From explicit to implicit - re-using crash models for static load cases with a minimal effort

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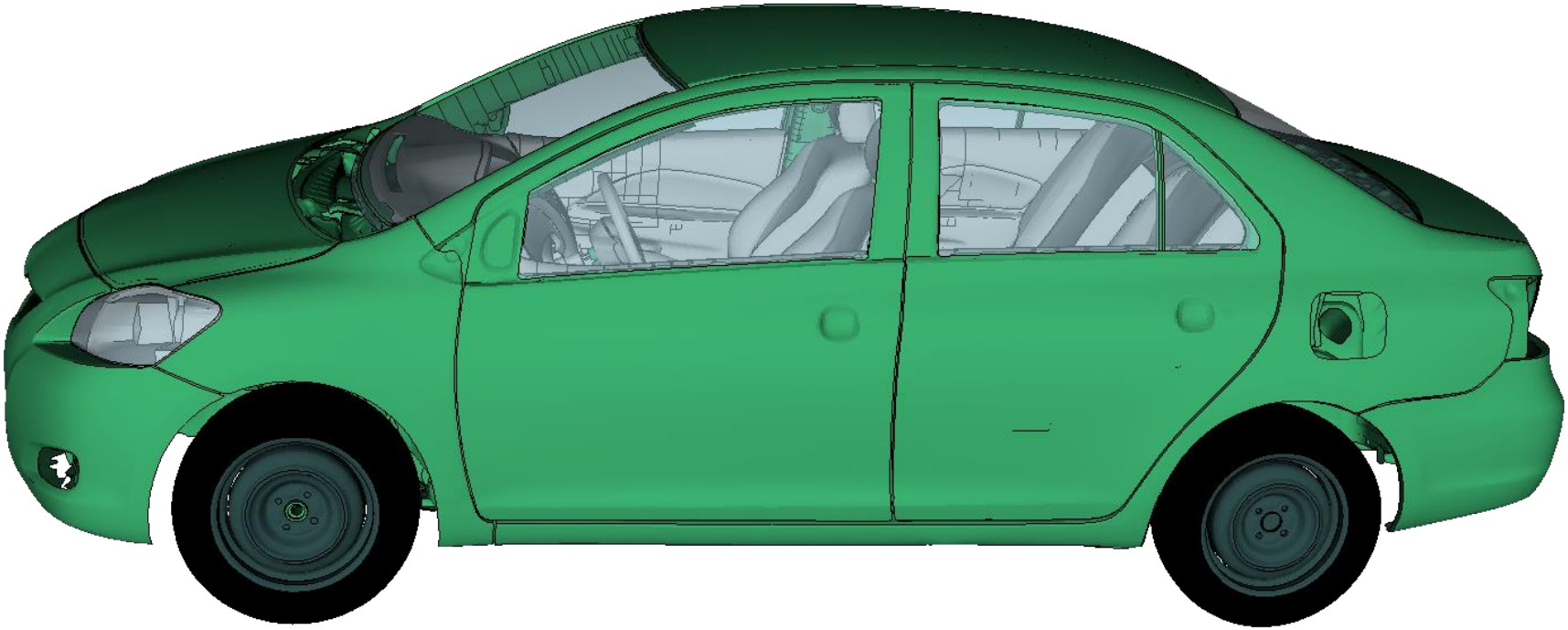

