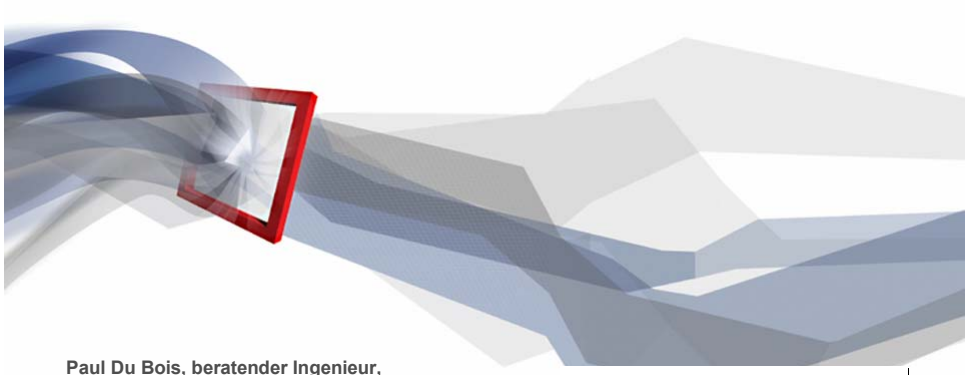
The influence of the mesh on crashworthiness accuracy and sensitivity



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Element quality versus mesh quality

- Element quality refers to single element checks such as warp angle, skew angle, aspect ratio a.o.
- Comprehensive specifications exist in most motor companies
- Mesh quality reflects the suitability of a global mesh to treat a certain loadcase and is not easily measured

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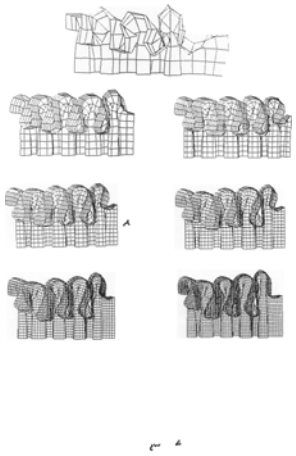
Mesh convergence

- If the mesh is refined, the results are not affected
- Requires smooth representation of the deformed geometry
- Does not require uniform or orthogonal meshing
- Usually a sufficient condition to predict intrusions



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Predicting acceleration peaks

- The mesh must be fine enough to capture the required frequencies, the maximum mesh size can be estimated using an intuitive application of Shannon's theorem :

$$l_c \leq \frac{c_{pb}}{6\nu_{\max}}$$

- Usually mesh convergence is the more stringent condition

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Predicting acceleration peaks

- Numerical dispersion must be minimized in order to compute accurate acceleration peaks
- Consequently a uniform and orthogonal mesh is required throughout the entire structure

