam) element quality checks**

(spotweld) beam length is less than minimum allowed size (74)

SHELL (1)

F Duplicate Shell - overlaps existing shell of same part (1)

MATERIAL (2)

F MAT_24/123: yield stress from <LCSS> curve over rules SIGY (6) **Material type 24 - warnings**

MAT_24/123: curve discretisation may lose data (86)

PART (4)

elements of rigid part are not continuously meshed (32) **Discontinuous rigid body – could be a mistake?**

F Part contains elements in different include file (1) **Model badly organised**

%age added mass on part exceeds allowed percentage (12)

%age added mass on spotweld part exceeds allowed percentage (2) **User-defined quality check – mass-scaling**

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Mesh Quality

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Meshing Quality Tools

- Various meshing quality tools are available in PRIMER:

  - Check for elements that don't meet specified criteria.
  - Contouring of elements according to quality, and also contouring of elements that fail the specified criteria.
  - Moving nodes, both manually and automatically to improve element quality.
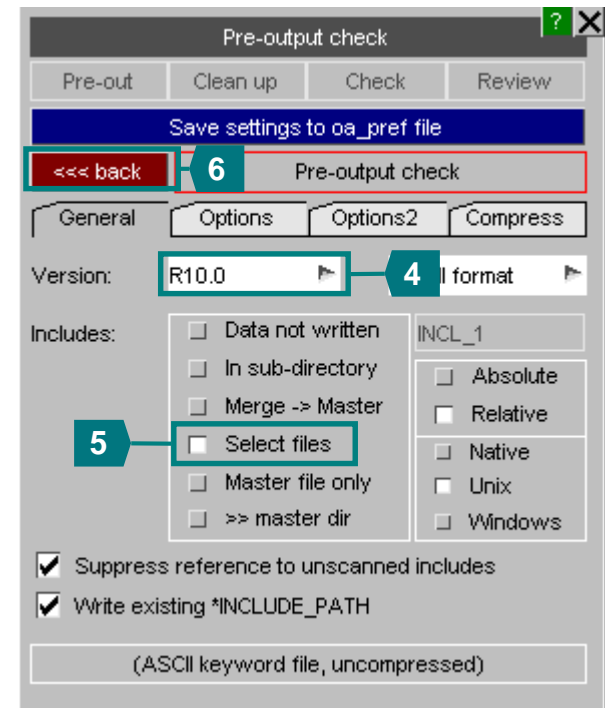 - Ability to split and combine elements, and also to check and align normals.
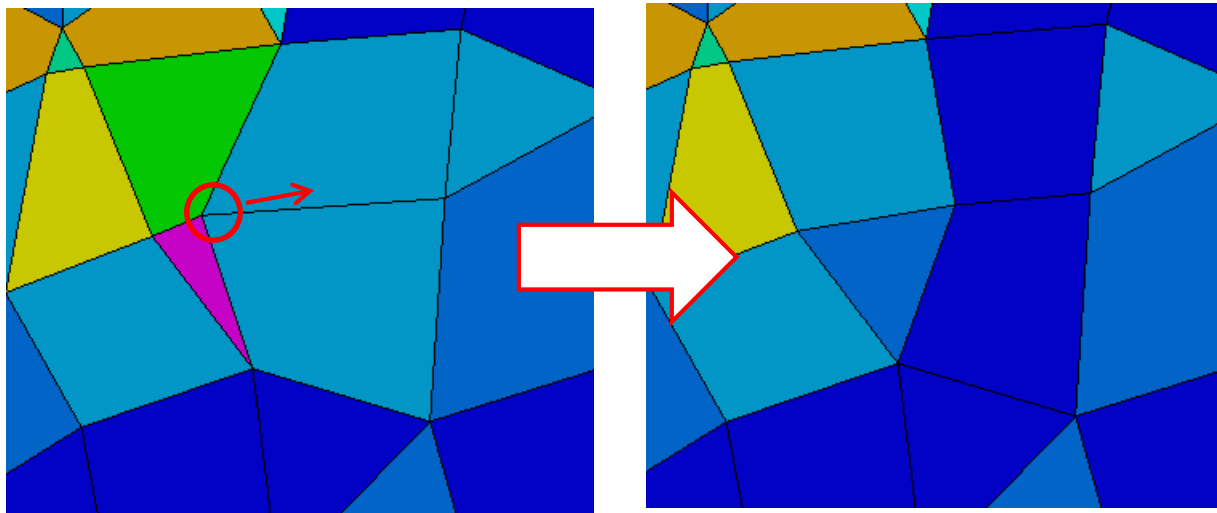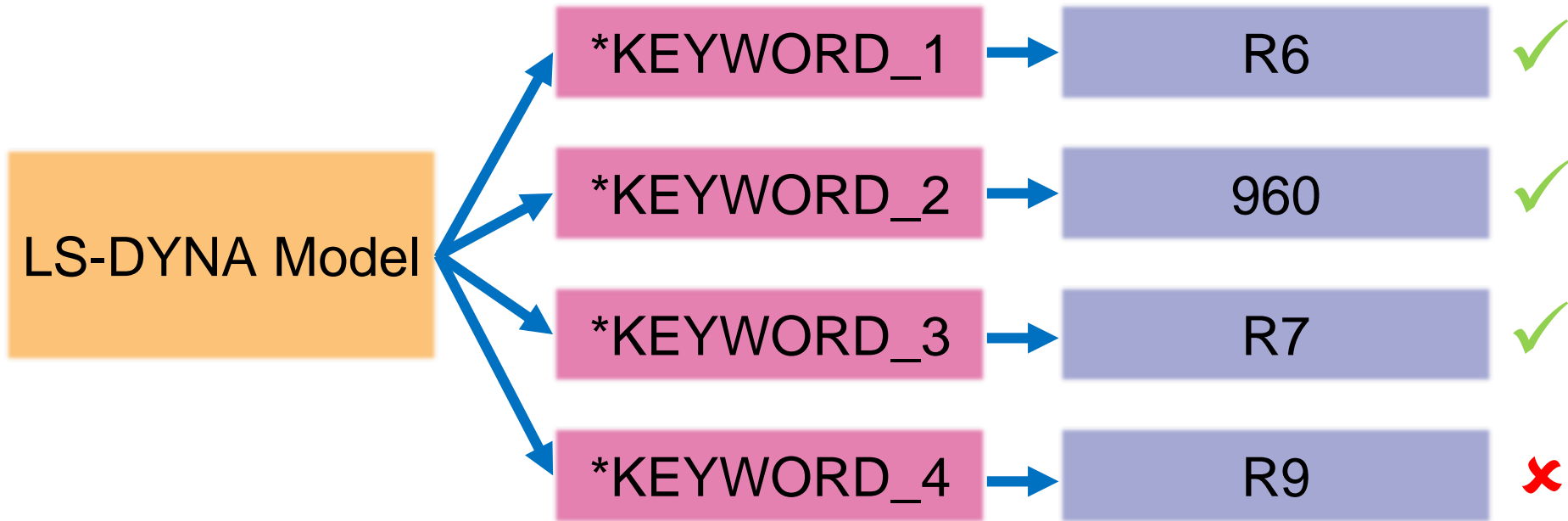
Writing out a model

Writing out the corrected model
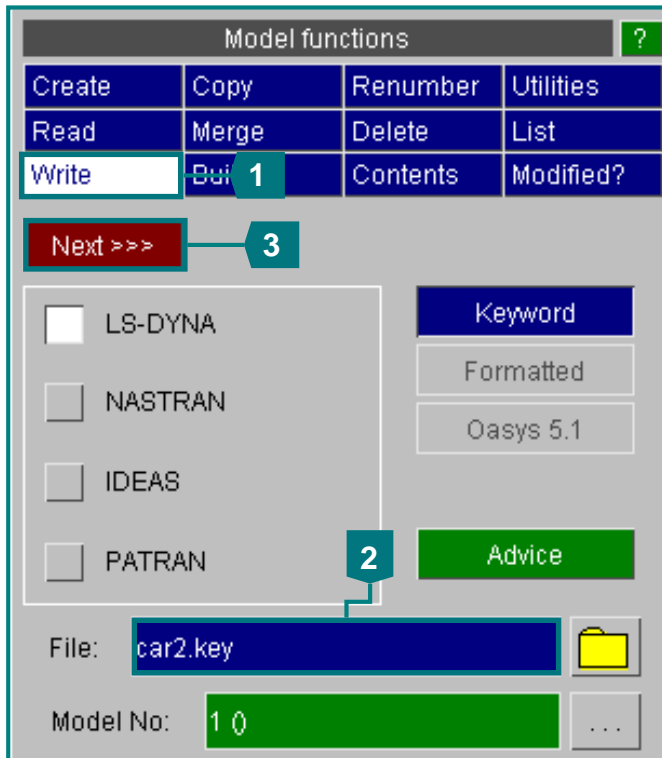
Model Write:

1. To write out the model, use **Write** from the main model menu.
2. Give a file name. *As the model has INCLUDE files, this will be the master keyword file.*
3. Press **Next >>>** to move to the next menu
4. Set the desired **Version** of LS-Dyna. *Input data not valid for this version (e.g. new KEYWORDs) will be omitted and a warning message printed.*
5. Pick the **Select Files** option – to choose which INCLUDE files are written in the next step
6. After selecting all the required options, press **Apply**

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Running model in R7.1.3, LS-DYNA will likely not run

LS-DYNA Model

*KEYWORD_1 → R6 ✓

*KEYWORD_2 → 960 ✓

*KEYWORD_3 → R7 ✓

*KEYWORD_4 → R9 ✗

Version keyword was introduced into LS-DYNA

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Writing out the corrected model
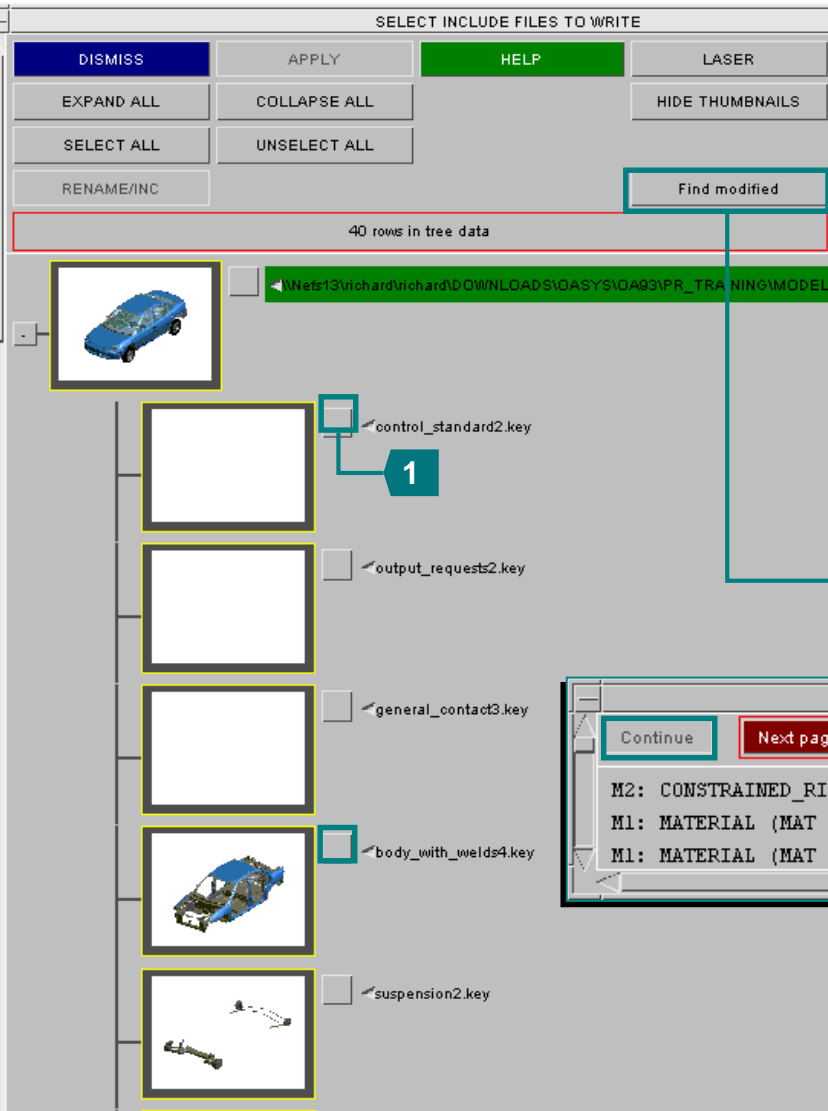
Model Write contd.:

1. **Either click the boxes to tell PRIMER which INCLUDE files to write…**

2. **… or ask PRIMER to Find modified INCLUDE files.** *This process will take one or two minutes as PRIMER compares with the files previously read off disk.*

3. *PRIMER will show a list of all the changes you've made in this session.* **Skip to the end** *of the listing then* **Continue** *to the next menu*
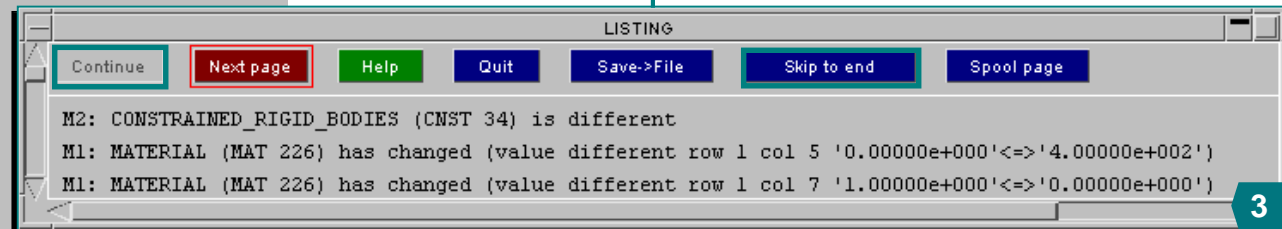
This list may be slightly different – depending on what modifications you've made

Writing out the corrected model
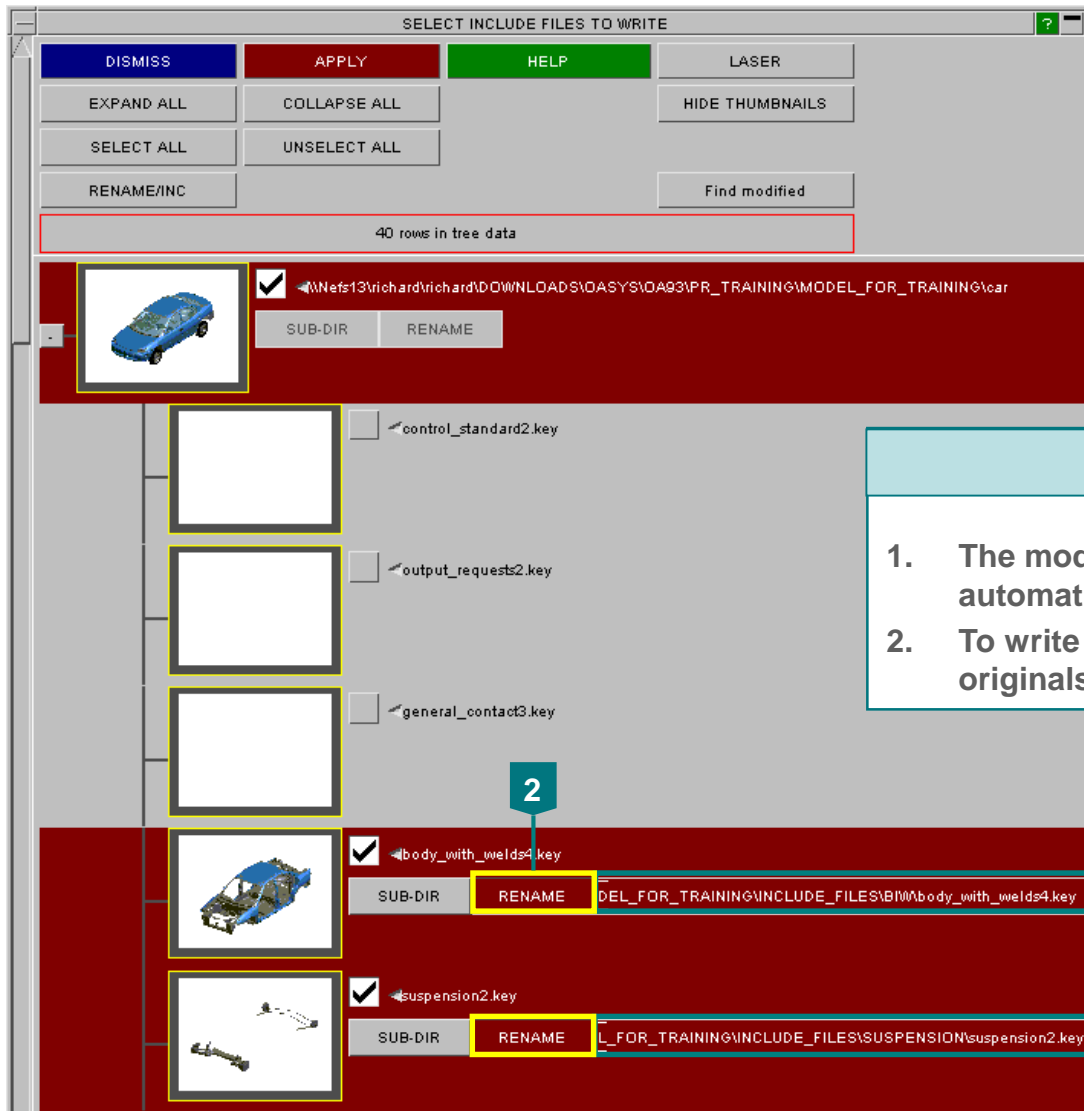
Model Write contd.:

1. The modified INCLUDE files are shown in red & automatically selected ☑.
2. To write the new files in the same directory as the originals, use **RENAME** and give a new file name.