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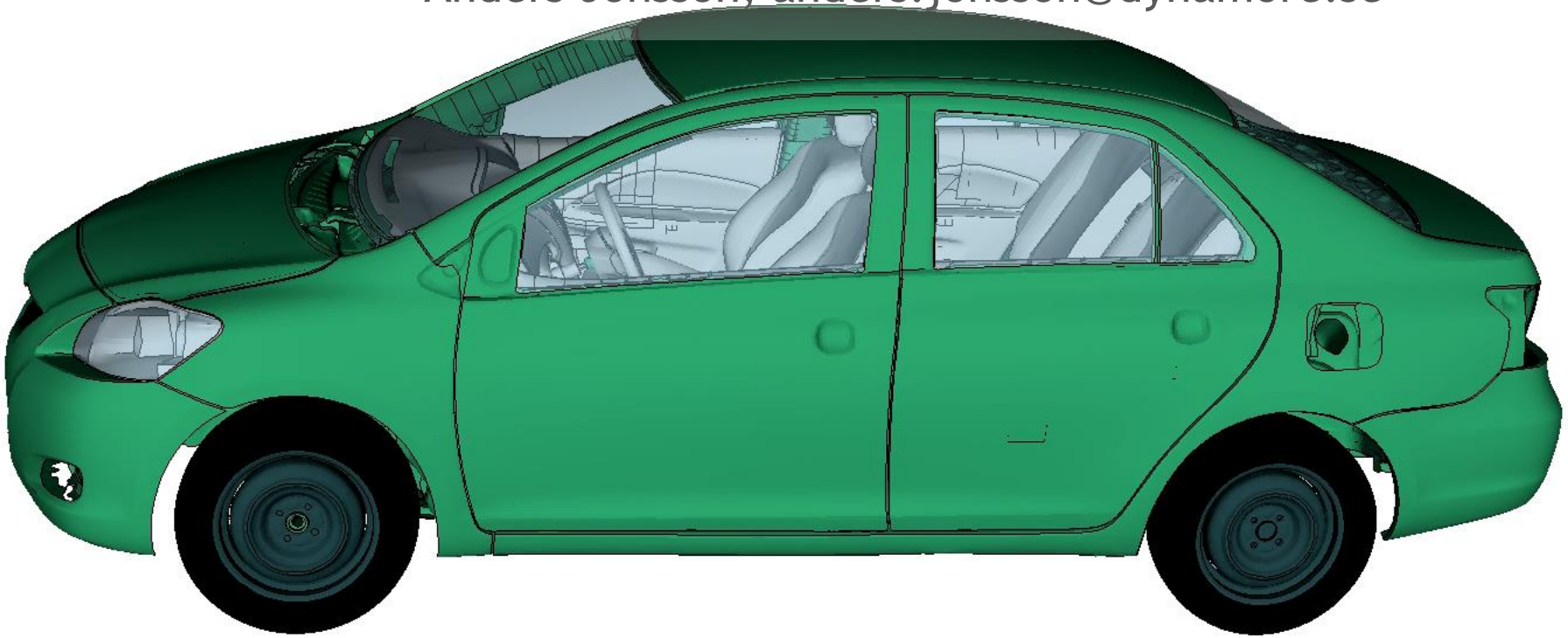
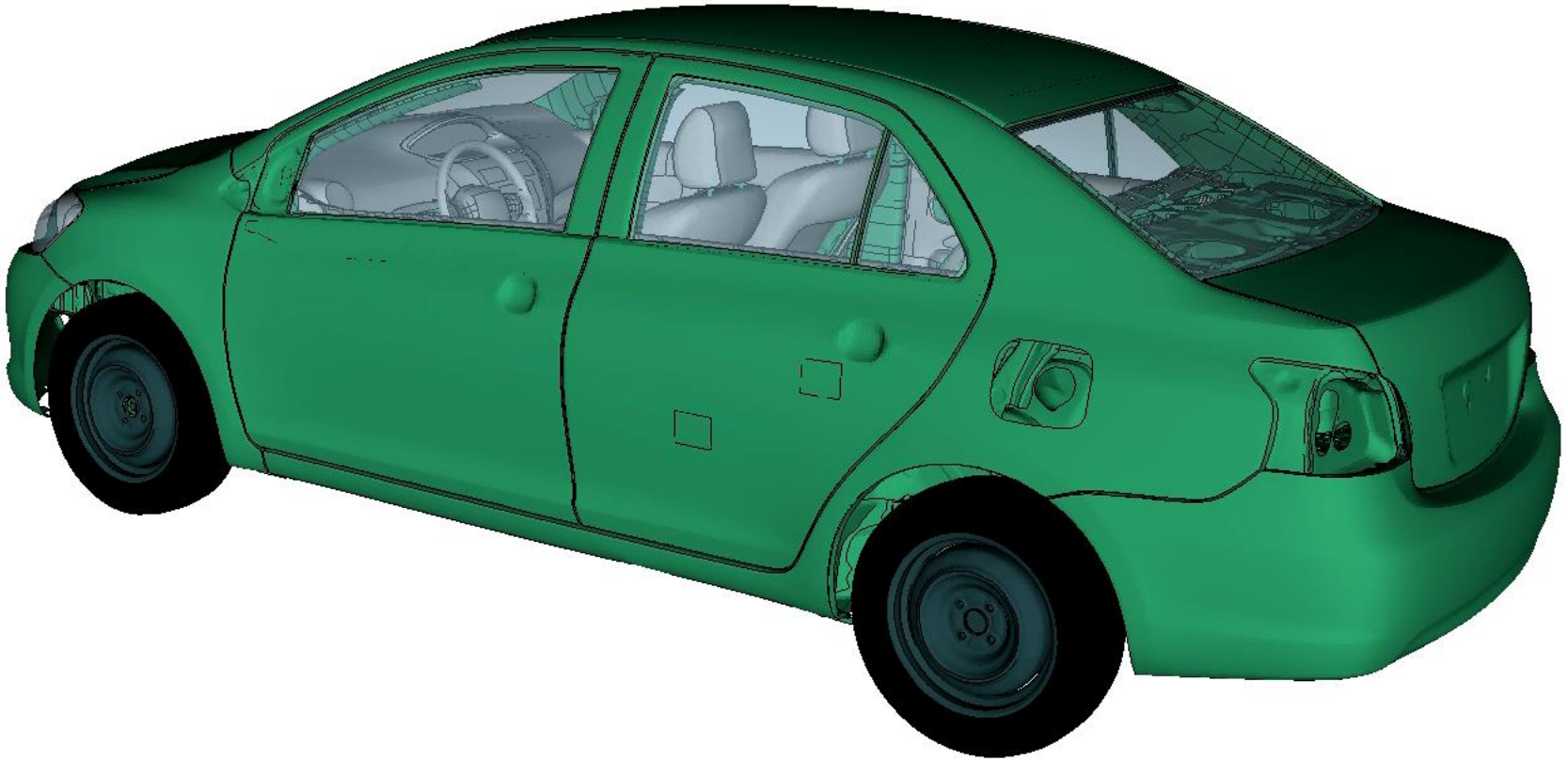


LS-DYNA implicit – Brief summary

- LS-DYNA Implicit works well
  - Also for large scale models, single surface contacts, material failure etc.
- It's possible to convert a large-scale explicit crash model to run in implicit
- LSTC and Dynamore are continuously working on making implicit more useful and easy-to-use
  - LS-PrePost GUI for simplified set-up of implicit analyses
  - LS-DYNA Bundle, including tutorials and guidelines
  - Guideline for implicit analyses, including examples

LS-DYNA implicit – Opening for new possibilities



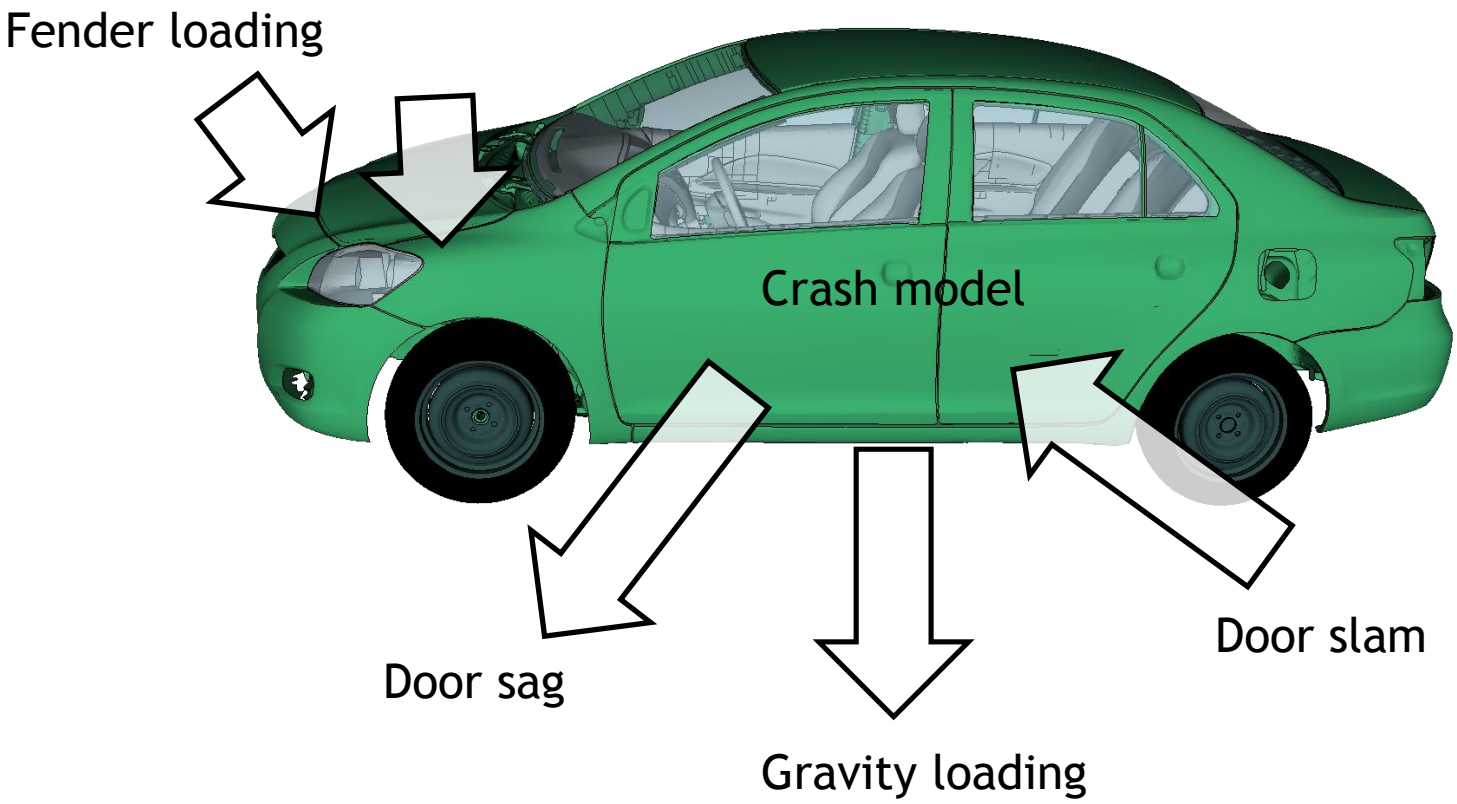
LS-DYNA implicit – Opening for new possibilities