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Tube crush study

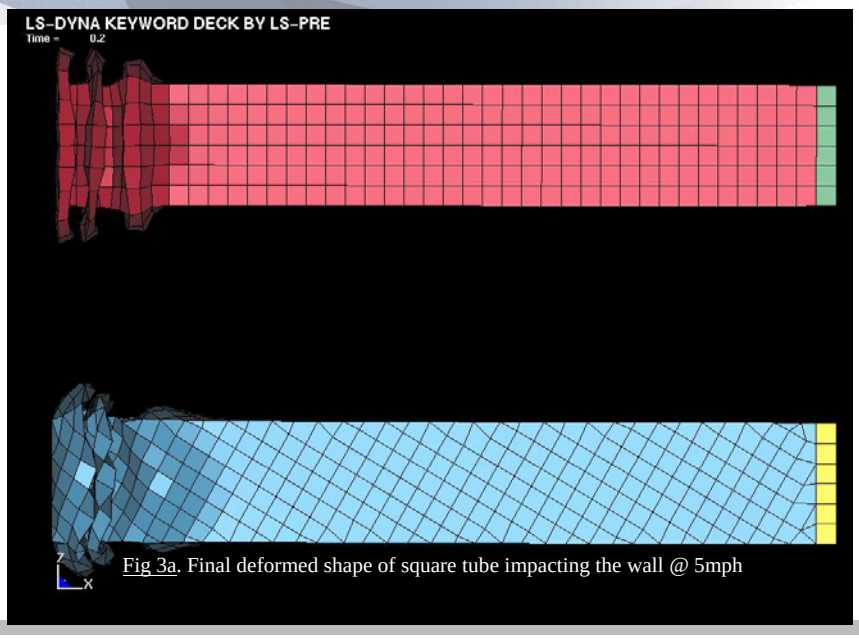

Fig 3a. Final deformed shape of square tube impacting the wall @ 5mph

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Tube crush study

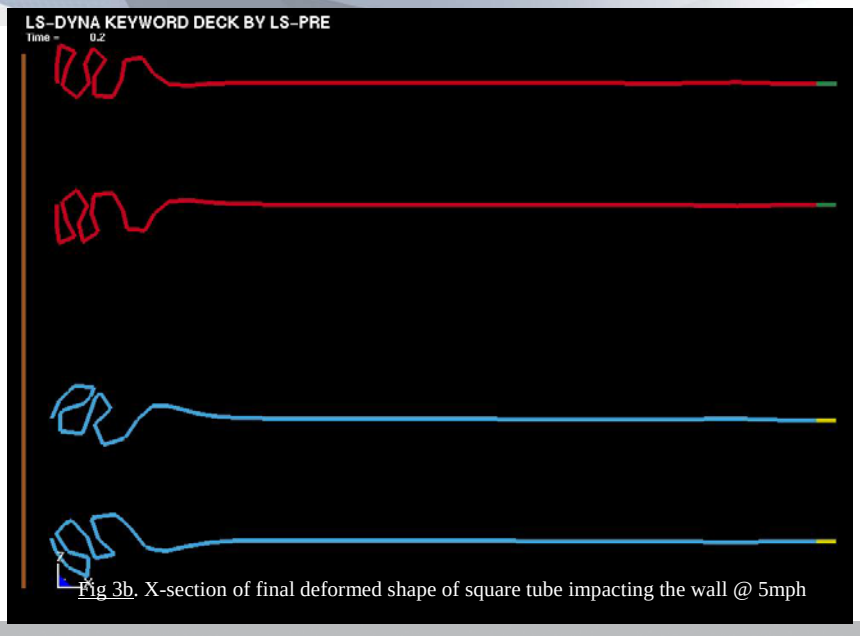

Fig 3b. X-section of final deformed shape of square tube impacting the wall @ 5mph