Model modified

Model modified

- Often, it is useful to see differences between models
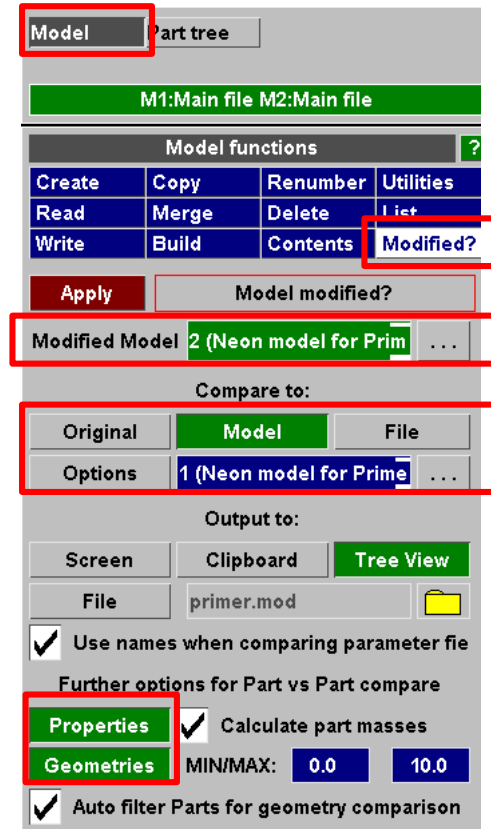
Model modified

- Differences between the two models are shown in a tree view.
- PRIMER gives you information about differences in keywords, as well as additions/subtractions of entities between models.
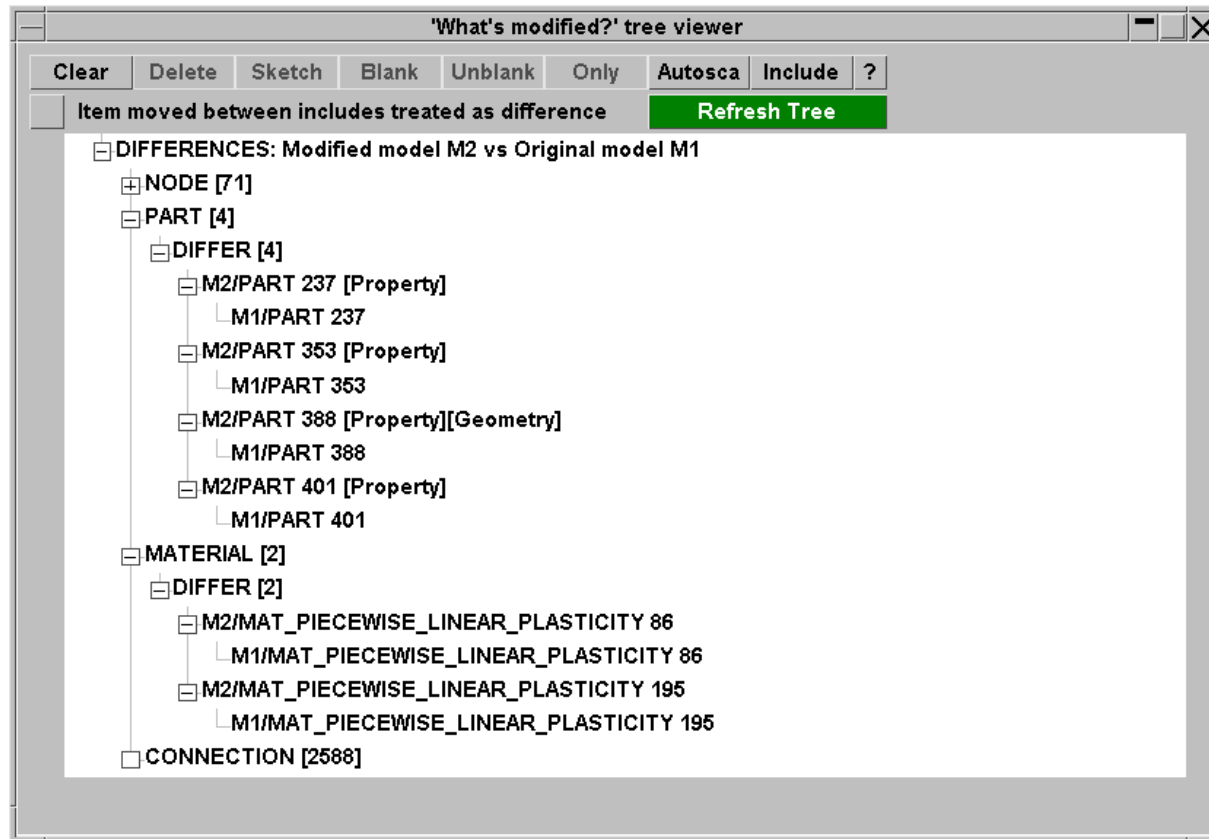
Model modified

- Various options are available when right mouse clicking on one of the differences:
    - Details will print details of the differences found.
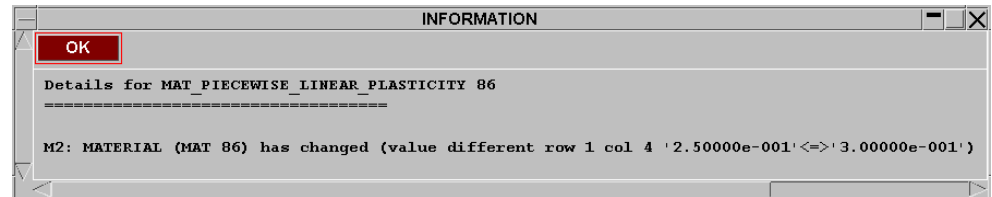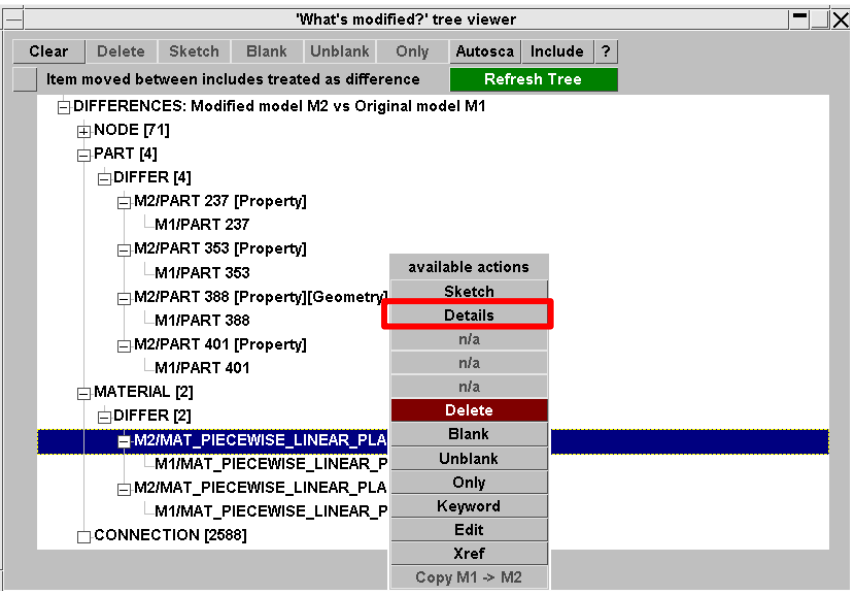
Model modified

- Various options are available when right mouse clicking on one of the differences:
  - Keyword will display keyword panels highlighting the differences between the two cards.

Model modified

- Various options are available when right mouse clicking on one of the differences:
    - Geometry differences between parts can also be checked and contoured.
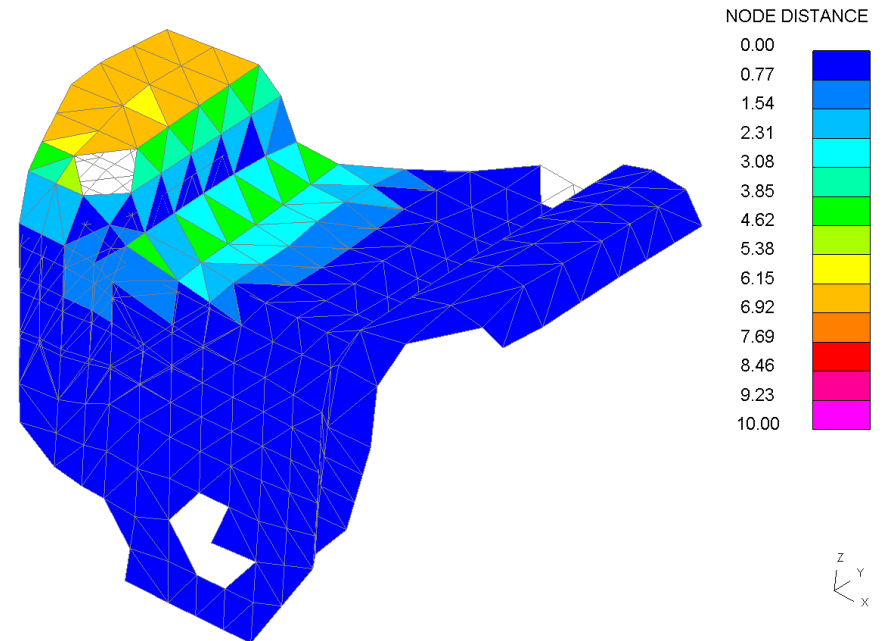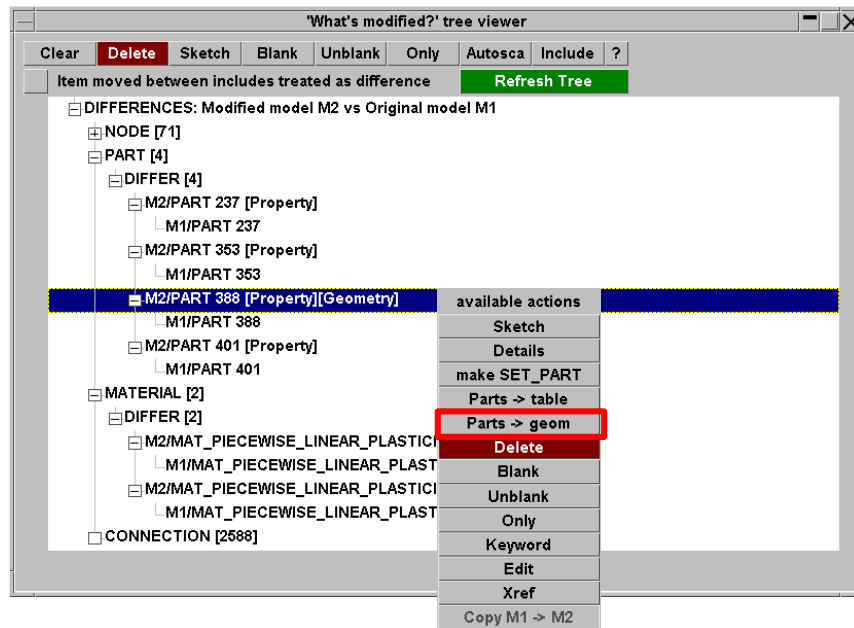
Contact Penetration Checking and Fixing

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Penetration checking

Contact Penetrations:

1. **"Penetration" means that a node is too close to an element, i.e. within the contact thickness defined by 0.5(t1+t2), where t1 and t2 are the contact thicknesses of the contacting elements**

2. **"Crossed edge" means an intersection of one element plane with another**

3. **PRIMER understands the different methods of defining contact thickness, e.g. SST on *CONTACT, or on *PART_CONTACT.**

4. **PRIMER tries to use the same equations as LS-DYNA to determine penetrations.**

Penetration checking

PRIMER can check for contact penetrations and crossed edges.

Crossed edges are when we have intersecting parts.

**Penetrations are when parts/elements are too close.**

Intersecting parts ("Crossed edge")

Parts too close ("Penetration")

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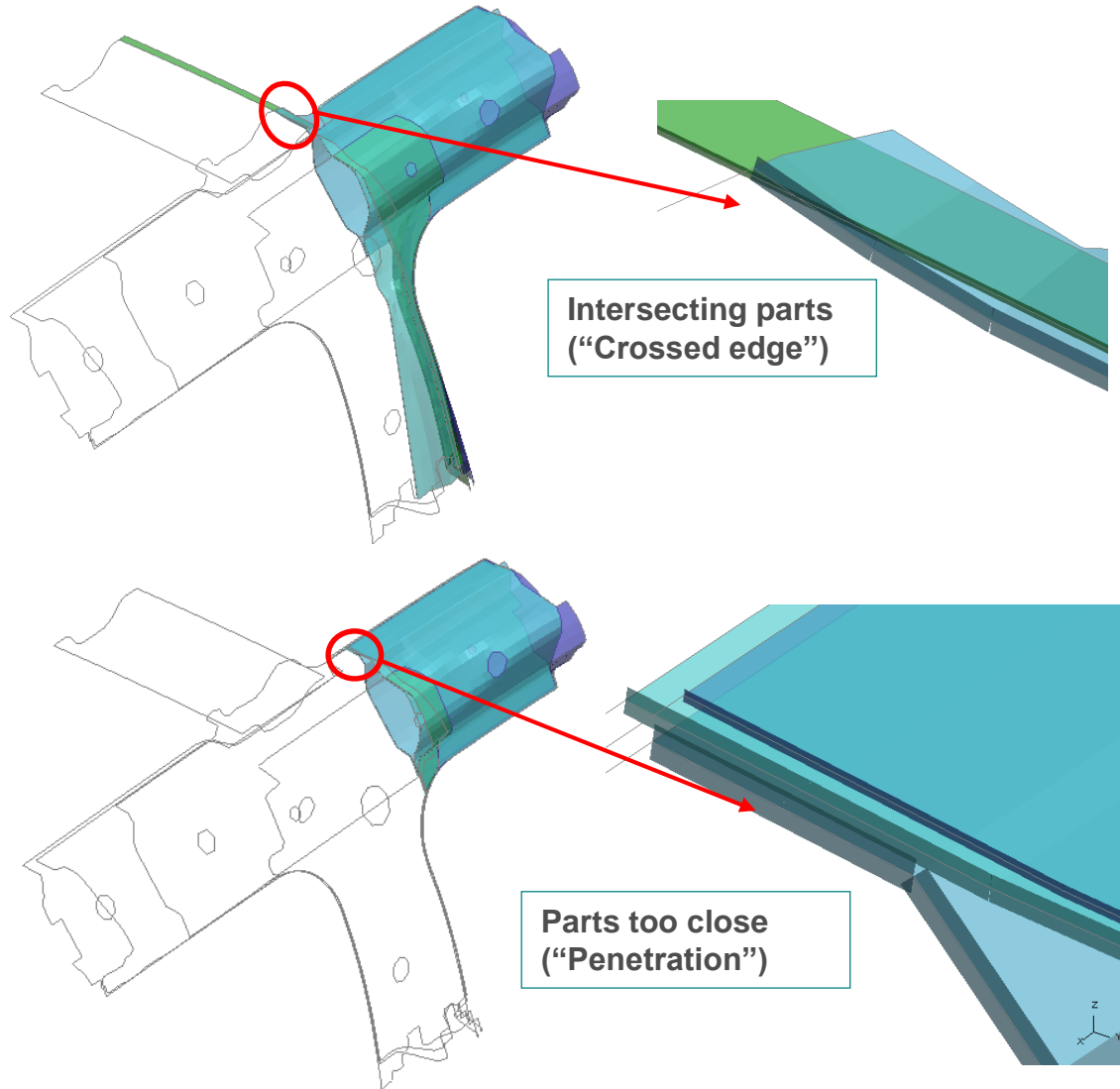
Penetration checking

Start the Contact Penetration checker from
Keyword=>Contact=>Sliding&Tied=>
Modify (select the Automatic Single
Surface contact) =>Pen Check