- This presentation will briefly demonstrate how a crash model can be re-used for static load cases using the implicit capabilities of LS-DYNA
- The objective was minimal effort for model conversion from explicit. No parts were removed from the car model.
  - (Local) re-meshing may be required fore some load cases, for example if highly resolved stresses would be desired in critical areas

Examples in this presentation based on a public FE-model of 2010 Toyota Yaris developed by the Center for Collision Safety and Analysis (CCSA) at the George Mason University (GMU) under a contract with the Federal Highway Administration (FHWA)

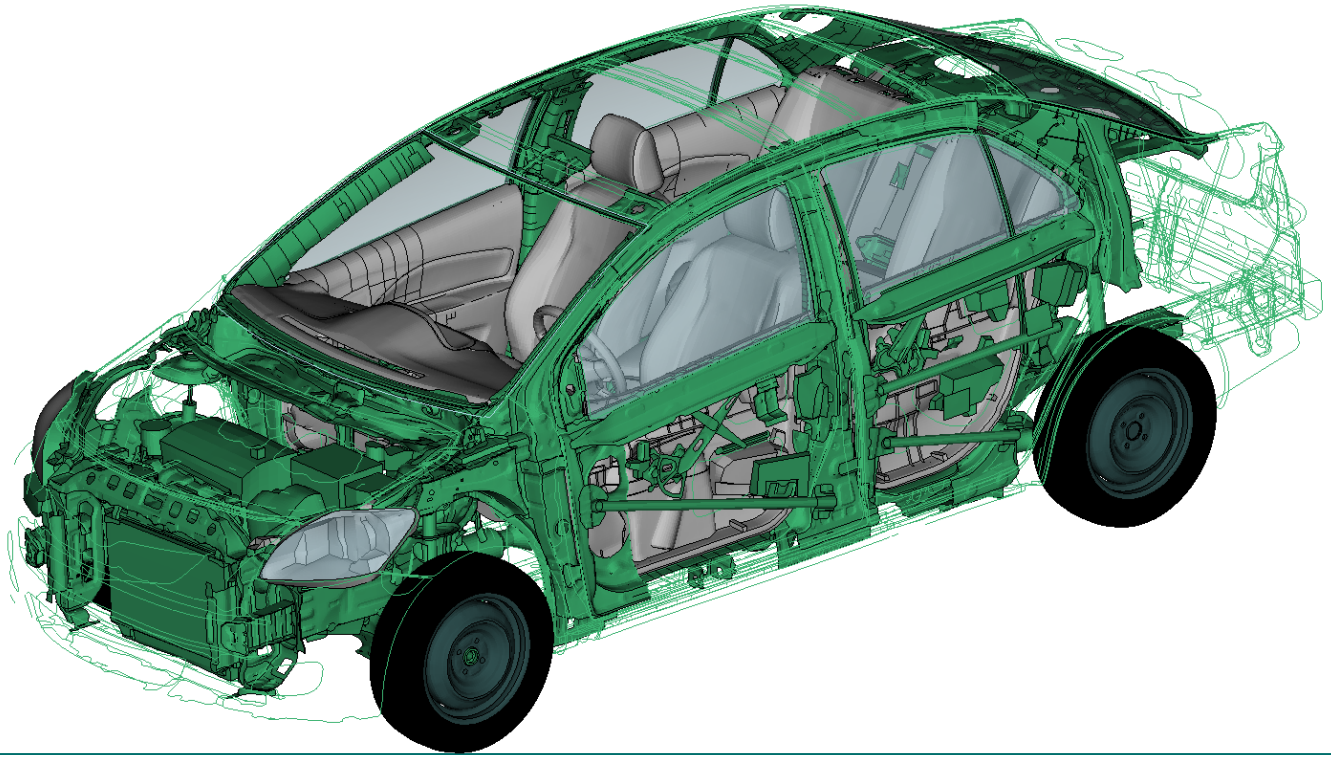
LS-DYNA implicit – Opening for new possibilities

- Start out with a model for explicit crash analysis
- Create a model that works in implicit by Minimal modifications
  - Many modifications could also be included in the crash model



Model data

- Examples in this presentation based on a public FE-model of 2010 Toyota Yaris developed by the Center for Collision Safety and Analysis (CCSA) at the George Mason University (GMU) under a contract with the Federal Highway Administration (FHWA)
  - Note: Complete model incl. engine and interior trim was used



Model data

- Examples in this presentation based on a public FE-model of 2010 Toyota Yaris developed by the Center for Collision Safety and Analysis (CCSA) at the George Mason University (GMU) under a contract with the Federal Highway Administration (FHWA)
  - Note: Complete model incl. engine and interior trim was used
- The same source was also used for similar examples on www.dynaexamples.com/implicit
- Model size is approximately 1.5 M elements. Car weight is 1100 kg, L ≈ 4.3 m, w ≈ 1.7 m, h ≈ 1.5 m.
- The different examples are run in mpp-LS-DYNA R9.1 or R10.0, using double precision on 16 – 24 cores.