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Tube crush study

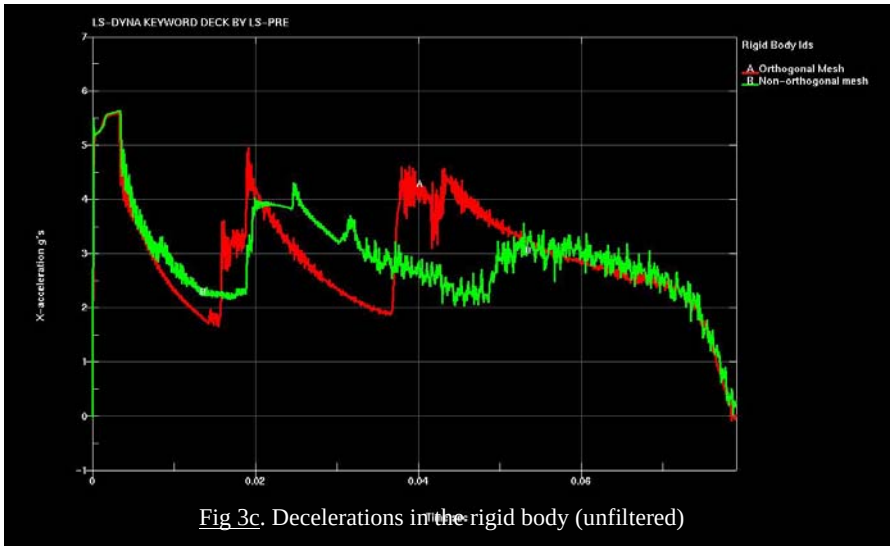
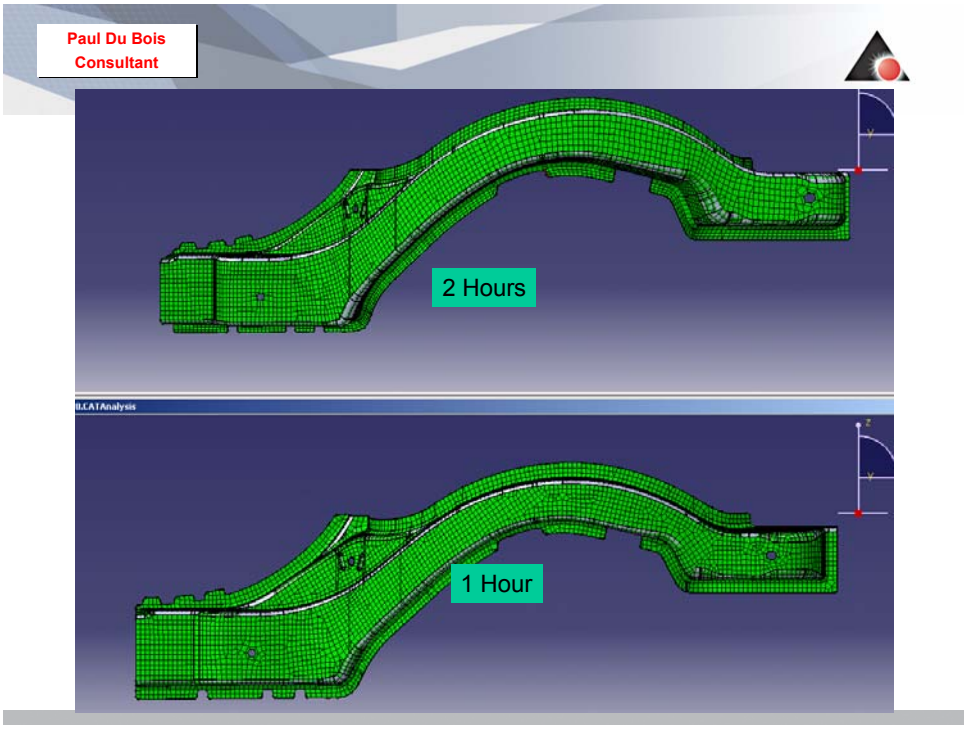


Fig 3c. Decelerations in the rigid body (unfiltered)



Stable versus chaotic response

- Sometimes models show large output differences for small input changes
- small input changes can be roundoff (platform, software version), node&element numbering, random noise on nodal coordiantes, rigid body transformations etc...
- Locally sensitive models can become chaotic if the buckling mode is affected

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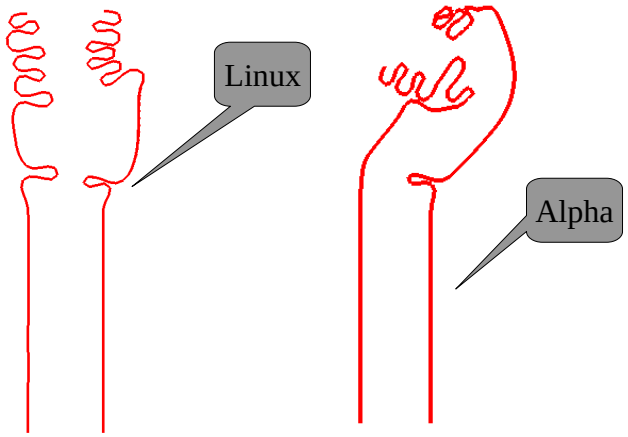
Example of an unstable model corresponding to stable physics