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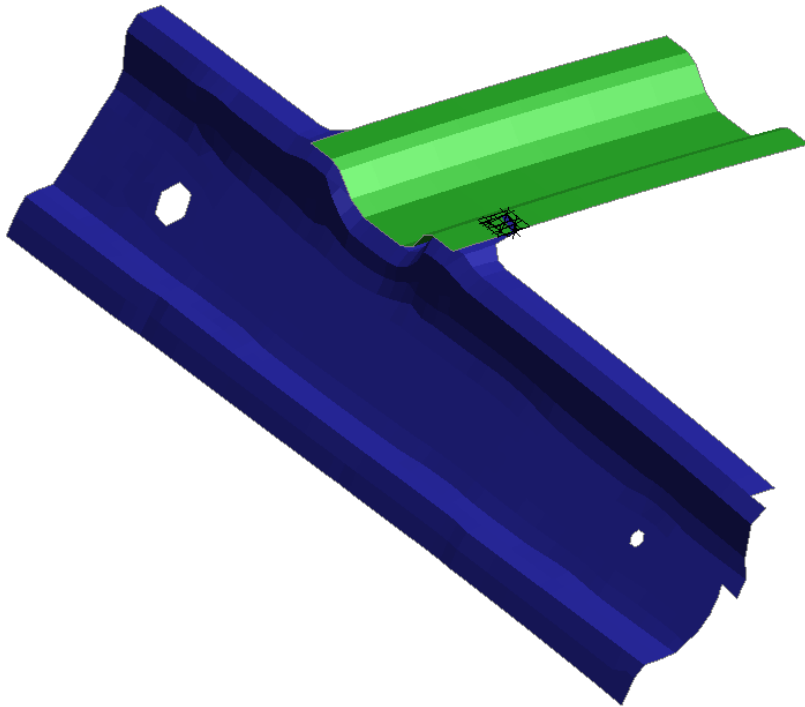The Software House of ARUP
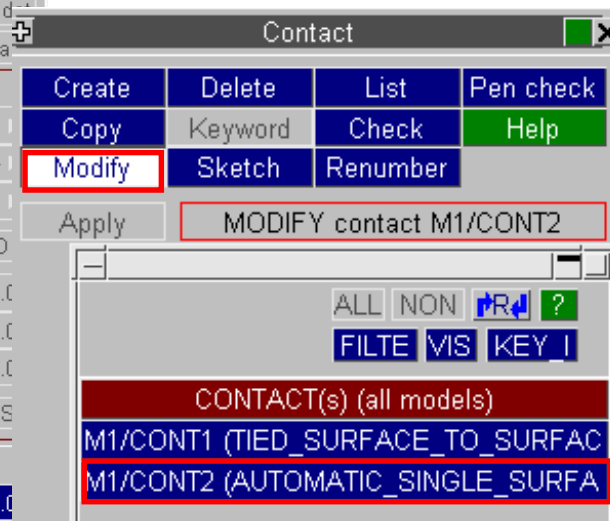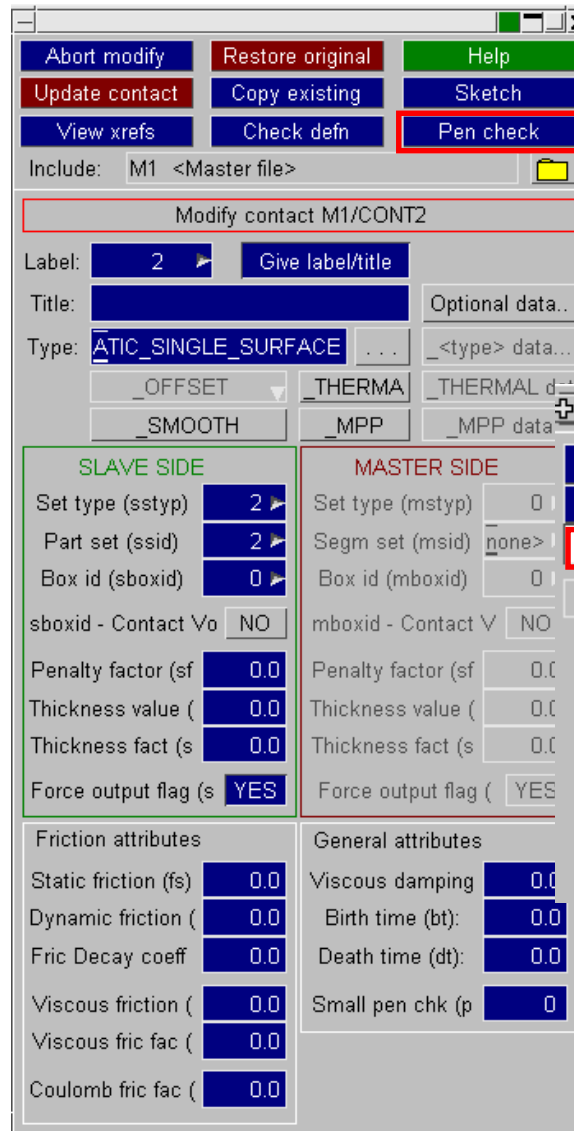
Penetration checking
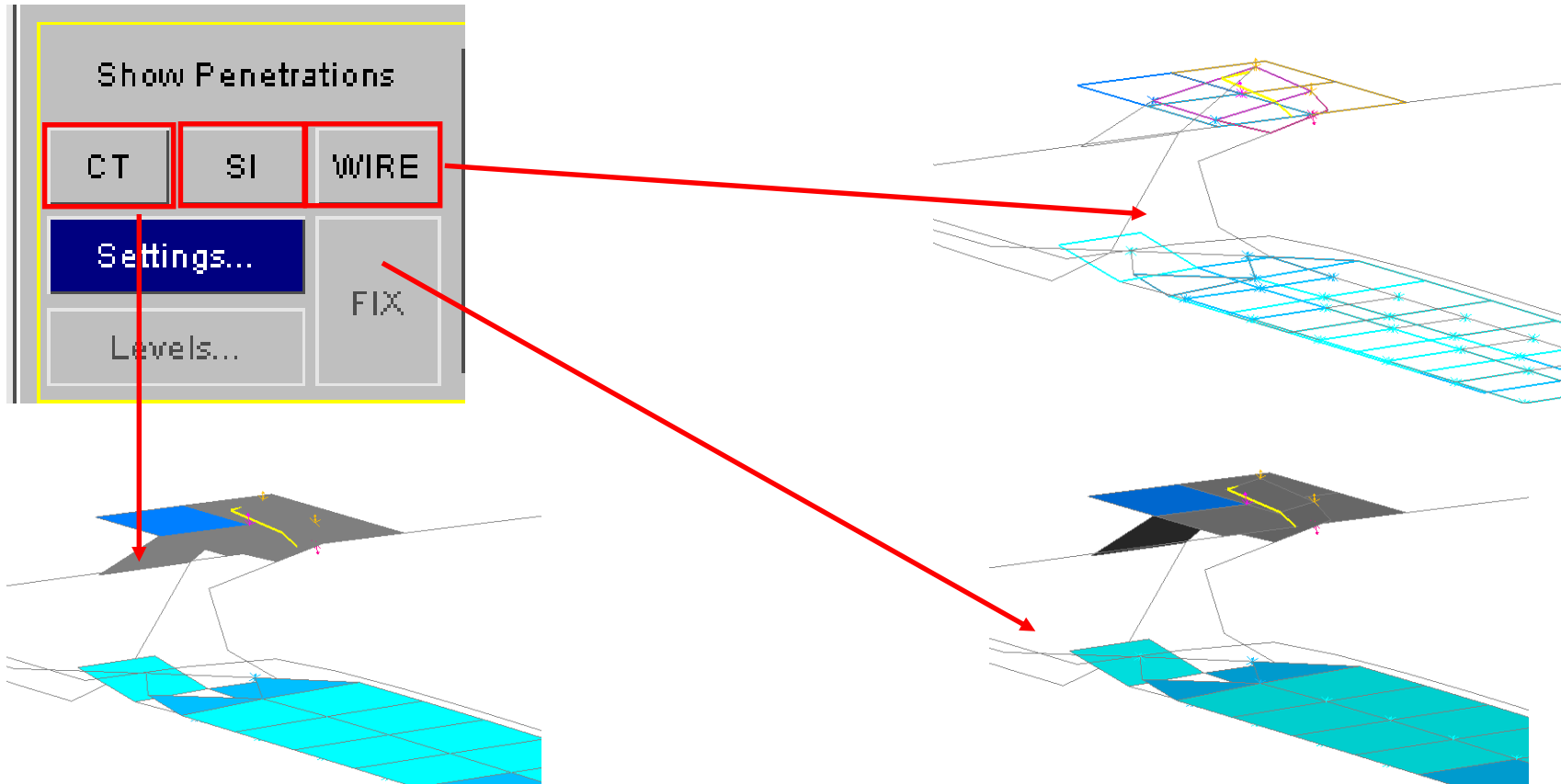
Crossed edges are shown by yellow lines on grey elements.

Penetrated elements are coloured according to penetration depth. The penetrating nodes are shown by coloured crosses, with coloured arrows showing the "escape vector" – where the node would have to move to, in order to eliminate the penetration.

Penetration checking

The pairs of parts that interact (penetrations or crossed edges) are shown. To display just one of those pairs or parts, click on it in the menu. Restore display of all parts using "Sel All".

Contact penetrations - Settings

Call up the Settings panel

PEN CHECK
- 0.032
- 0.116
- 0.199
- 0.282
- 0.365
- 0.449
- 0.532
- 0.615
- 0.699
- 0.782
- 0.865
- 0.948
- 1.032
- 1.115

PEN CHECK M1/CONT2

| Dismiss | Check all | Options... |
| List Errors | Check visible | |

All segments of contact checked

2   AUTOMATIC_SINGLE_SURFACE
<No title defined>

select parts | sel none | sel all | sel xedge | ?

P8231:P8710 (5 x-edges 6 pens)

P8710:P82151 (0 x-edges 108 pens)

P8712:P82151 (0 x-edges 76 pens)

penetrations magnitude >=   0.0

| sketch | unblank | recursive |

contour penetrating
- CT | SI | WIRE
- Settings...   FIX
- Levels...

Pen: 190 vis 190 total
X'ed: 5 vis 5 total
Min: 3.2391e-002
Max: 1.1148e+000
Sum: 4.9069e+001

| ->warnings.k | Element detail | Beams on x-edge |

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Contact penetrations - Settings

In the Settings panel, the different displays (penetrated elements, penetrating nodes, crossed edges) may be turned on or off, or labelled. Drawing the elements with their Contact Thickness can sometimes help to visualise why there is a penetration.

The coloured arrows show where the node would have to move to, in order to eliminate the penetration.
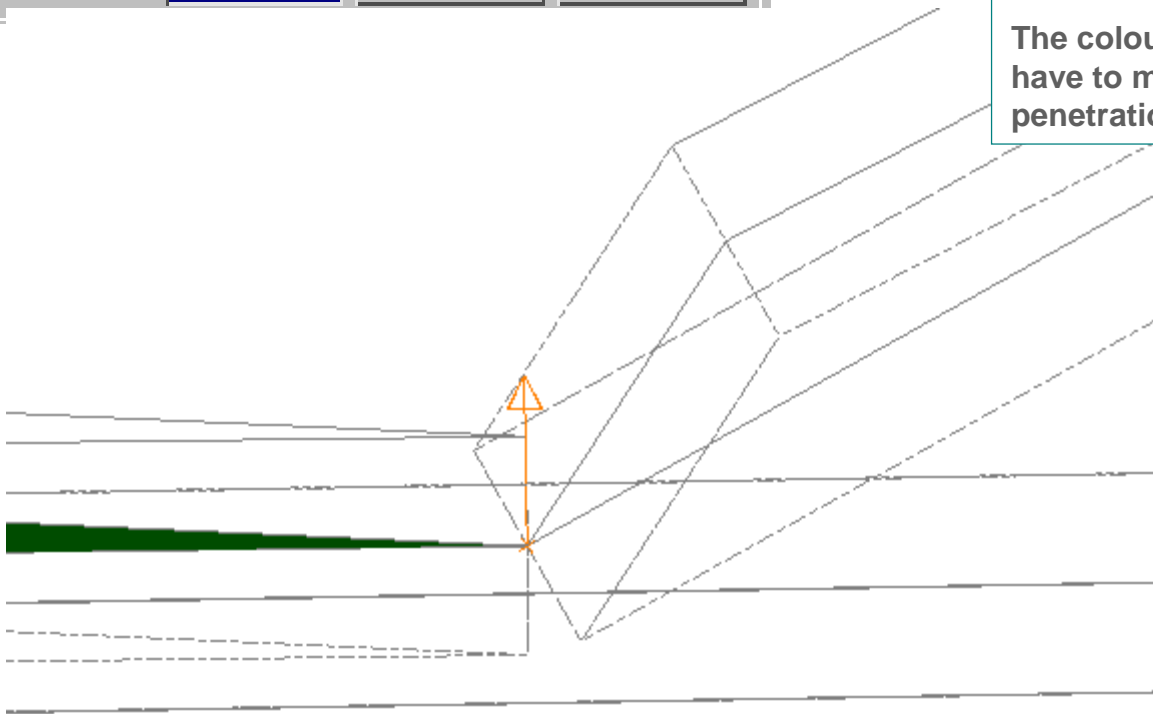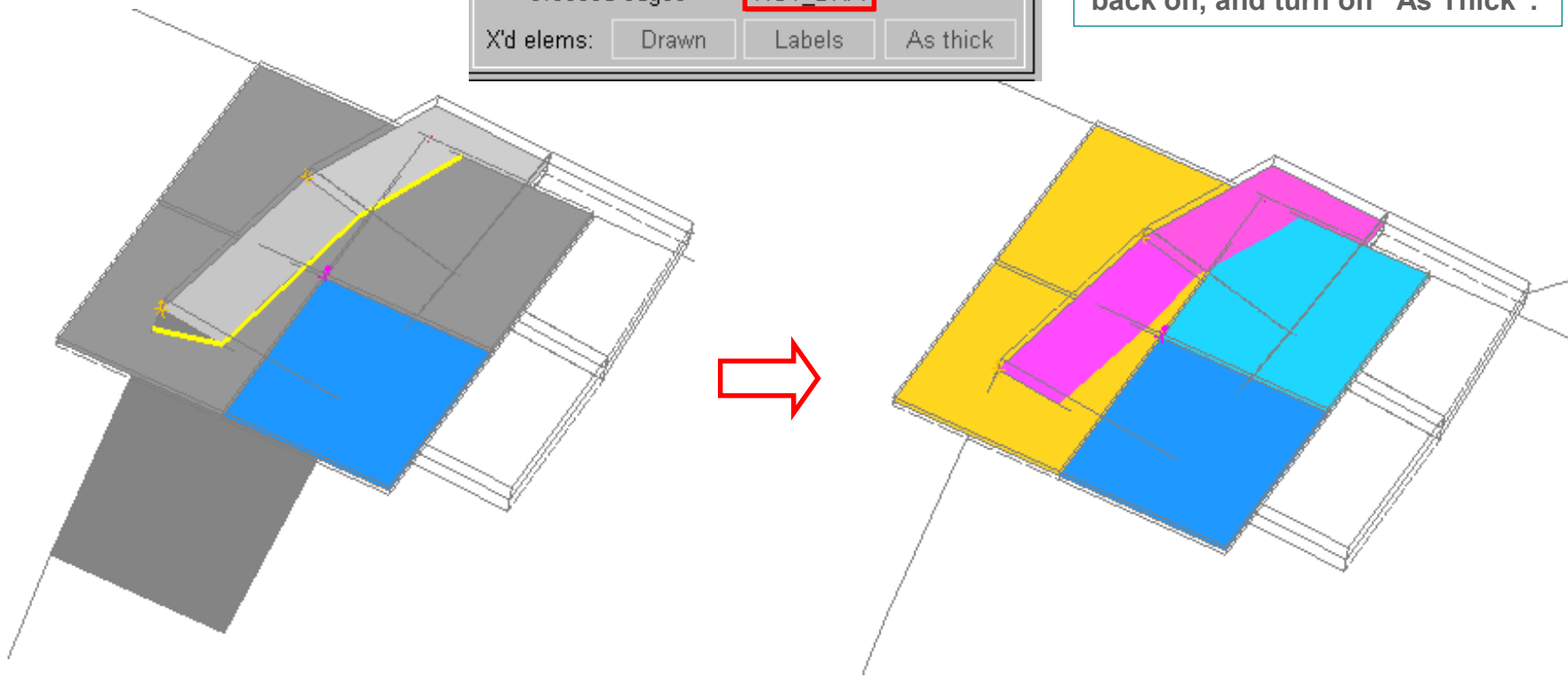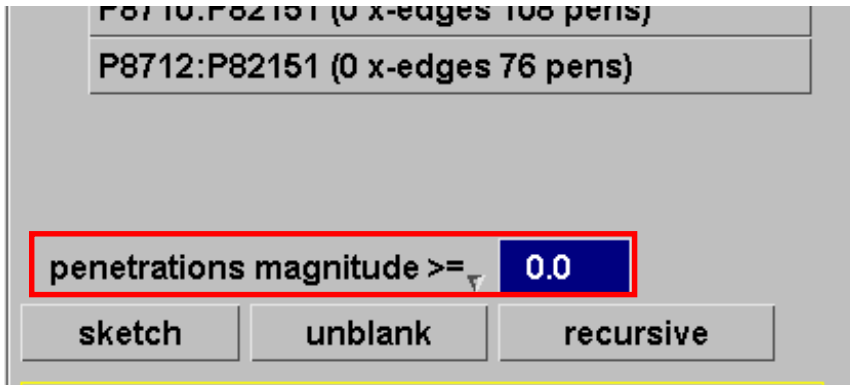
Contact penetrations - Settings

Try turning off Crossed edges, press UPDATE.

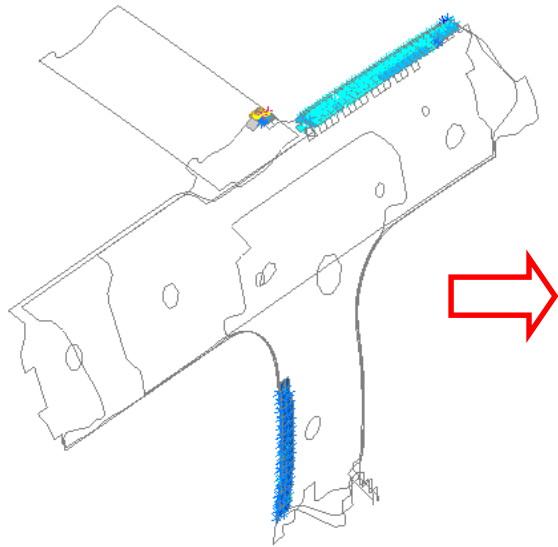Before proceeding to the next step, turn the crossed edges back on, and turn off "As Thick".

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Contact penetrations - Settings

P8710:P82151 (0 x-edges 108 pens)

P8712:P82151 (0 x-edges 76 pens)

penetrations magnitude >= `0.0`

sketch | unblank | recursive

The LS-DYNA control flag **IGNORE** is recommended – this makes the contact algorithm tolerant to small penetrations. To find out whether any penetrations exceed a certain tolerance – say 0.2mm – input a minimum value in the Pen Check Panel. Update Plot. PRIMER now displays only penetrations greater than 0.2mm

PEN CHECK
0.032
0.116
0.199
0.282
0.365
0.449
0.532
0.615
0.699
0.782
0.865
0.948
1.032
1.115

PEN CHECK
0.200
0.270
0.341
0.411
0.481
0.552
0.622
0.693
0.763
0.833
0.904
0.974
1.044
1.115
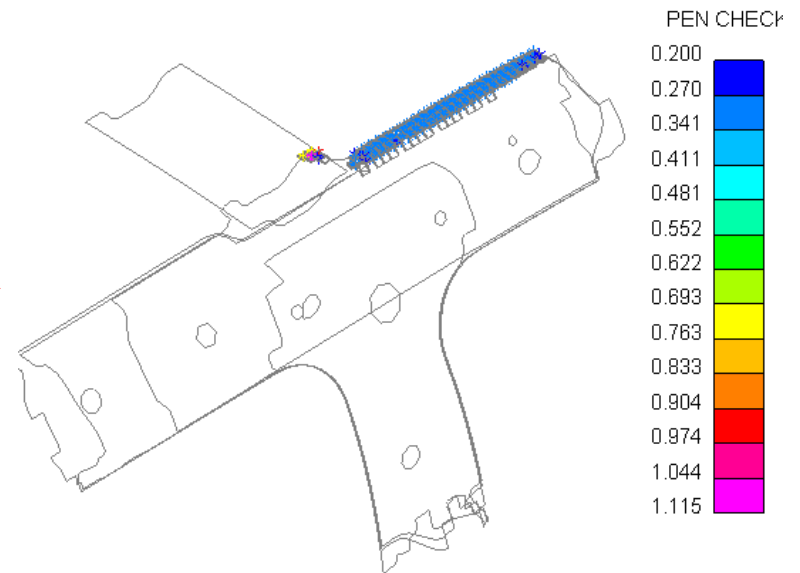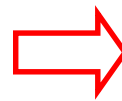
Contact penetration ratio

To find out whether any penetrations exceed, say, 0.2 times the shell thickness, set the data component to "ratio thickness remaining", and the value to 0.8 (i.e. PRIMER will display colours only where the remaining thickness, after the penetration is subtracted, is 0.8 or less times the thickness.