LS-DYNA implicit set up

- The implicit load cases were set-up using the Guideline for implicit analyses.
  - **NEW Revision out now!** Download it from www.dynasupport.com/howtos/implicit/some-guidelines-for-implicit-analyses-using-ls-dyna
- It provides
  - recommended settings for different analysis types,
  - recommended element formulations, materials,
  - some small examples
  - and a trouble-shooting guide for convergence problems
- Also the LSTC Bundle contains some material regarding implicit analyses

Explicit to implicit – Modifications

- Unconnected parts or assemblies will cause rigid body modes, which may prevent convergence in implicit statics
- Check model connectivity!
  - Perform an eigenvalue analysis. Just add `*CONTROL_IMPLICIT_EIGENVALUE`
  - Use Check > Connectivity > Detect unconnected assemblies in ANSA
  - Check tied contacts. Setting `IPBACK` = 1 on `*CONTACT_TIED_...` may be a quick fix for avoiding loose spot-welds
- Connectivity causing hinges or mechanisms
  - For example beam -> solid using common nodes
  - A CNRB connecting to one node of a solid will also cause a spherical joint
  - Joints
- Check for unsupported features
  - User defined material models
  - For example, `*MAT_TABULATED_JOHNSON_COOK` is not supported in implicit
- General model QA
  - Check mesh quality, initial penetrations etc.

Specific modifications: Yaris

- Removed “dummies” from crash model
- The tire airbags were a separated and switched to *AIRBAG_LOAD_CURVE
- The suspension was modified to *ELEMENT_DISCRETE_LCO
- Spherical joints in the steering were replaced by CNRBs. Some “spinning beams” in the front suspension were constrained
- Added three springs between exhaust system and BiW to reduce rotations
- Added CRNBs between radiator and side tube to eliminate hinge

```
*** Warning 60301 (IMP+301)
    Using *CONSTRAINED_SPOTWELD with nodes without rotational dofs.
```

- Added CNRBs between windows and doors (to compensate for missing rubber seals)
- For the door-related load cases, the door hinges were aligned and some CNRBs between the BiW and the door were removed

Specific modifications for implicit

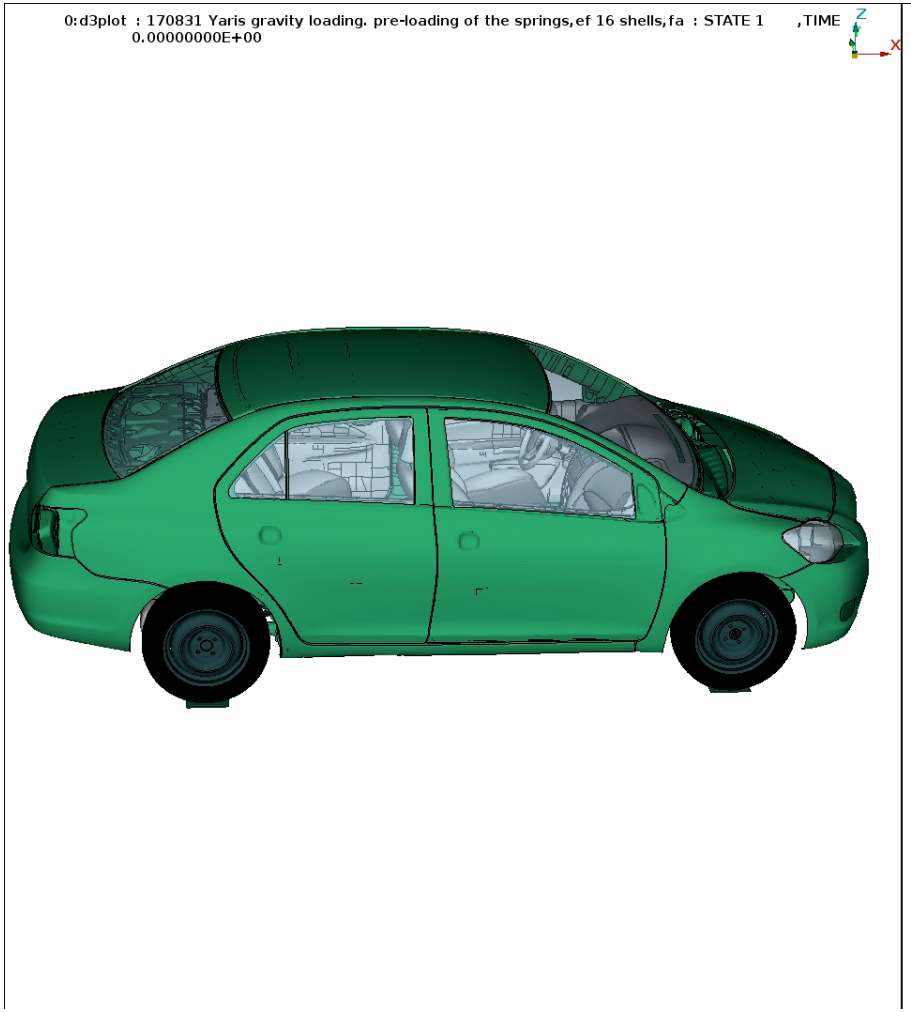
- The single surface contact was switched to Mortar contact (Note! Still **one** automatic single surface contact definition for the whole model)
- Added *IPBACK* to the tied contact for spot welds
- Switched to shell elform 16 using *CONTROL_IMPLICIT_EIGENVALUE
- The standard control card settings for non-linear implicit analyses from the Guideline were used
- The geometrical stiffness effect was disabled (*IGS* = 2 on *CONTROL_IMPLICIT_GENERAL)
- Rate effects were disabled (*IRATE* = 2 *CONTROL_IMPLICIT_DYNAMICS)