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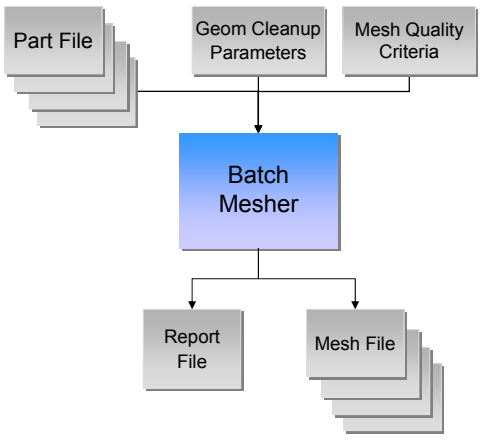
BatchMesher: How it works



- Input:
  - iges, Catia, UG, hm (midplane, if necessary)
  - Geometry cleanup parameters
  - Elementcriteria
- Parts can be meshed independently on different hardware resources

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Different mesh strategies

hand-meshed

batch-meshed, orthogonal

batch-meshed, non orthogonal

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Simulation data

- Body in white in a front-crash with LS-Dyna (3 LS-Dyna versions)
- 102 parts, 13.6 m/s initial velocity
- Models: Hand-meshed / batch-meshed (orthogonal) / batch-meshed (non orthogonal)
- Element size 8 and ~~10~~ → 6 models

Name	Elementsize in the chassis beam	Number of elements	%-Trias
hm_10	10	229000	6.7
bm_10 (orth.)	10	227200	6.7
bm_10 (non orth.)	10	234700	7.3
hm_8	8	234800	6.6
bm_8 (orth.)	8	232100	6.6
bm_8 (non orth.)	8	238700	7.1

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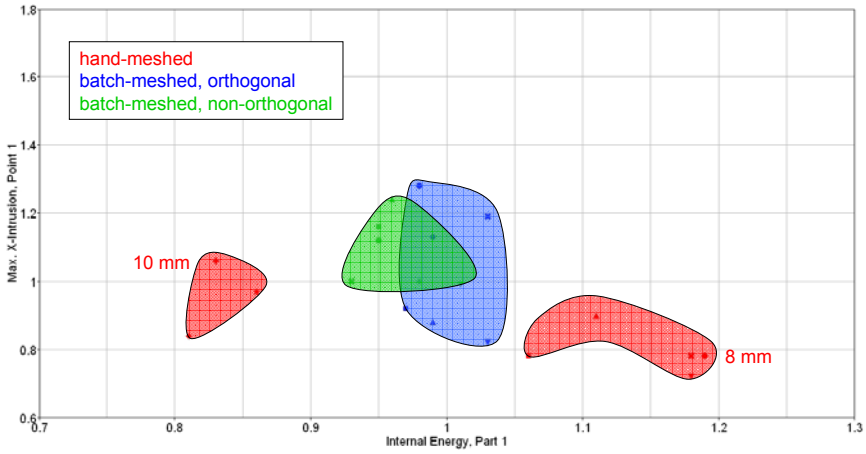
Scattering (Max. X-Intrusion / Internal Energy)



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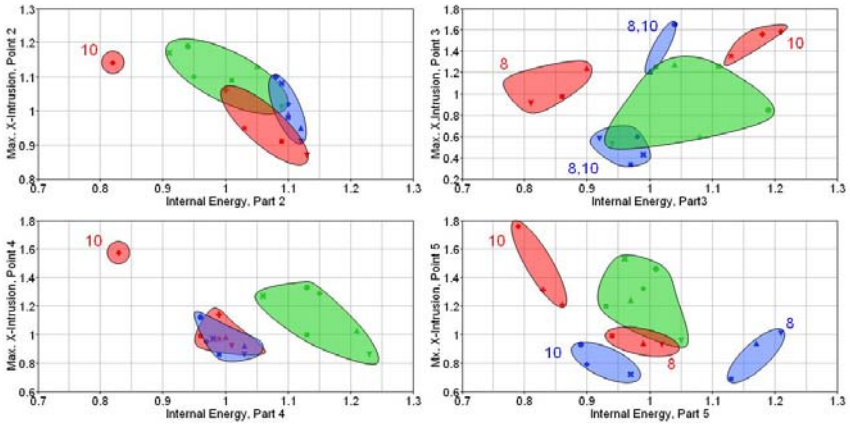
Scattering (Max. X-Intrusion / Int. Energy)