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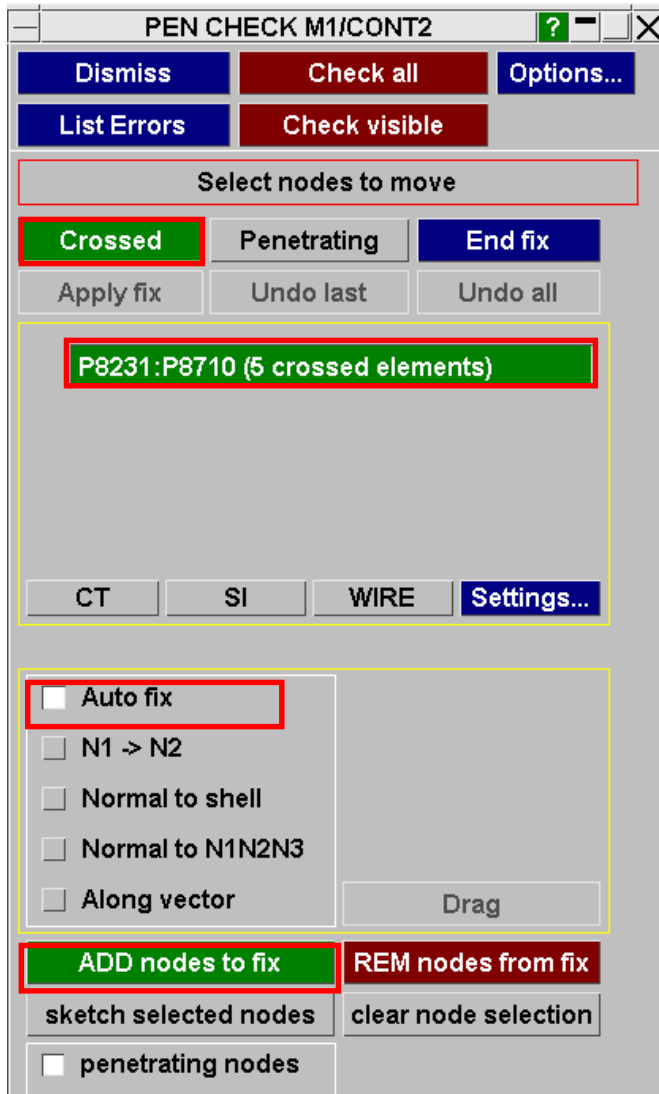
Crossed edges - Fixing

Press FIX. We recommend to fix the crossed edges first.

PRIMER offers the pairs of parts that are intersecting. Click on the only pair. PRIMER shows just these parts.

Zoom in on the affected region.
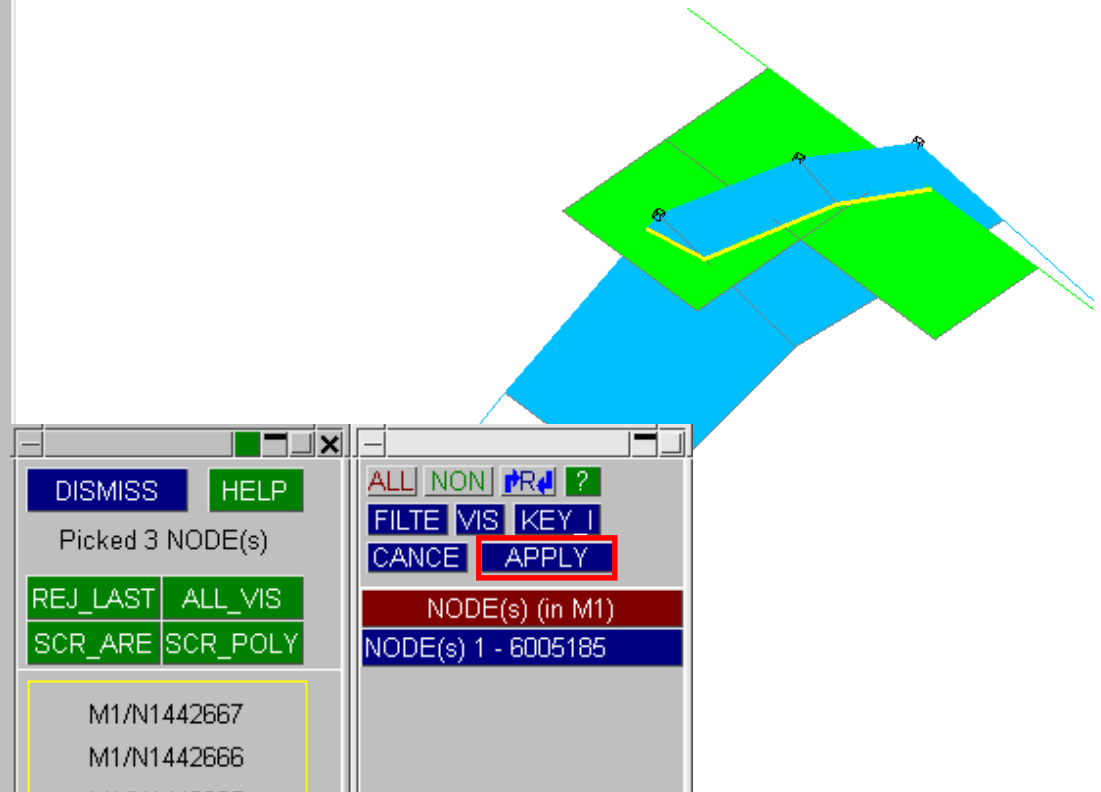
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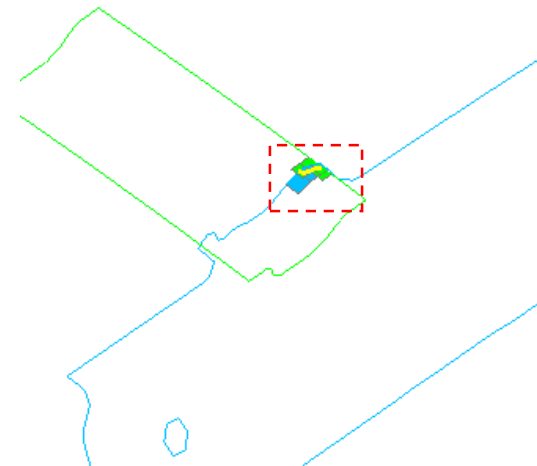
Crossed edges - Fixing

We must tell PRIMER which nodes are on the "wrong" side. Use "ADD nodes to fix" to select the three nodes shown, APPLY to confirm the node selection.

There is a choice of manual (e.g. dragging) or automatic methods to calculate the movement of each node.

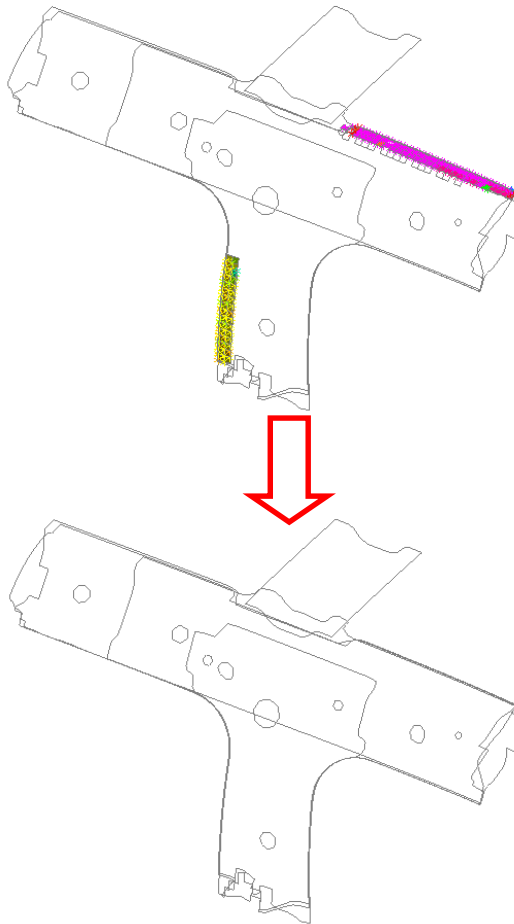Switch to Penetrating, ensure the menu is switched to Manual, press SI.

Although we have fixed the crossed edges, the same two parts are still penetrating. We will now fix these penetrations manually.

Use "ADD nodes to fix" to select the nodes to be dragged. Try dragging using "normal to shell", until these penetrations disappear.

Pick nodes with coloured arrows

View from underneath

Pick this shell

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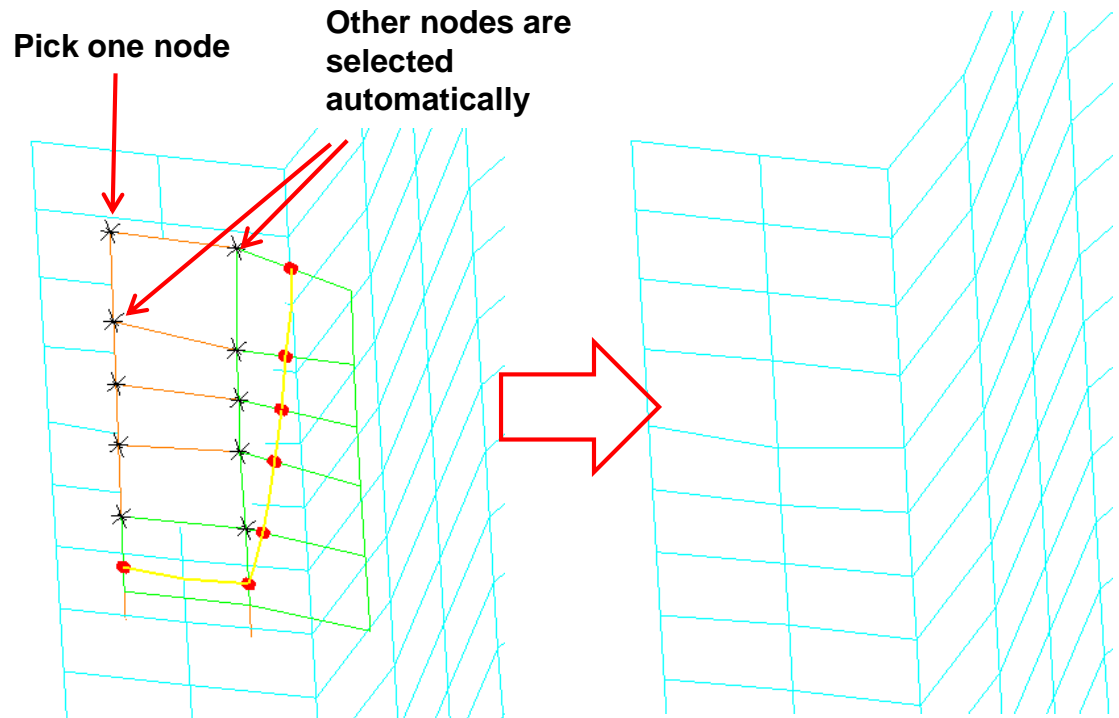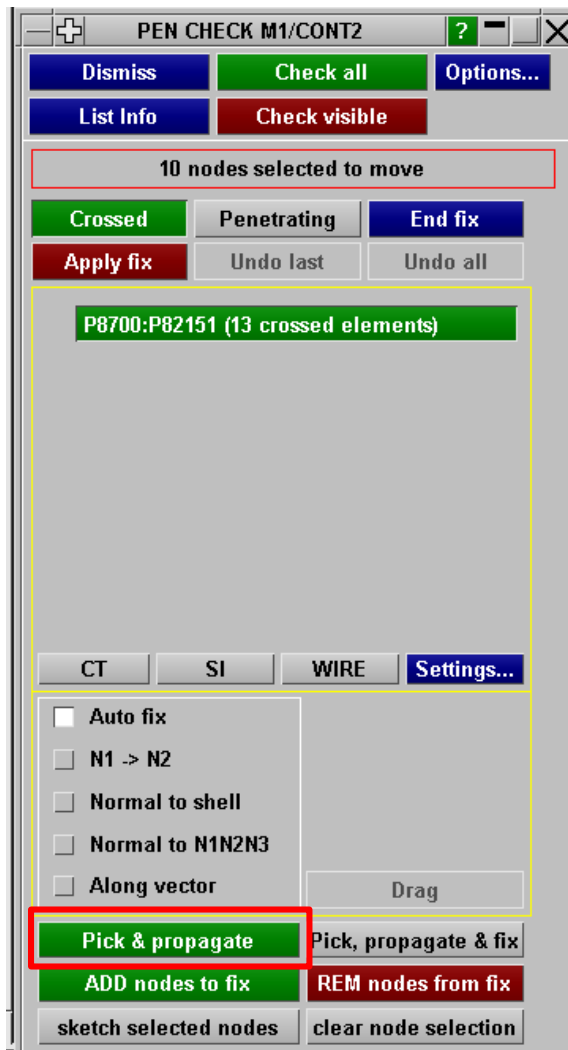
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Unblank the whole model (shortcut U). We will fix the remaining penetrations using the Automatic method.

Switch to Automatic Fixing. Press Apply.

PRIMER moves the penetrating nodes iteratively to reduce the penetrations. In this model, all the penetrations are fixed.

In more complex models, some penetrations may remain; these need to be fixed manually. Usually the reasons are either (a) crossed edges have not been fixed or (b) since PRIMER moves only the penetrating nodes (shown with coloured arrows), not the penetrated elements, this is not always enough to resolve complex multi-layer situations.

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Penetrations: Crossed Edge Fixing