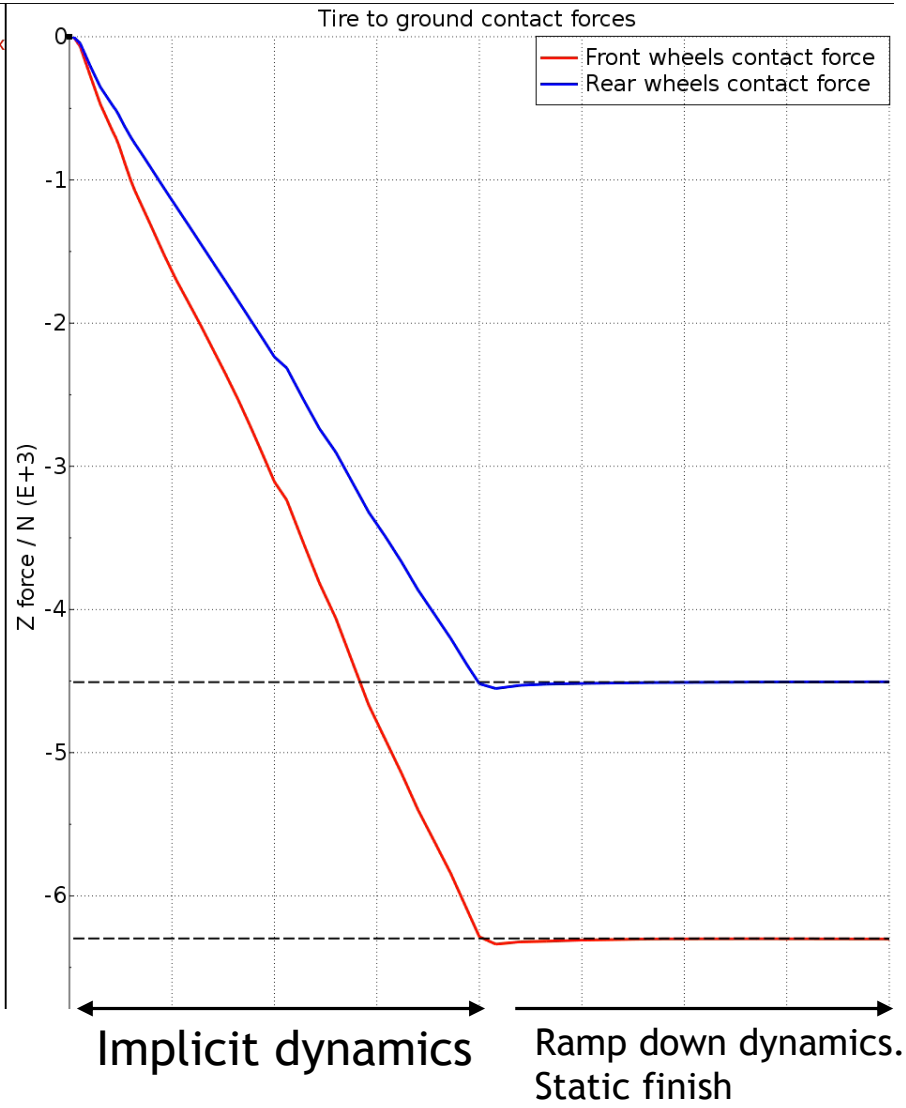
Studied load cases

- Gravity loading
  - Initially dynamic with static finish
- Door sag loading
  - Static load case
  - At 70° door opening angle
  - Gravity, and 1 kN loading at striker
- Hood / fender loading
  - Force controlled (1 kN), static load case
  - Fender/side position
  - Front position
- Door slam loading
  - Purely dynamic load cases
  - Prescribed initial rotational velocity of the door about the hinge: 1 rad/s, 2 rad/s