hand-meshed
batch-meshed, orthogonal
batch-meshed, non-orthogonal



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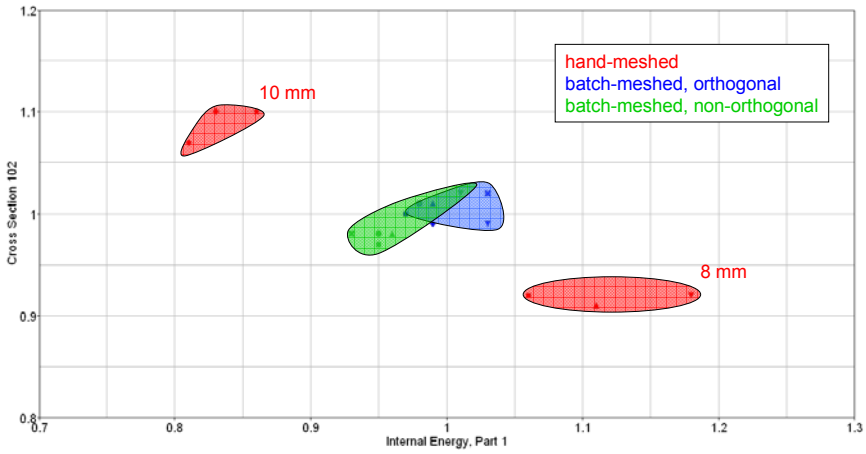
Scattering (Average Section Force / Internal Energy)



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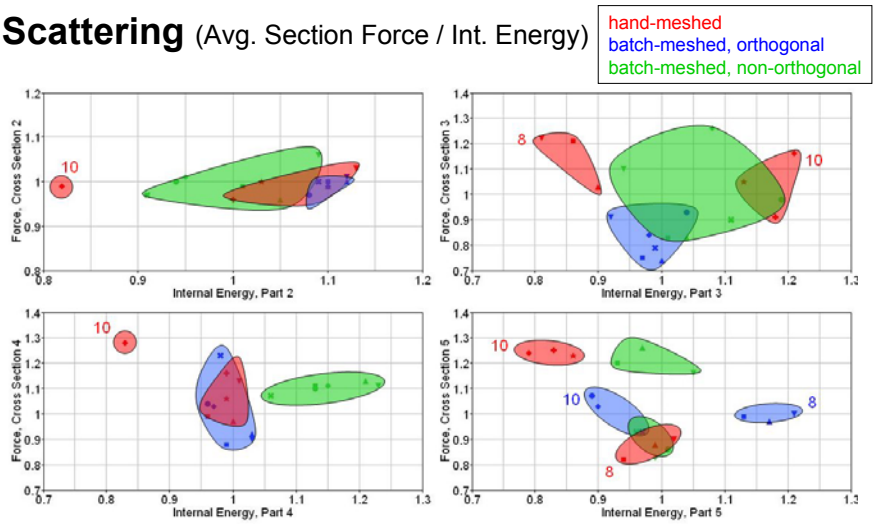
Scattering (Avg. Section Force / Int. Energy)



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Detailed legend for scatter plots