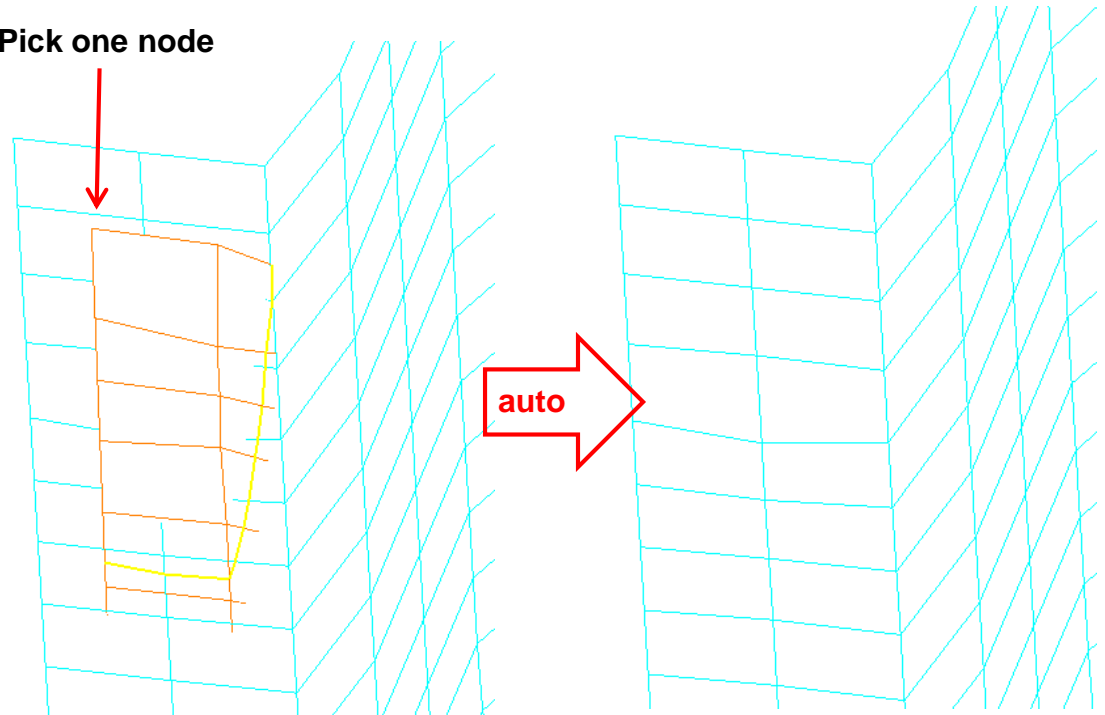**Pick one node**

Other nodes are selected automatically

"Pick & propagate" allows user to pick one node; PRIMER then automatically selects all the other nodes that are on the same side of the Crossed Edge. Selection can be adjusted using ADD, REM
Fixing the selected nodes is a separate operation. The usual methods are available, e.g. "Auto fix", "Normal to shell", etc
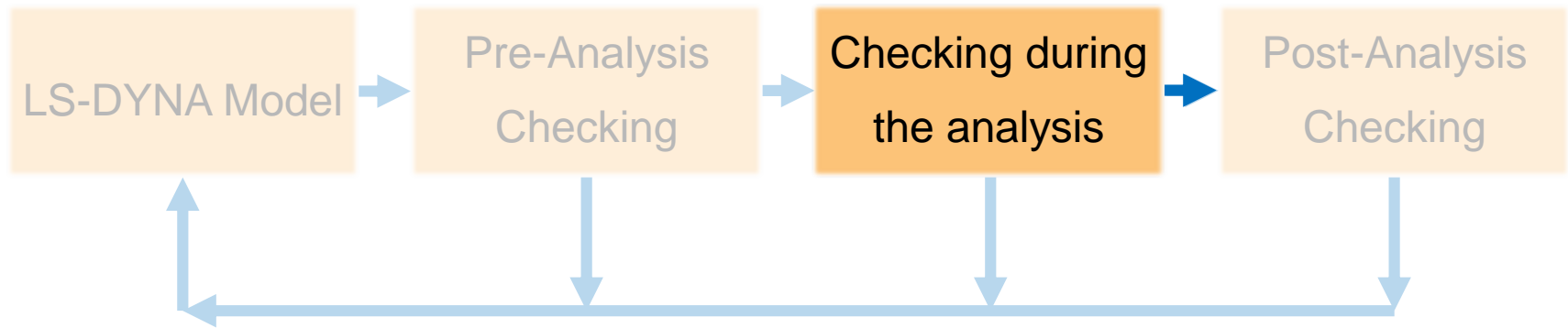
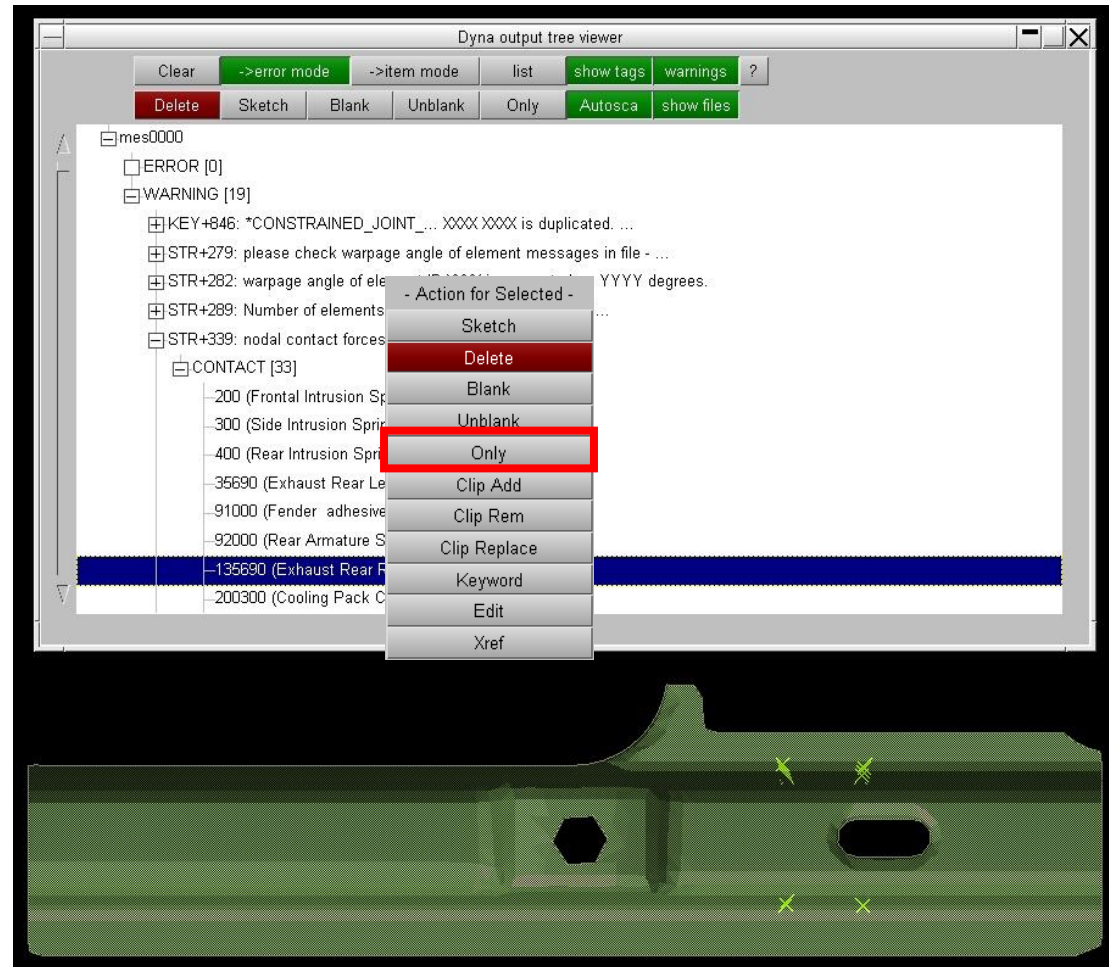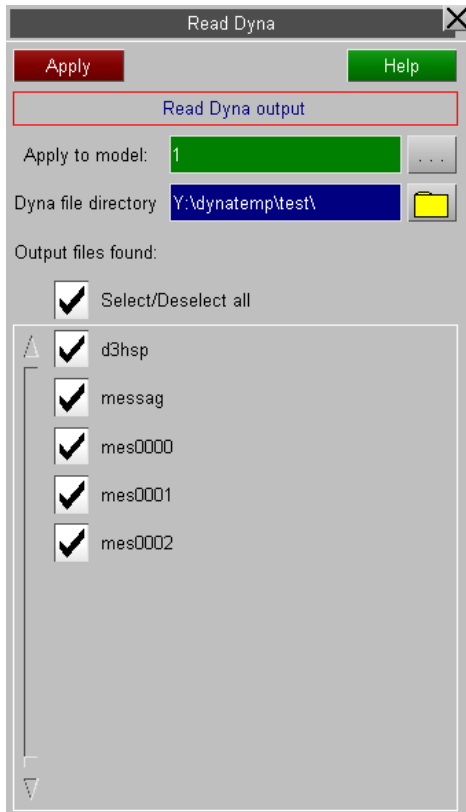# Penetrations: Crossed Edge Fixing
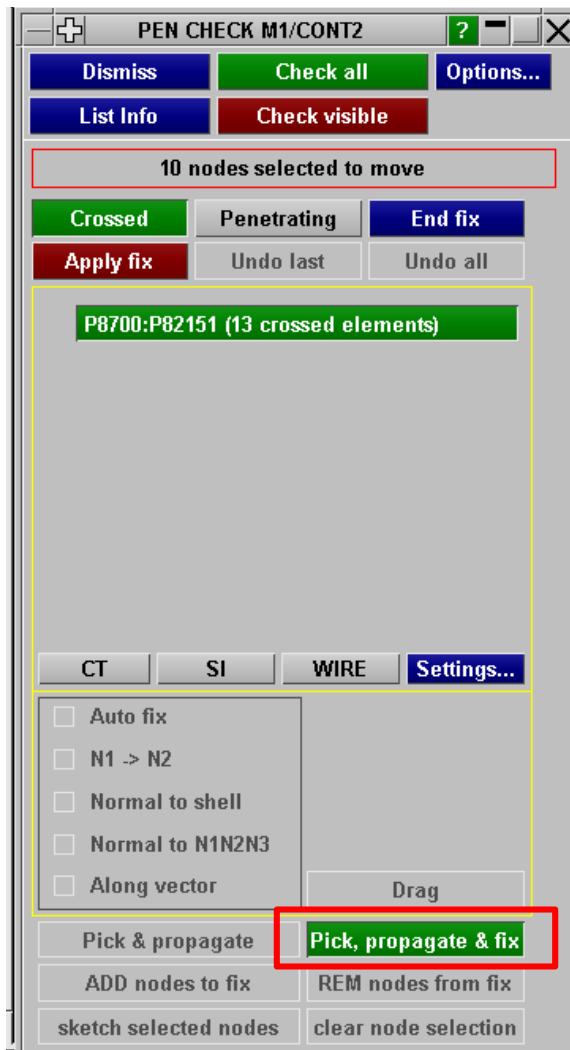
Pick one node

auto

"Pick, propagate & fix" allows user to pick one node; the selection of other nodes that are on the same side of the Crossed Edge, and the fixing, are both performed automatically in a single operation

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LS-DYNA Model Checking

LS-DYNA Model → Pre-Analysis Checking → **Checking during the analysis** → Post-Analysis Checking

Reading LS-DYNA Output Text Files

LS-DYNA Output file reader

LS-Dyna output files from the selected directory can be interrogated for errors, warnings or other data. If the associated model is loaded, entities to which the output message refers can be manipulated.
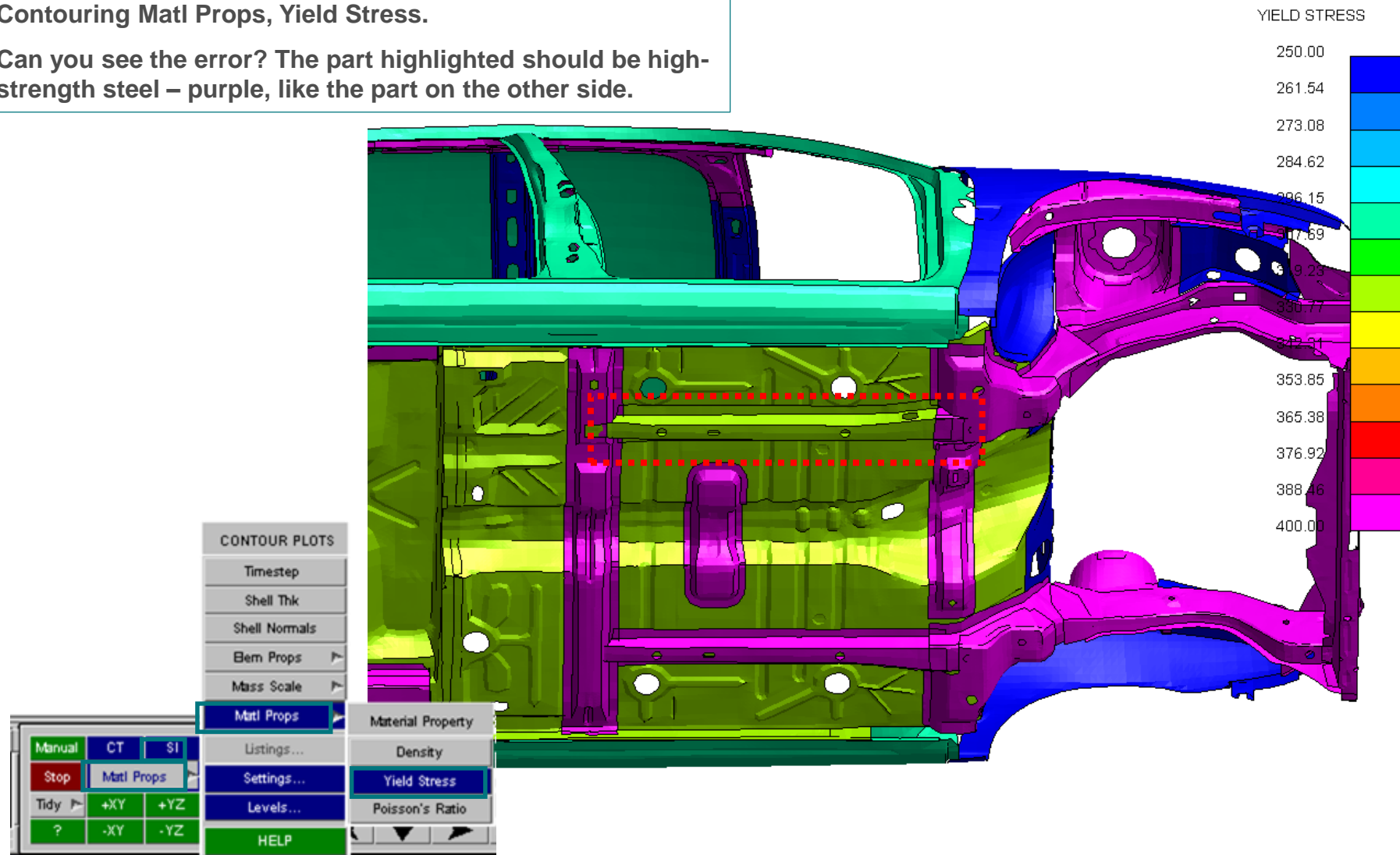
Visual Checking Features

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Contouring

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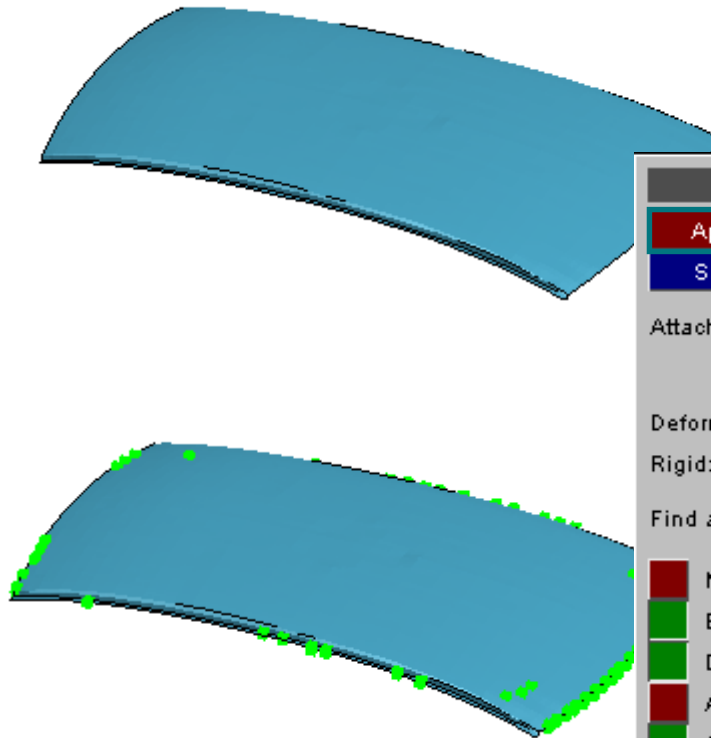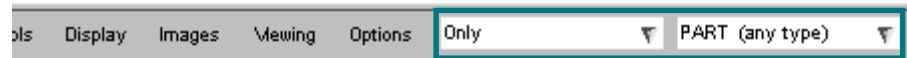
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Visual Checking - Contouring

Contouring Matl Props, Yield Stress.

Can you see the error? The part highlighted should be high-strength steel – purple, like the part on the other side.

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Attached

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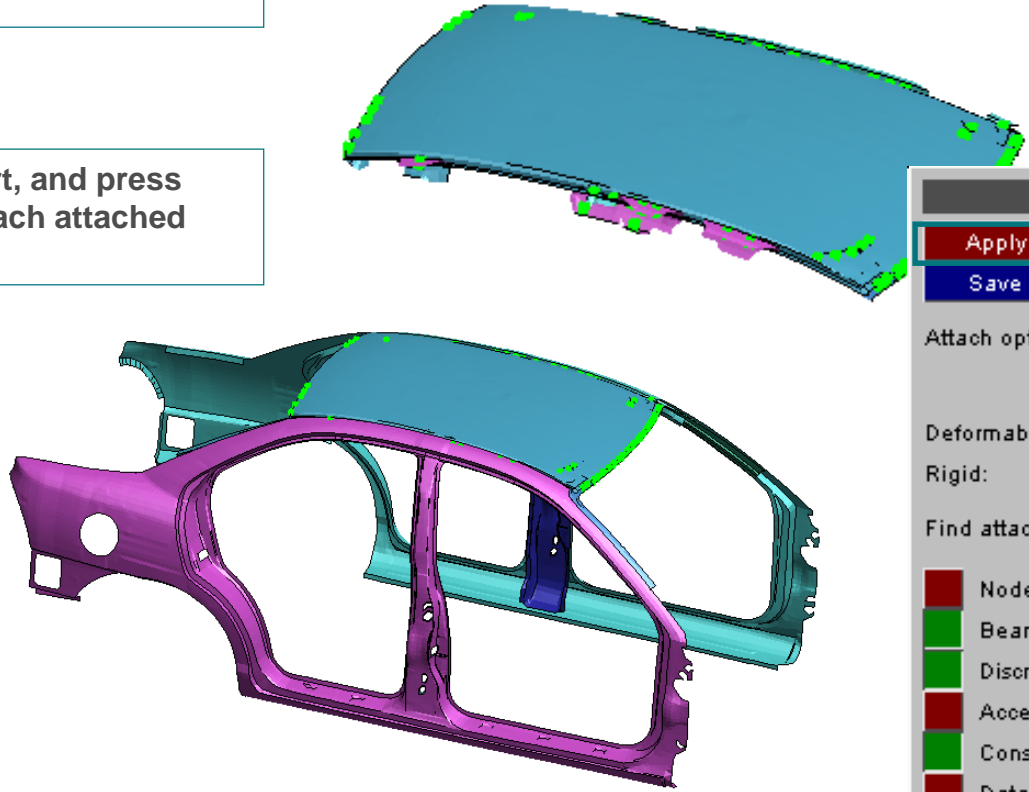
Visual checking – Find Attached

Under Tools, press **ATTACHED**. In the attached menu, press **APPLY**. PRIMER finds and displays any entities joined to the entities already displayed – in this case, mesh-independent spotwelds that are joined by a tied contact. PRIMER uses the same thickness tolerances etc as LS-DYNA to decide which nodes are tied by a tied contact.

Visual checking – Find Attached

Press APPLY a few more times. Elements of the panels attached to the spotwelds appear.

Now click Attached Part, and press APPLY. The whole of each attached part appears.

Visual checking – Find Attached

To find every connected entity (without pressing APPLY many times), click Recursive. Press APPLY. PRIMER automatically continues to find attached entities until no more are found.
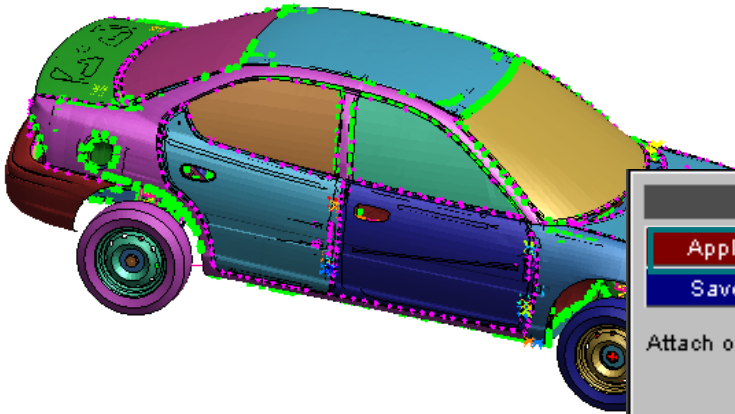
Finally, press R to reverse the blanking. Any loose part will now be displayed. These need to be fixed to the car.