Run with constrained suspension

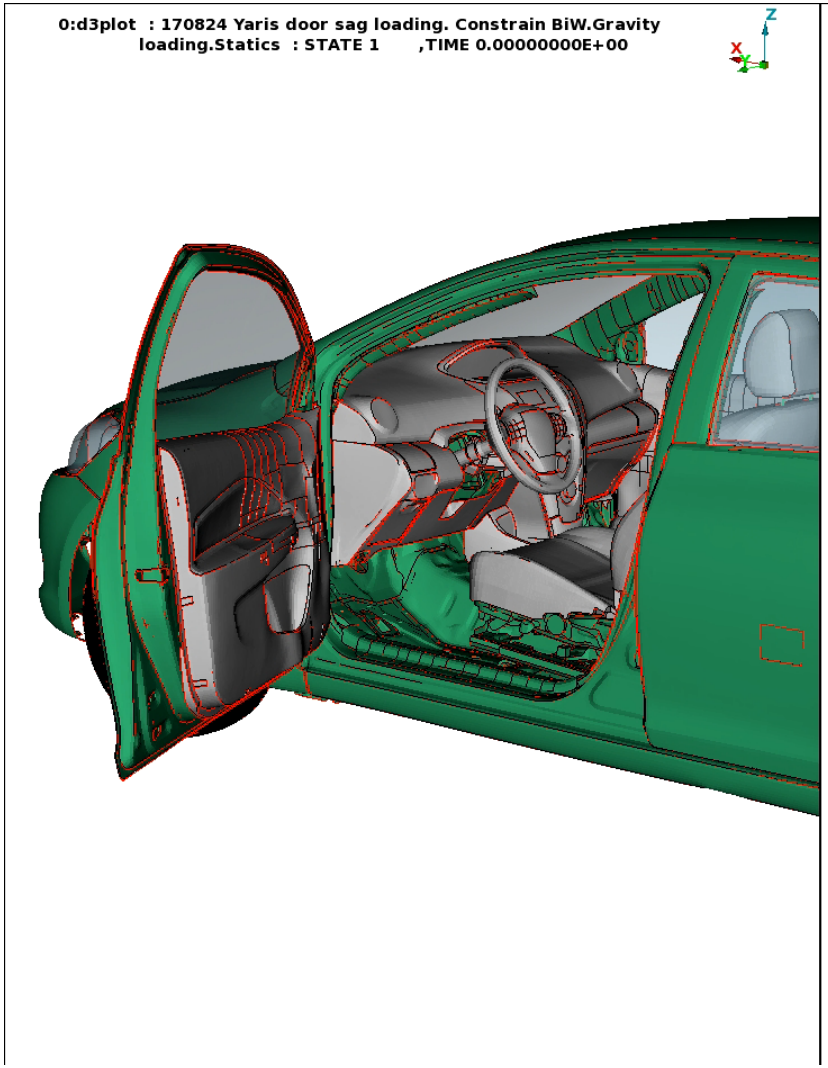
Gravity loading

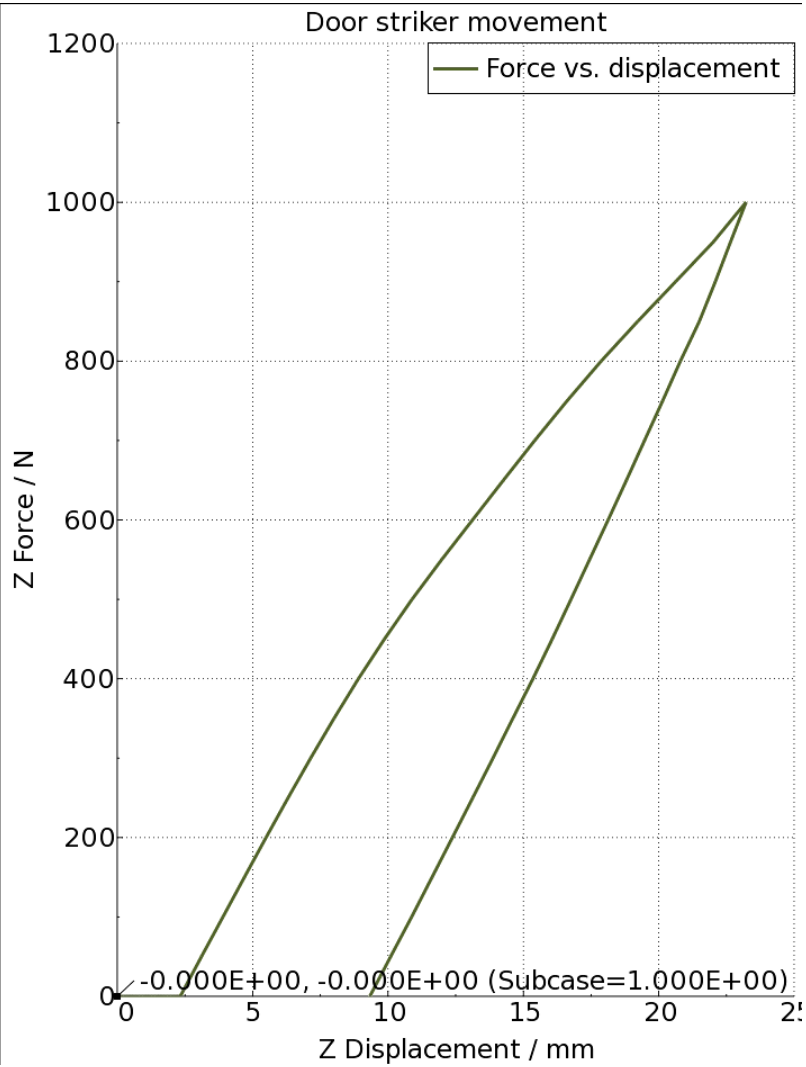




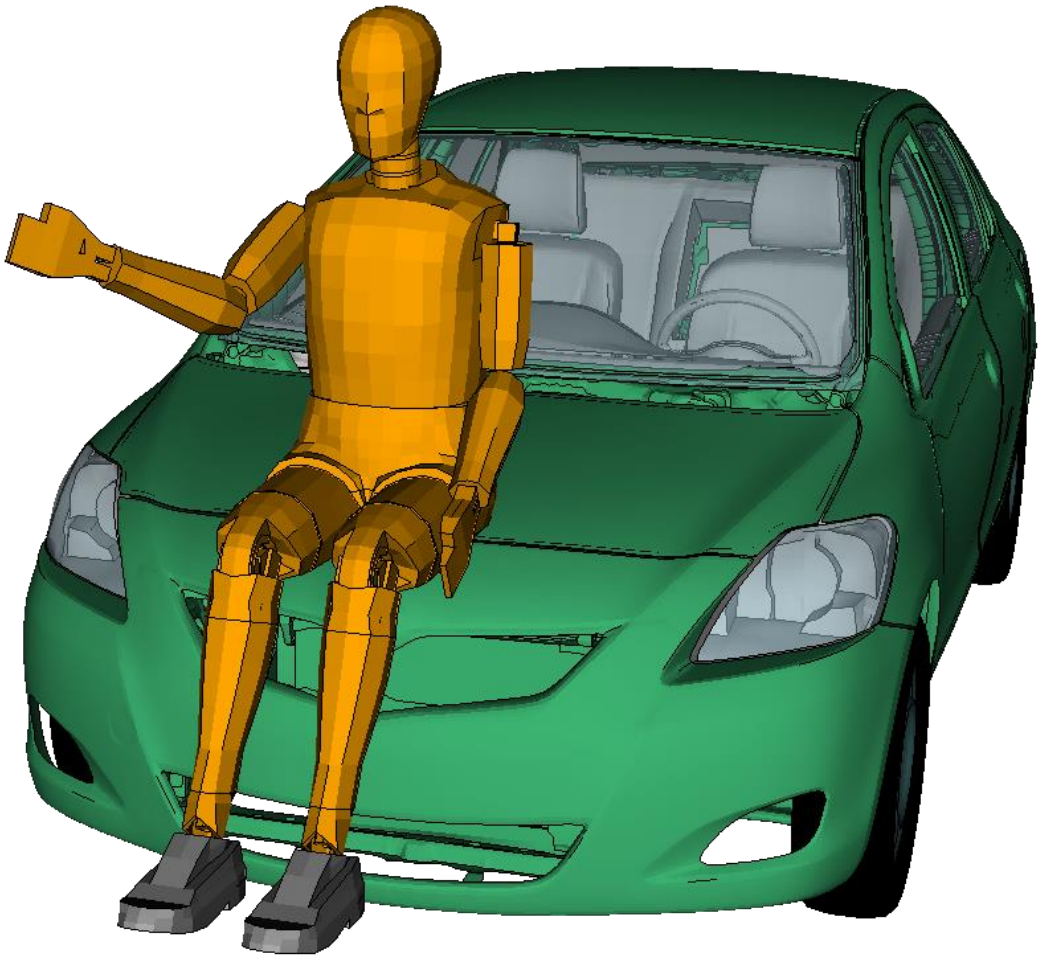
Door sag loading.