- hm_8, 3858p_smp
- hm_8, 3858single_mpp
- hm_8, 3858single_sse_mpp
- hm_8, 3858single_sse_mpp, 4CPUs
- hm_8, 3858single_sse_mpp, 6CPUs
- hm_10, 3858p_smp
- hm_10, 3858single_mpp
- hm_10, 3858single_sse_mpp
- bm_8, 3858p_smp (orth.)
- bm_8, 3858single_mpp (orth.)
- bm_8, 3858single_sse_mpp (orth.)
- bm_10, 3858p_smp (orth.)
- bm_10, 3858single_mpp (orth.)
- bm_10, 3858single_sse_mpp (orth.)
- bm_8, 3858p_smp, may04 (non orth.)
- bm_8, 3858single_mpp (non orth.)
- bm_8, 3858single_sse_mpp (non orth.)
- bm_10, 3858p_smp (non orth.)
- bm_10, 3858single_mpp (non orth.)
- bm_10, 3858single_sse_mpp (non orth.)

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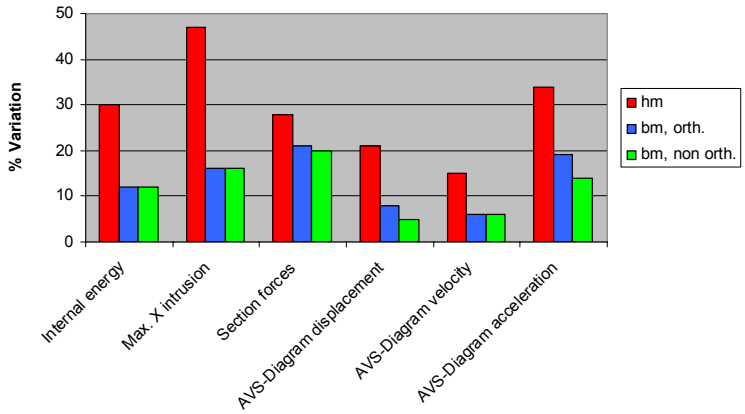
Influence of element size (size 8,10)



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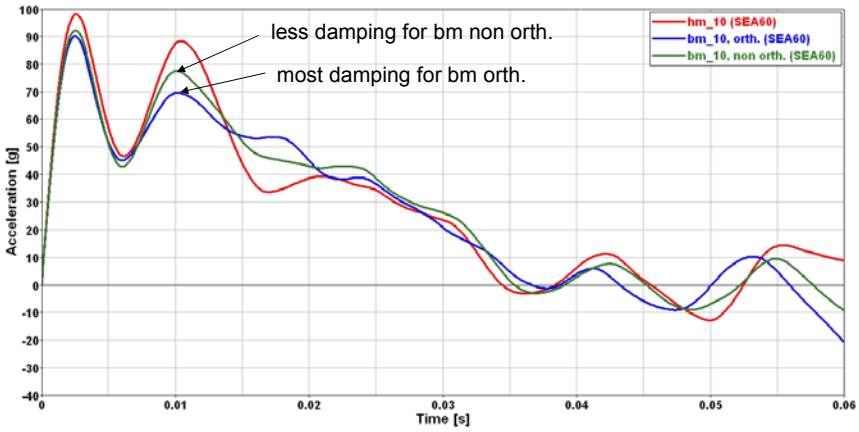
Acceleration



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Conclusion

] Same mesh strategy for size 8 and 10

- ⇒ Less scattering in the batch-meshed results
- ⇒ Reduction of the factor ‚human being' in the meshing process
- ⇒ Easy exchange of parts while keeping the same mesh structure
- ⇒ batch-meshed results seem less sensitive
- ⇒ however the batched-meshed results show some dispersion
- ⇒ even with orthogonal batch meshing
- ⇒ it is not known if this dispersion will disappear if the mesh becomes very fine

] Time for meshing:

- Hand meshed: approx. 150 hours
- Batch meshed: 30 hours (w/ initial version of software), potential to decrease to 8 hours with now available automated pre and post routines

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acknowledgements

- Thanks to Suri Bala and … from lstc for providing the tube crush example
- Thanks to DaimlerChrysler, Auburn Hills for providing the orthogonal meshing example