Display   Images   Viewing   Options   Only   PART (any type)

Attached

| Apply | Blank | Entities | Help |

| Save current | Restore saved |

| Attach opts: | Beam 3rd nodes | Beam PID's |
| | Tied contacts | Recursive |

| Deformable: | Attached part | Single elems |
| Rigid: | Whole part | Single elems |

Find attached through: (All off)   (All on)

Node	Solid
Beam	Shell
Discrete	Mass
Accelerometer	Airbag
Constrained	Contact
Database	Define
Set	

Exploded View

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Exploded view

Selected entities of a specific type can be pushed away from other entities of that type while being treated as choate blocks. Supported entity types are: includes, parts, part sets and part tree assemblies


Two modes - part-based and node-based - are available:
1. **Part-based explosion will cause parts that are meshed together to move apart while ignoring shared nodes**
2. **Node-based explosion may cause parts that are meshed together to deform to account for the shared nodes**

Options to control explosion centre, direction, step size, padding around entities and overall scree space are available

Explosion offsets may be saved for subsequent retrieval

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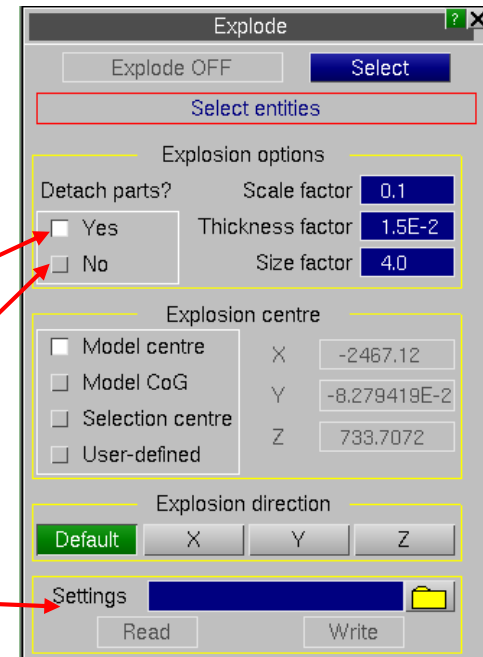
Connections between includes

Connections between includes
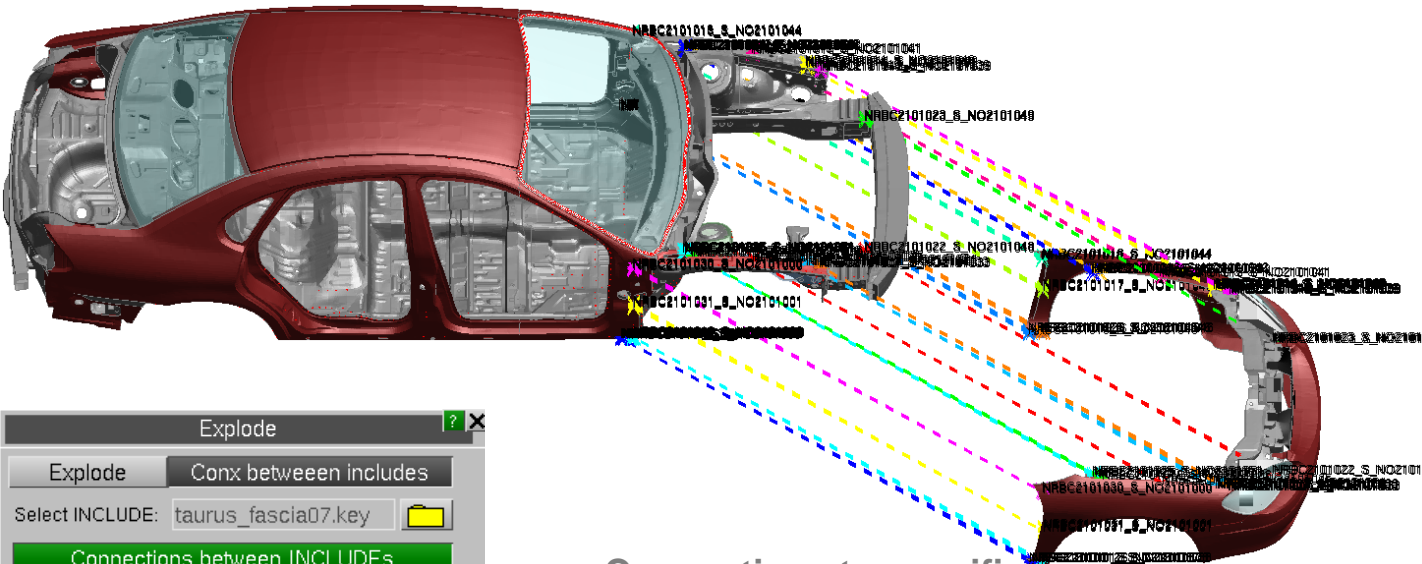
- **Connections between selected include and others in the model can be viewed in the Explode menu**

- **Relevant includes are exploded away from others and unconnected includes hidden**
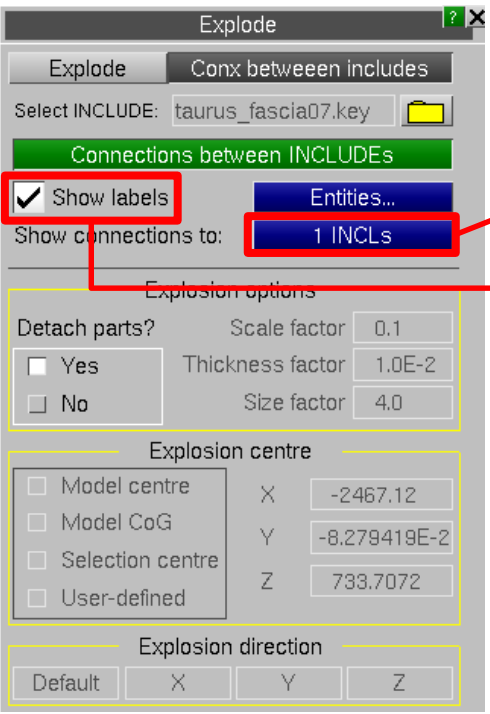
- **Connections to specific includes can be viewed**

- **Connection labels can be shown/hidden**

- **"Connections" include constrained items, elements and tied contacts**

- **Accessible from the Include tree**

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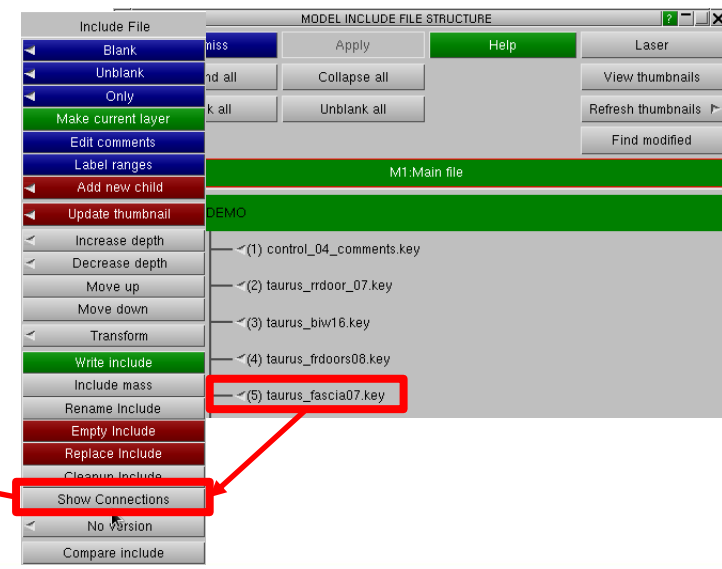
Cut Section

Cut section

Cut Section

1. Shortcut **X** to bring up the cut-section menu.

2. Shortcut **N** to activate node-picking, then click near the centre of the roof. Display changes to a cut-section at constant X through the picked node.

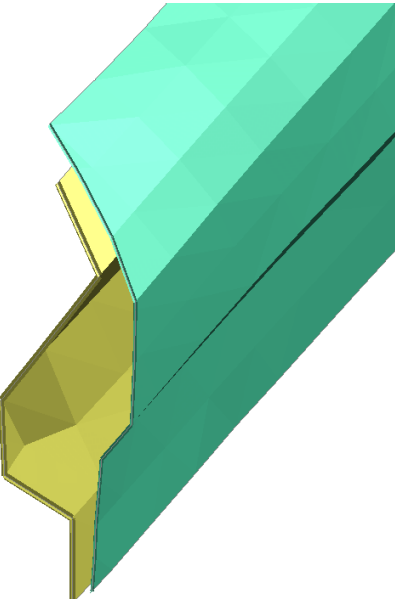3. In the menu, change Negative Action to **Normal** (i.e elements behind the plane are drawn normally.

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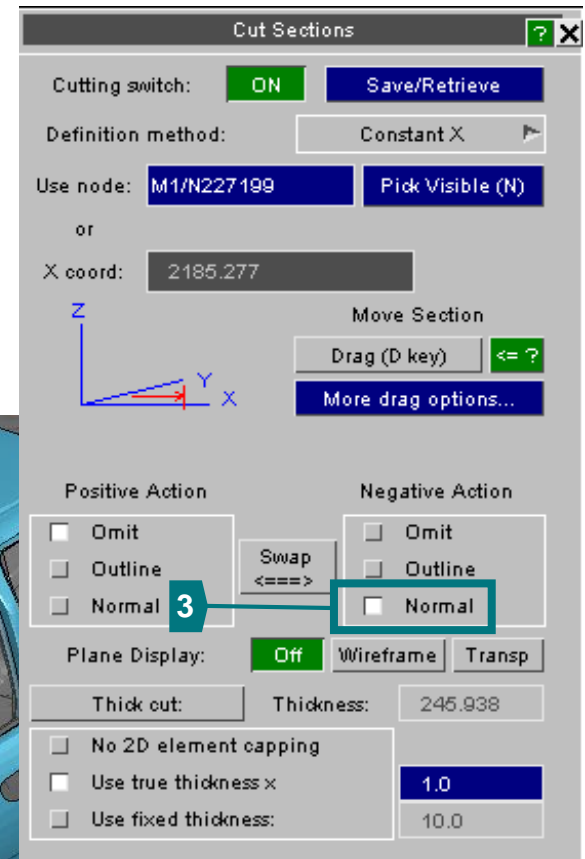
Cut section

Cut Section

1. **Zoom in on the cantrail. The cut edges of shells are drawn with their actual thickness – useful for seeing whether there are gaps (as in this model) or interferences.**

2. **Shortcut D, drag the section through the model.**

Cut section - properties

Find

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Find

- The "Find" function can be used to easily find entities in the model, and see their surroundings.

Checking Include Files

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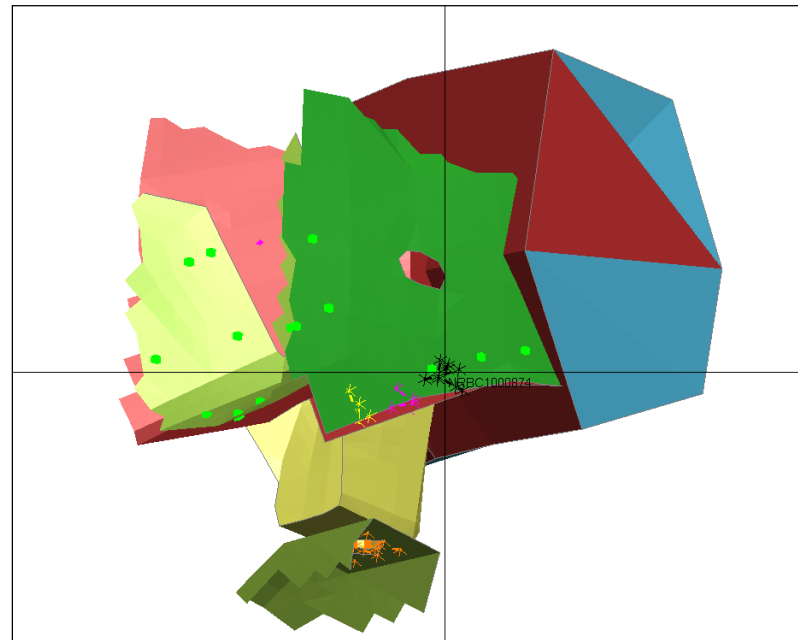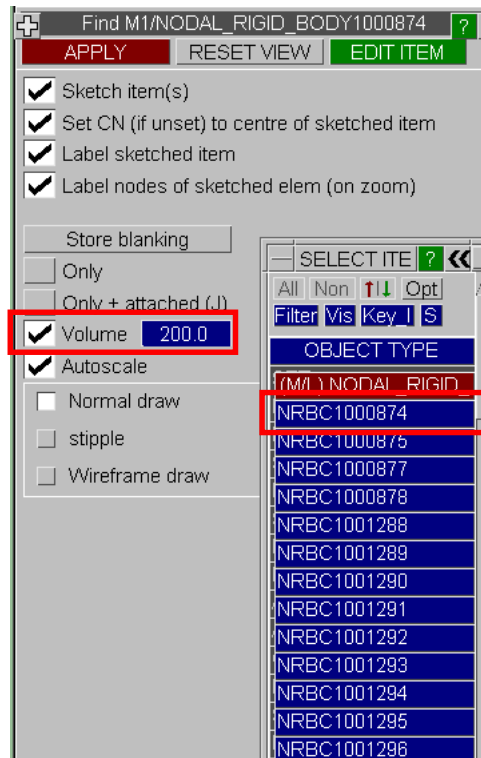
INCLUDE file for newly created entities

- If the user copies or modifies data, the modified or new data is put into the same INCLUDE file as the original data.
- When the user creates new data, how does PRIMER decide into which INCLUDE file it should be put?
- Answer: the "Current Layer" means the INCLUDE file for newly created data.
- To set the current layer, right-click on Include file in Part Tree, Make Current Layer.

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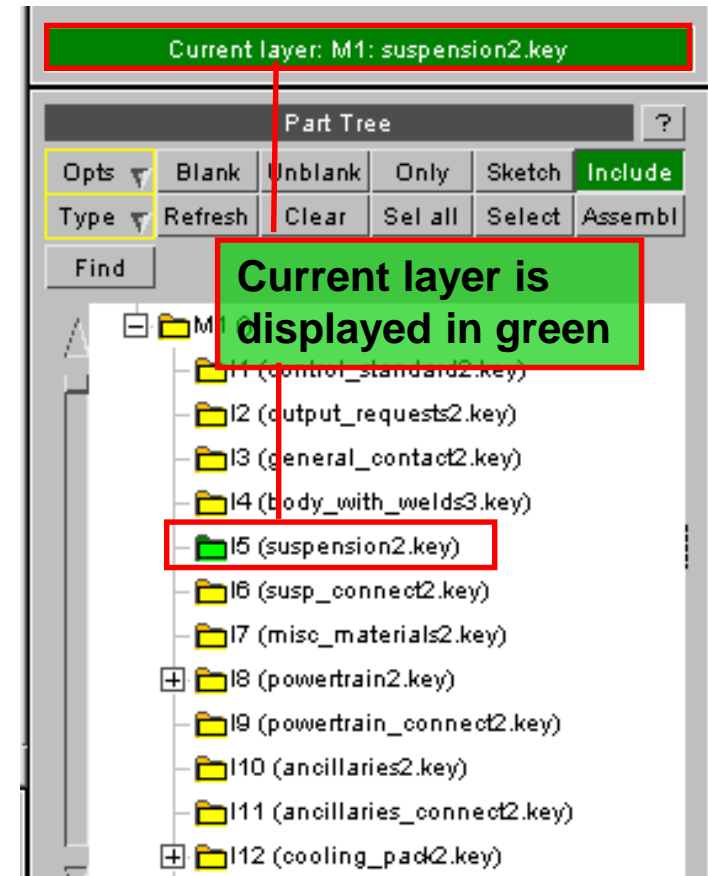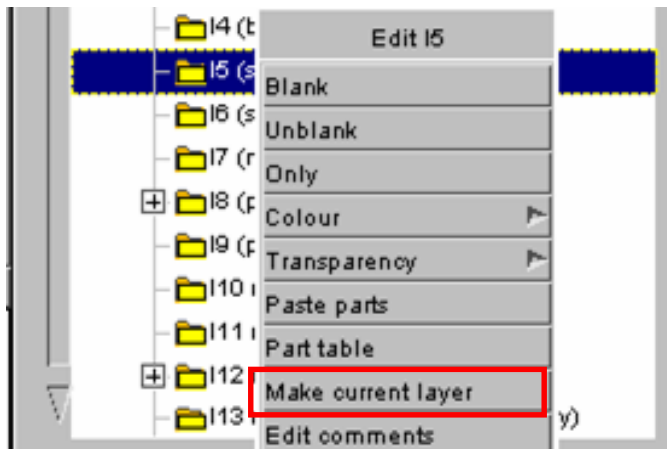
Numbering an INCLUDE file

- **This allows you to specify ID ranges for each include file**

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Numbering an INCLUDE file

- Two ranges can be set for each include
  - One range for nodes/elements + some other types
  - One range for all other labelled entities.
  - Both ranges can be the same.

- Label ranges can typed in, or imported from a CSV file.

- Label ranges are saved as comments to each include file.

- The panel will tell you if you have entities within an include file which is outside the specified range.

- Entities can be renumbered into range through this panel.

- Ranges are also used during creation of entities when assigning ID's.

Visualising Labels

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Visualise Labels

- A graphical display shows which labels (ID's) are used, and which are free.

Visualise Labels

"Entity" mode: labels are displayed according to entity type (Node, Solid, Shell…).