Solution time: 8h 48min on 16 cores



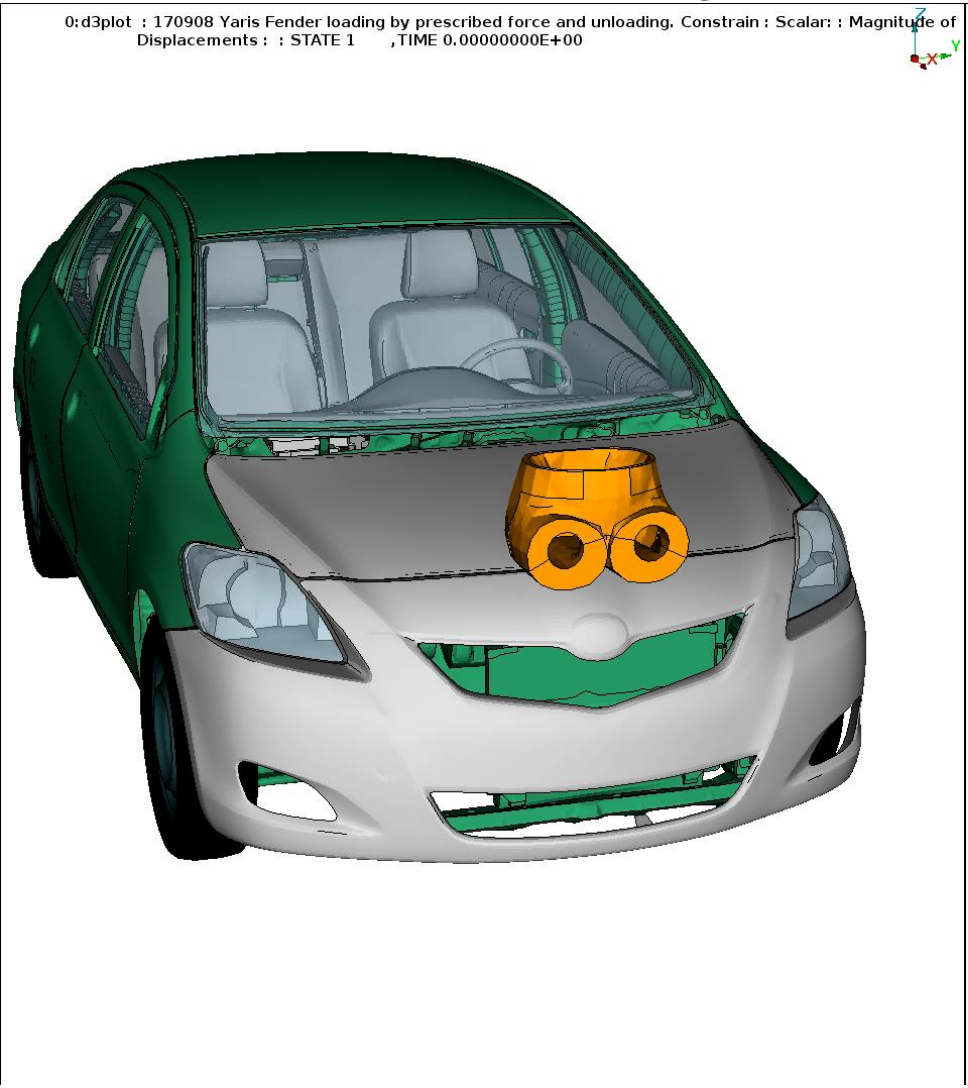


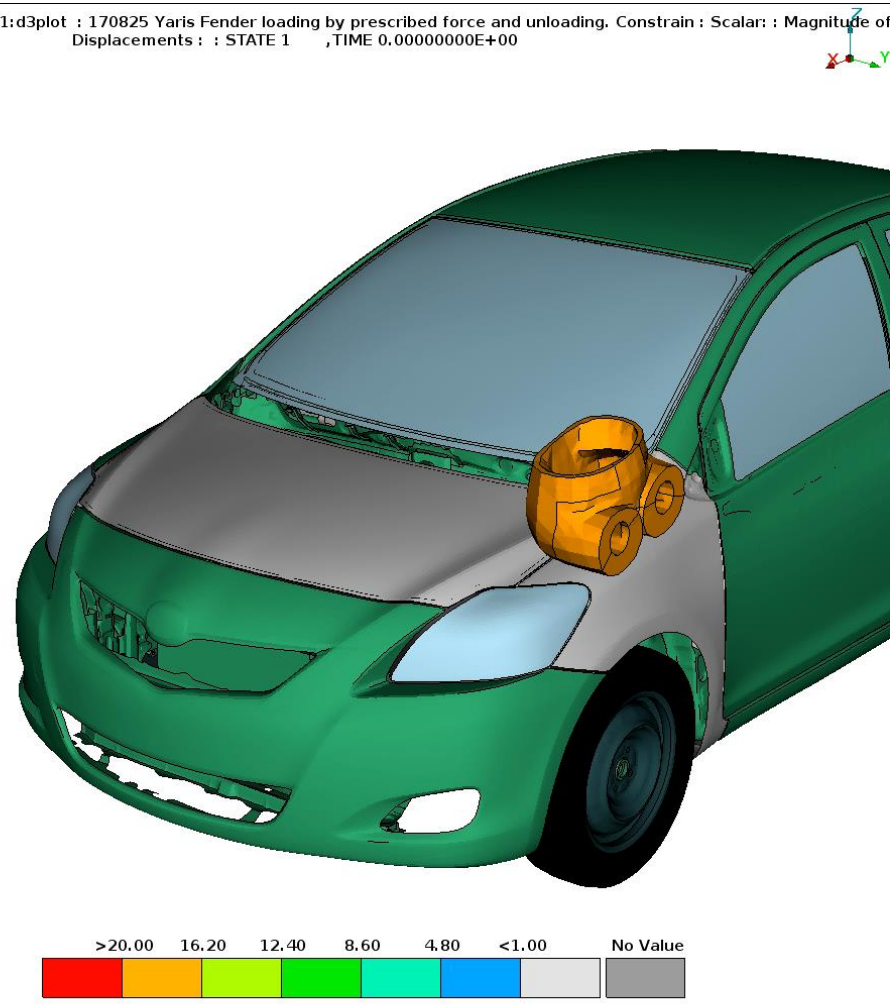
Hood / fender loading



Hood / fender loading.