Visualise Labels

Black blocks indicate "used" labels

White areas indicate "free" labels

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Visualise Labels

Hovering the cursor over ranges will display the "used" or "free" information

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Visualise Labels

Visualisation options

Right mouse click in a "used" block will give various options

Renumber to a specified starting label

Switch to multi-select mode – drag across multiple blocks to select them

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Visualise Labels

Right mouse click in a "free" range will give options to renumber entities into this range

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Visualise Labels
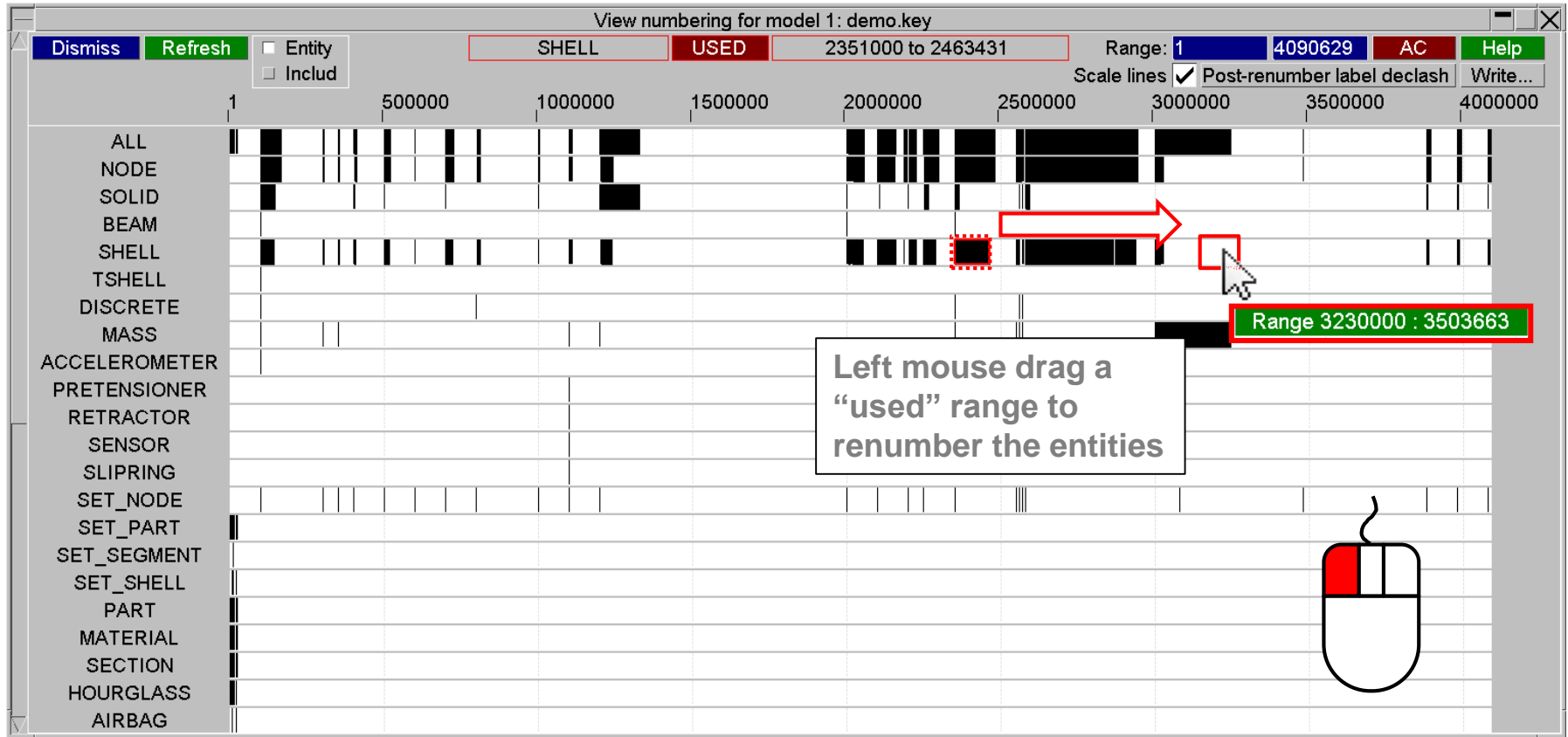
Visualise Labels

Control of numbering scale (horizontal axis):

Visualise Labels

"Include" mode: labels are displayed according to Include File

Pale colour: permitted label range for the Include File. These can be changed by dragging.

Dark colour: entities that are present in the Include file within the correct label range. The same options for controlling these are available as described on previous slides (drag, right-click, etc.)

Orange colour: entities that are outside the permitted label range

The options for controlling the blocks of entities are the same as described on previous slides (drag, right-click, etc.)

Deleting Entities – Maintaining Model Integrity

# Remove Panel

Remove
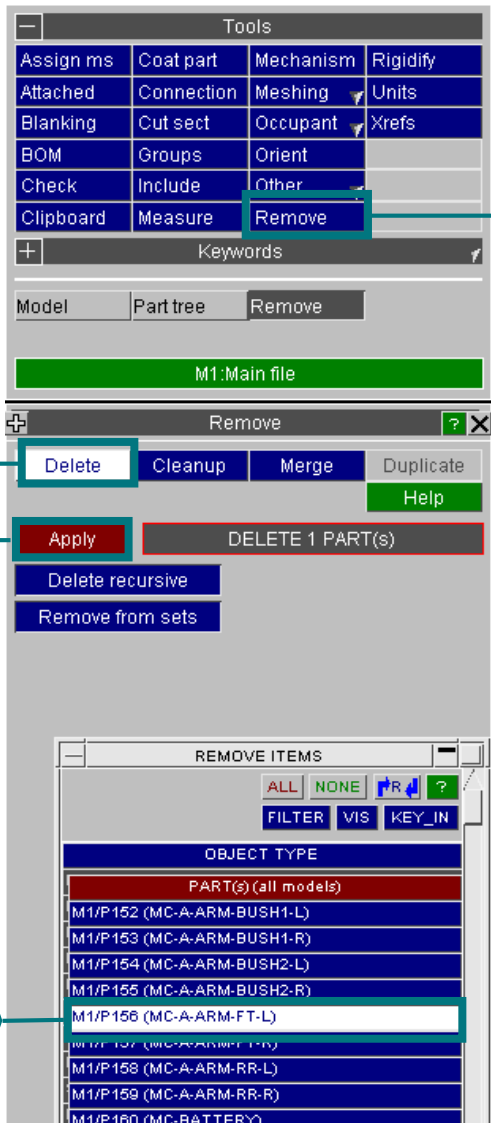
Remove

The remove function can be used to delete entities whilst maintaining the integrity of the model. First, unblank the whole model (U).

1. **Go to Tools – Remove, to display the remove menu.**

2. **The Delete sub-menu is shown by default. Select a part & Apply.**

3. **The next menu shows what entities PRIMER decides should be deleted together with the part. *In this this example some Constrained entities are also highlighted – if left in the model these would cause an error.***

4. **The user can Sketch each entry on the list and choose which types to leave undeleted. In this case delete all using DELETE_SEL.**

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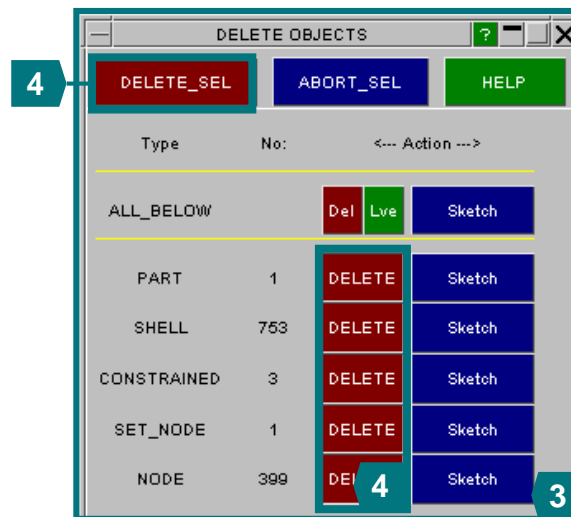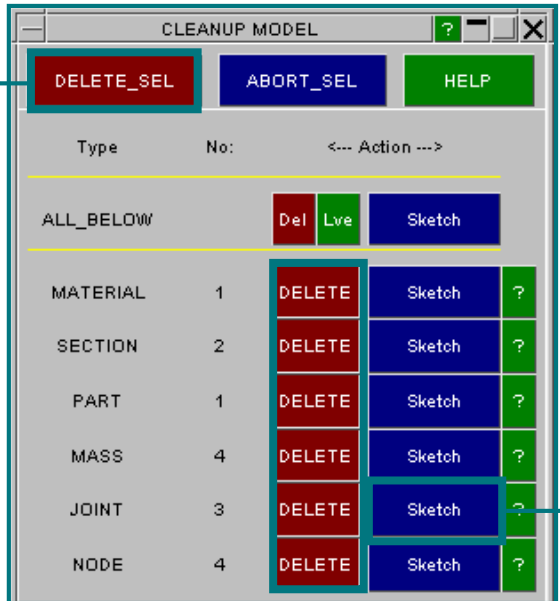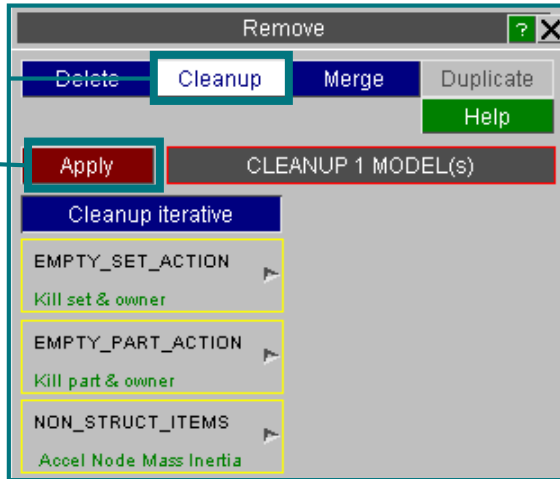
Remove

Remove (cont)

The **cleanup** function identifies data that is no longer needed in the model.

1. Select **Cleanup** sub-menu to remove entities that are no longer used.

2. Click **Apply**.

3. In the next menu we see what PRIMER recommends to be deleted – **Sketch** the joints to see their location. *If these joints are left in the model LS-Dyna will terminate with an error.*

4. Delete all using **DELETE_SEL**.

Xrefs

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X-Refs

X-Refs (Cross reference)

Linkage (cross references) between entities may be viewed using Xrefs.

1. **From parts menu, Edit a part.**

2. **VIEW_XREFS will open the Cross reference viewer**

3. **The left menu contains entities that refer to this part.**

4. **The right menu contains entities that this part refers to – right click & open – we can see that only 1 parts references this material**

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Investigating and Creating Mass
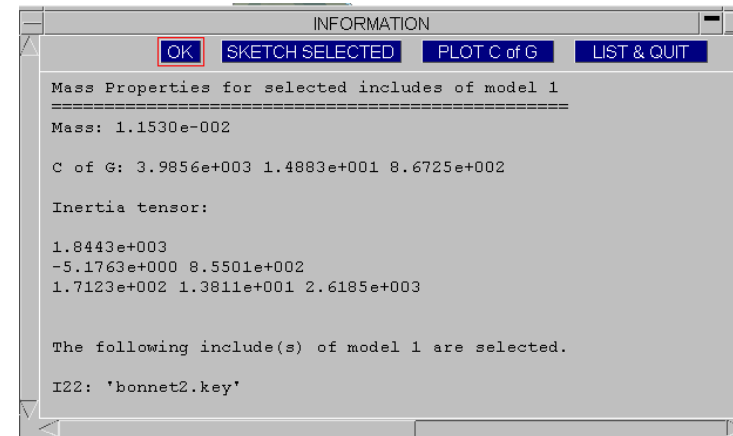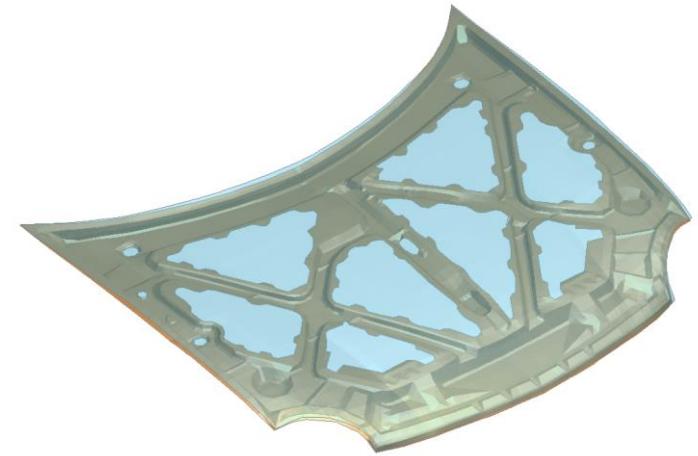
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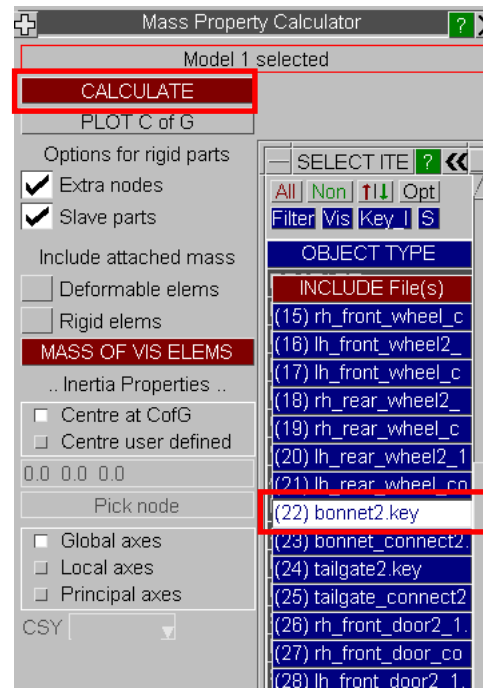Oasys Ltd
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Mass Properties

Mass Properties

- The "Mass Properties" function can be used to calculate mass properties of selected entities.
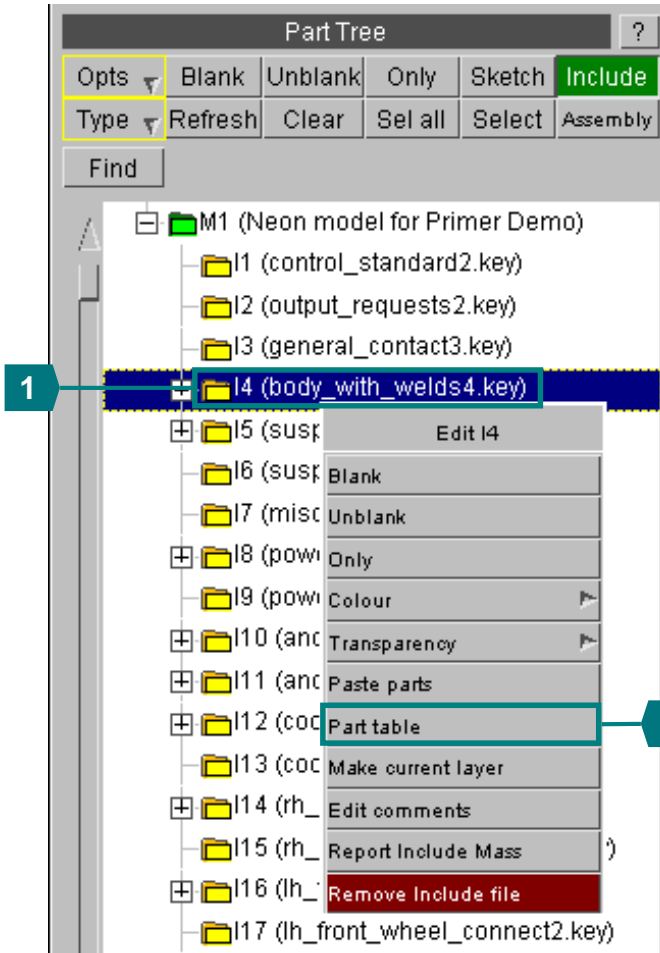
Find

1. In the Tools menu, click **Mass Prop.**

2. Select **INCLUDE FILE** in the selection menu. Choose **(22) bonnet2.key**.

3. Click **CALCULATE**. PRIMER will calculate mass properties of the include based on the settings on the panel, and report the result.

4. Various options are available for how to handle attached mass, and inertia calculations.

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Part Table

Part Table

Part Table

Part Table
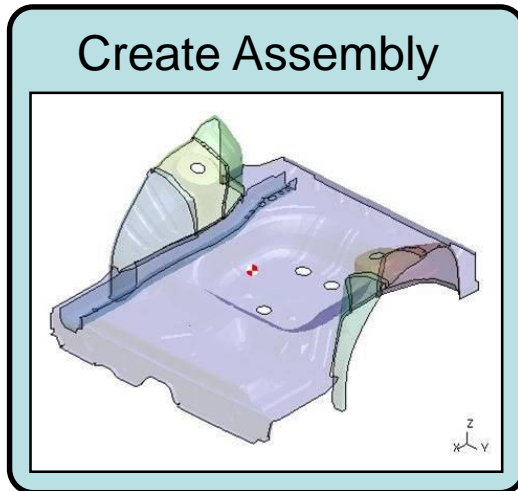
The table now shows the requested data.

1. **Click on the column heading "Part Mass".**
    The parts are now in order of mass, lightest at the top.
2. **Click again. *Now the heaviest parts are at the top.***
3. **The total mass is shown on the column heading.**

PART TABLE

Dismiss | View... | Refresh | Write... | Table Changes: | Undo | Apply   Mass in table: 0.217077   ?

Part ID	Part title	Gauge	Mat ID	Part Mass [0.202763]	Added Mass [0.0143142]	NIP	Elform
353	CH-CBN-FLOORBRD-FT	0.705000	195	0.0131395	0.000394783	3	2
354	CH-CBN-FLOORBRD-RR	0.706000	196	0.0122001	9.26798e-005	3	2
355	CH-CBN-OUTER-L	0.829000	197	0.011437	0.00028267	3	2
416	CH-ROOF	0.702000	250	0.0068424	3.09549e-005	3	2
362	CH-CBN-SILL-B	1.701000	204	0.00637916	2.13682e-005	3	2
414	CH-RAILS-U-RR-R	1.916000	248	0.00516152	4.8488e-005	3	2
410	CH-RAILS-U-RR-L	1.916000	244	0.00515992	4.84855e-005	3	2
391	CH-RAILS-FT-R-I	1.895000	225	0.0038872	0.00245228	3	2
389	CH-RAILS-FT-L-I	1.895000	223	0.00382221	0.000903256	3	2
311	CH-A-PILLAR-B-O-R	1.611000	153	0.00351327	5.43483e-005	3	2
352	CH-CBN-FIREWALL	0.735000	194	0.00344807	0.000228272	3	2
310	CH-A-PILLAR-B-O-L	1.611000	152	0.00344365	5.47752e-005	3	2
381	CH-RAD-SUPPORT-B1	1.314000	215	0.00304176	0.000217485	3	2
347	CH-CBN-DECK-SPKR-SUPP	0.960000	189	0.00287323	1.84788e-005	3	2
610	CH-RAILS-U-RR-R-REINF	2.520000	295	0.00277413	7.5753e-005	3	2
609	CH-RAILS-U-RR-L-REINF	2.520000	294	0.0027737	7.80346e-005	3	2

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Assign Mass

Assign Mass

- Massing up an assembly:

Create Assembly

Input Required Mass

Distributed mass added using
`*ELEMENT_MASS`

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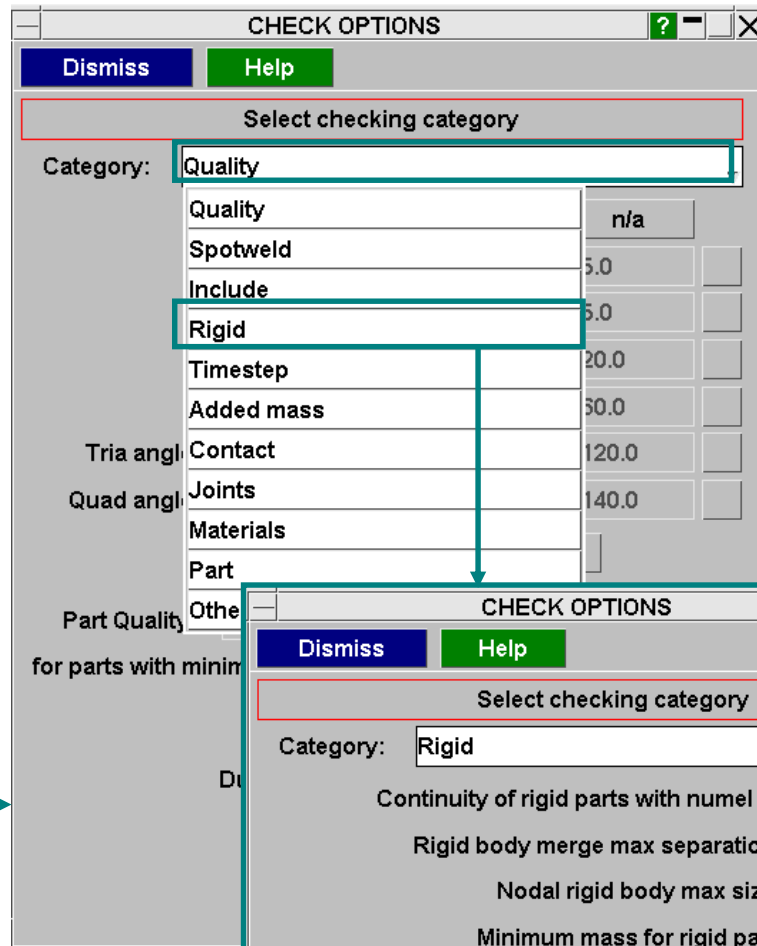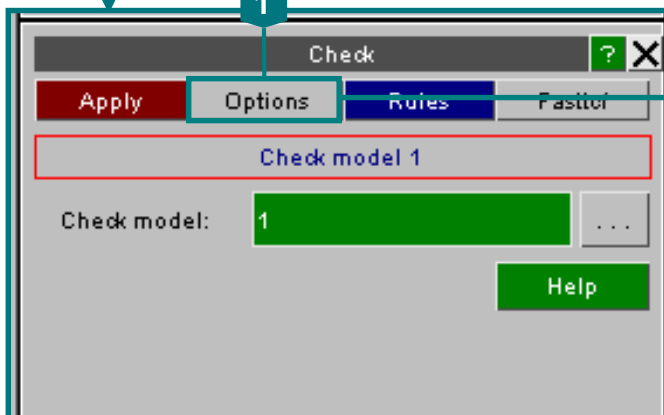The Software House of ARUP
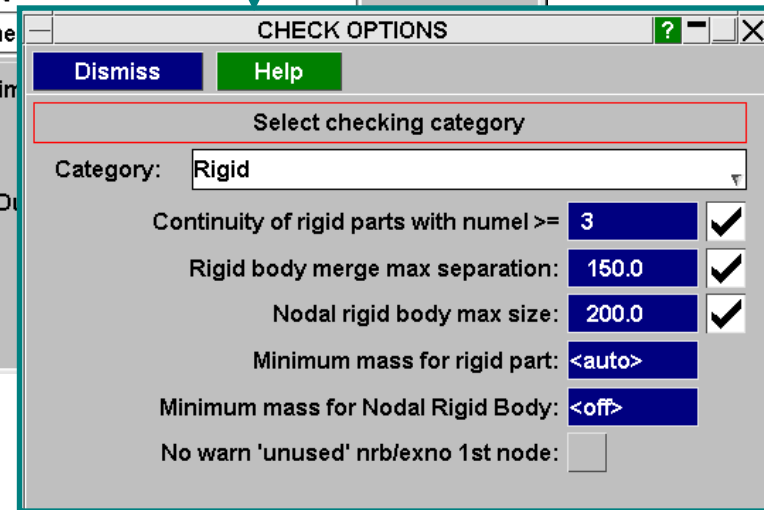
Check Customisation

User-defined checking options

User Defined Options:

1. To set user-defined values for some of the Error & Warning checks, click **Options** from the main check menu
2. Tick the boxes and set the desired limits – *this will apply to the current PRIMER session only*

Use drop-down to change category

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User-defined checking options

User Defined Options:

1. **For a permanent setting, use Options, Edit prefs from the top tool bar.** *Note – this does not affect the current PRIMER session unless you then "Refresh preferences"*

2. **Expand [+] PRIMER → [+] checking → [+] model quality checks → [+] rigid → [+] Rigid body merge check → rigid body merge max separation**

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User-defined checking options

- PRIMER has a capability for customising error checking.
- A user-written file can change the status of selected errors, and add extra messages which will appear in the error log file. The user's scripts can then scan the error file for these messages and take action accordingly.
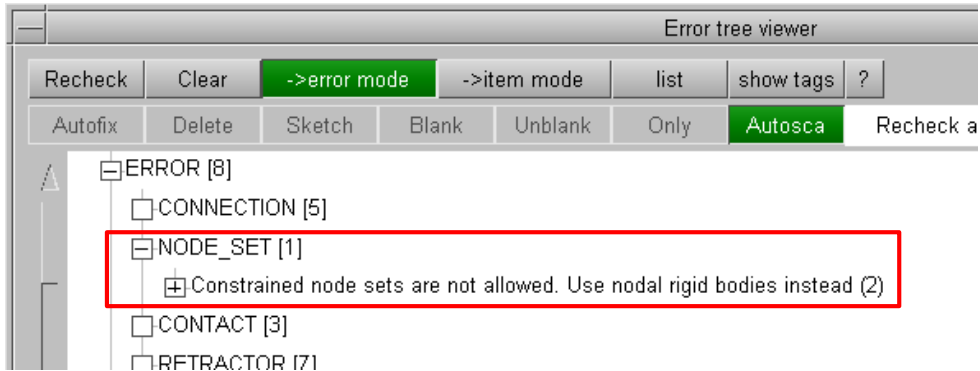- This can be created interactively in PRIMER

Example file:

```
PART_122,    ERROR,    Fatal - do not run this model
M_ST_24_07,  WARNING,  Demoted to warning
M_ST_24_10,  IGNORE,
```

Error tags – identifying the selected error. The tags can be made visible in the error tree.

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User defined checks

User-defined checks are written in Javascript and kept in $OA_INSTALL (or User's Home directory) \PRIMER_library\scripts\checks
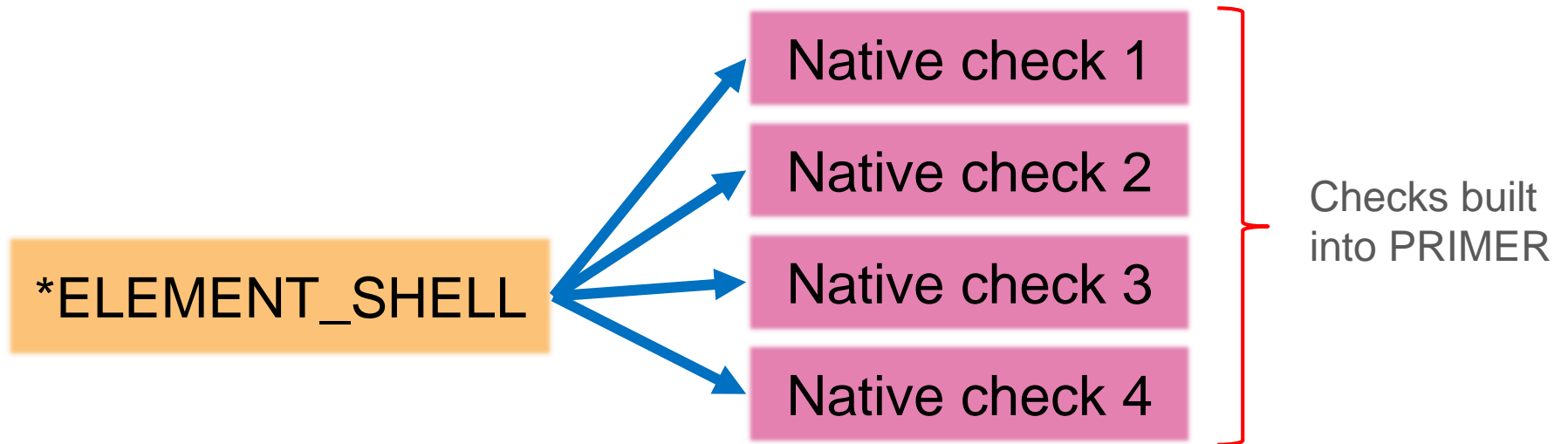Each script must have a filename that matches the Javascript Class name for the entity type being checked (e.g. Part.js applies to every Part being checked); checks that apply to the whole model must be in a script named custom.js
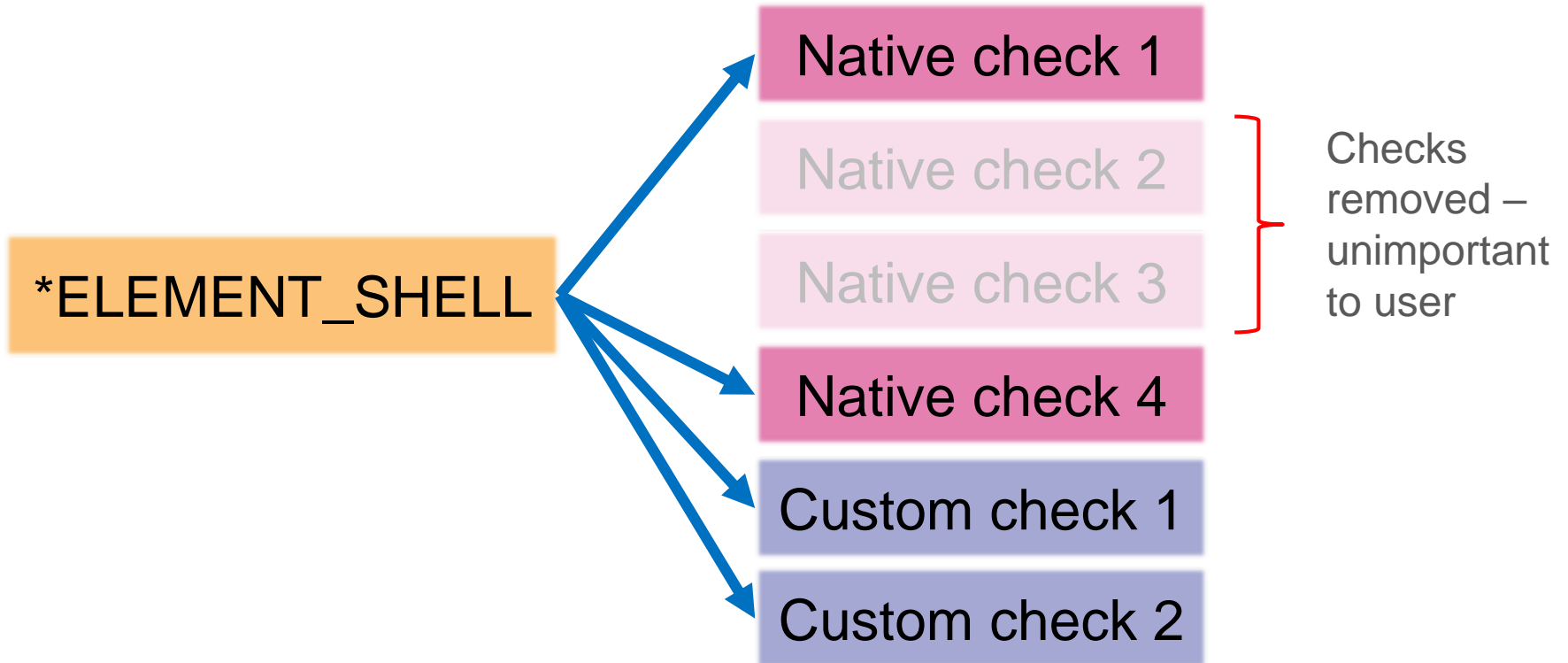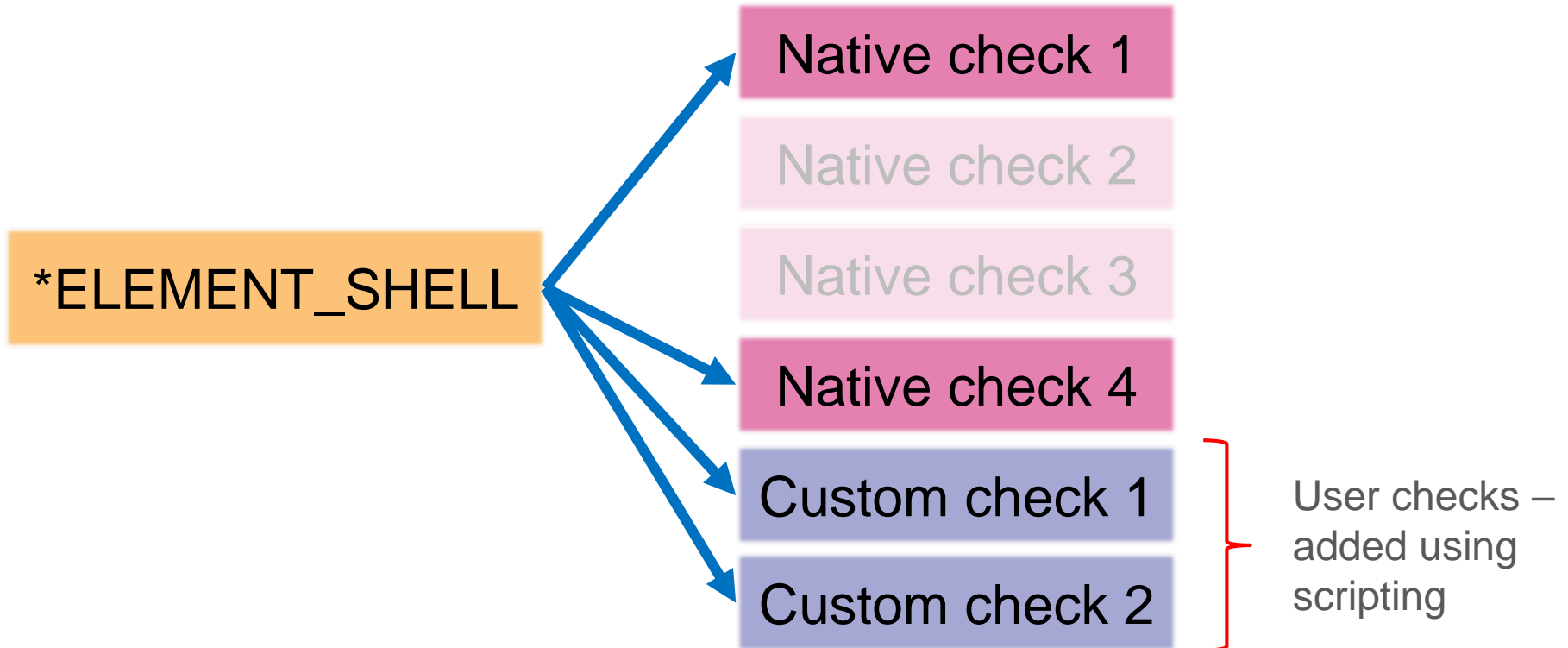The user-defined checks are applied in addition to PRIMER's normal Model Check..

```
// arguments[0] is name of script
var m  = arguments[1];          // arguments[1] is model
var ns = arguments[2];          // arguments[2] is node set

ns.Error("Constrained node sets are not allowed. Use nodal rigid bodies instead");
```

Check Customisation

*ELEMENT_SHELL

Native check 1

Native check 2

Native check 3

Native check 4

Checks built into PRIMER

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*ELEMENT_SHELL

Native check 1

Native check 2

Native check 3

Native check 4

Custom check 1

Custom check 2

Checks removed – unimportant to user

*ELEMENT_SHELL

Native check 1

Native check 2

Native check 3

Native check 4

Custom check 1

Custom check 2

User checks – added using scripting

Dashboard for model checking and health

Colours indicate the status of each check/metric.

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Model Checking & QA