Solution time: 7h 38 min on 24 cores





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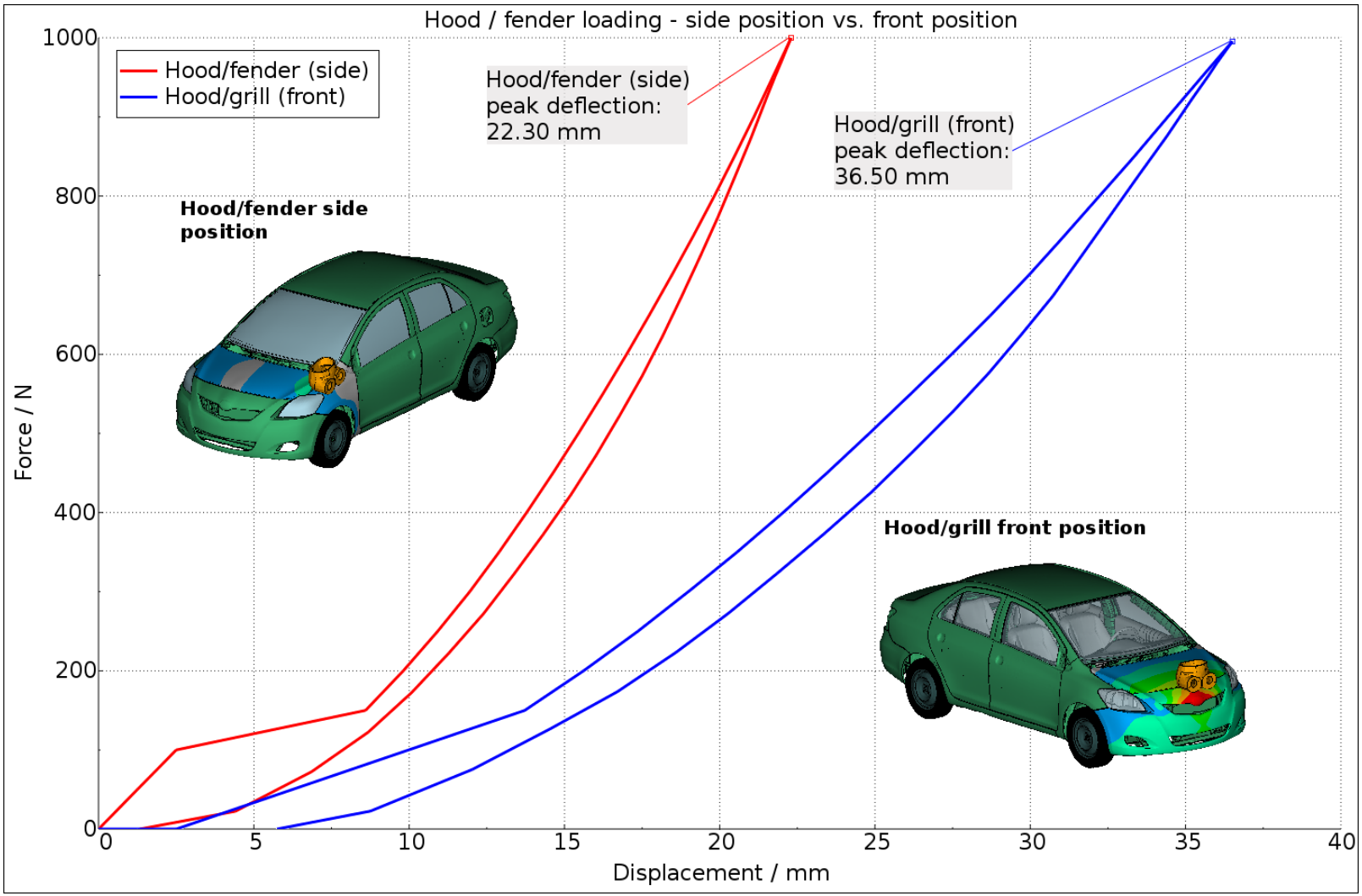
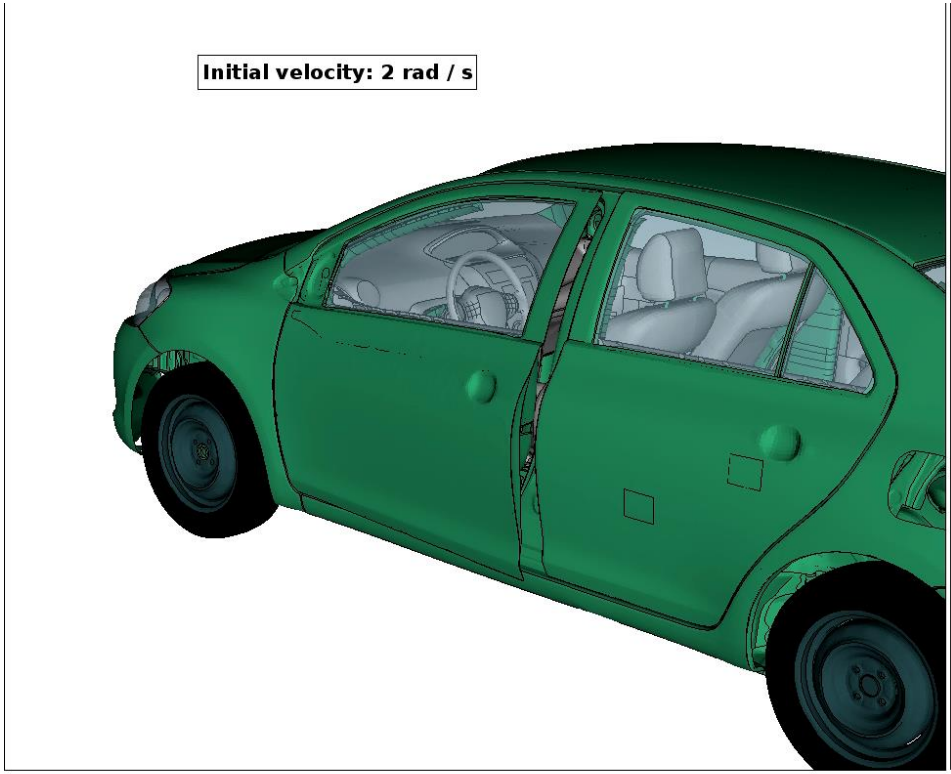
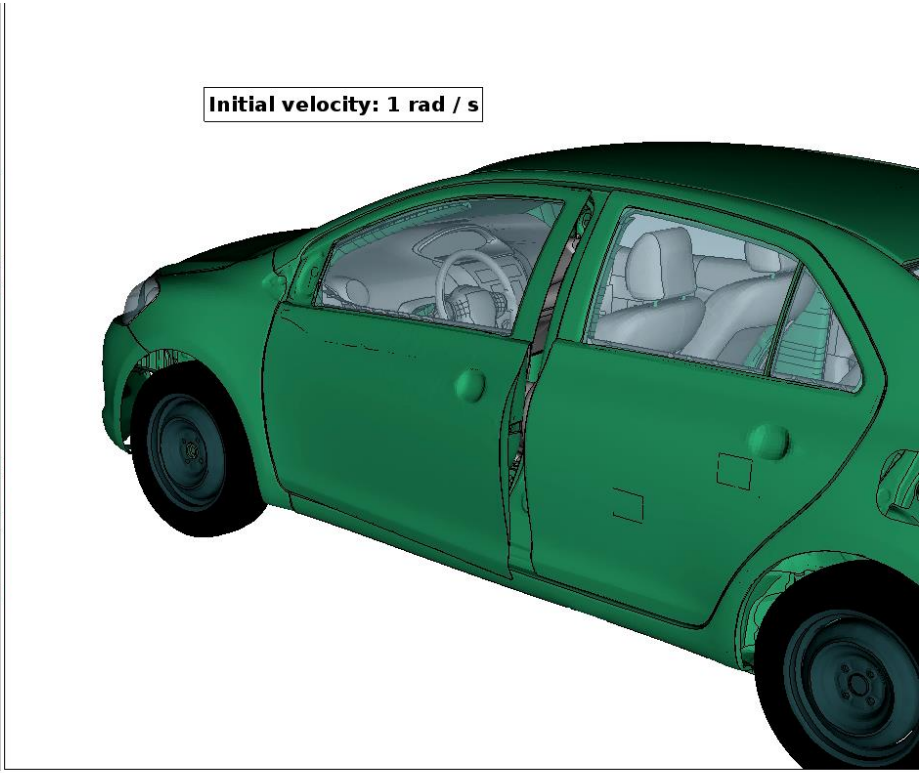


Door slam.

Solution time: 11h 9min on 16 cores





Summary: From explicit to implicit

- It’s possible to convert a large-scale explicit crash model to run in implicit by minimal modifications
  - Both static and dynamic load cases can be studied in implicit
- LS-DYNA Implicit works well
  - Also for large scale models, single surface contacts
- LSTC and Dynamore are continuously working on making implicit more useful and easy-to-use
  - LS-PrePost GUI for simplified set-up of implicit analyses
  - LS-DYNA Bundle, including tutorials and guidelines
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N o r m a l t e r m i n a t i o n

Thank you!

DYNA MORE

Your LS-DYNA distributor and more