SABIC

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Long Glass Fiber-Polypropylene Light Weight Instrument Panel Retainers & Door Modules

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Sharing our futures

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2. Materials

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5. Warpage control

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History: 2002 to present

Comments at that time:

This is for the Ford Fiesta.

Why are there no other cars?

Disbelief in door module concept.

It is an extra part.

Assembly outside current line considered complicated

Situation 2008 - LGF-PP Door modules

in production or development

Ford
VW
Skoda
Hyundai
Kia
Fiat
Mercedes
Chrysler
BMW
Jaguar
……

and injection molded hatchback doors

Dashboards examples LGF-PP

Standard Injection Molding

VW:

Golf, Golf Plus, Touran, Bora, Jetta

Skoda:

Octavia, Superb

Audi:

A4

Ford:

Fiesta, Focus, Fusion

Mercedes:

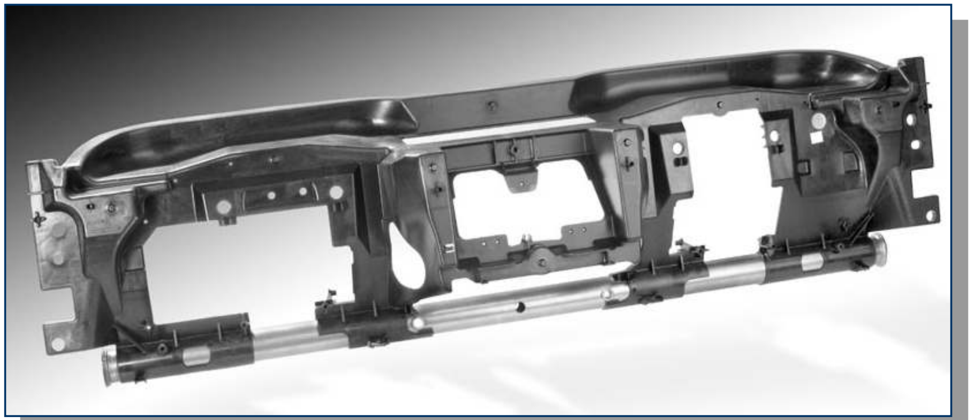
A, B, C, M, R

Volvo:

S40, V50

Opel:

Vectra



2. Materials

Both dashboards carriers and door modules:

- Good flow
- High stiffness
- Safe fracture
- Dimensional stability

and more recently: Light weight (why more recently?)

High impact strength is not required, but good crash behavior is.
Example: Dashboard carriers don't need Charpy notched > 10 kJ/m^2, E.g. short glass mSMA can be OK

Material choice IPs

20% long glass PP

+ thin-wall possible (t=1.7mm, 2000 ton)

0 needs thorough knowledge of warpage predictions to guarantee correct shape.

PP talc 20%

- low stiffness/strength at 80° C (2.5mm PP/talc = 1.8mm LGF-PP)

+ material price/kg (not per part?!)

SMA short glass 12%

- poor flowability (2.5mm, 4000 ton)

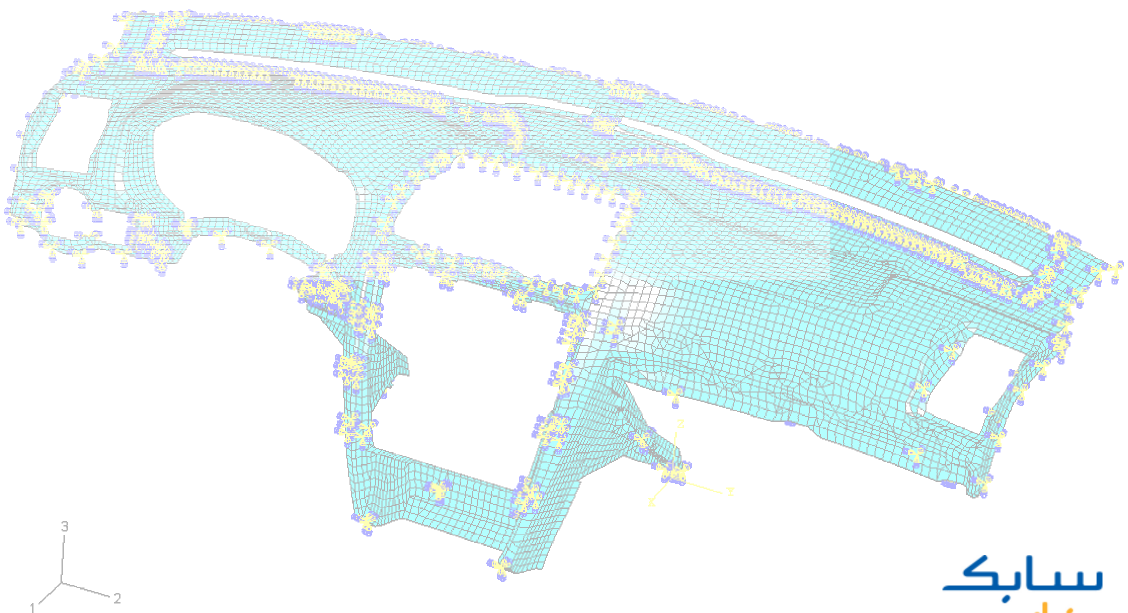
0 same mechanical properties as LGF-PP 20%

+ warpage OK, foam adhesion easy

3. Costs

Cost price calculation example IP carrier

Calculations basis is design / development for 3 different OEM dashboards:



Calculated weight factor IP-carrier

	mSMA-SGF 12%	PC/ABS unfilled	PP-LGF 20%
Density	1.15	1.15	1.05
Density factor	1.10	1.10	1.00
* mSMA min wall thickness = 2.2mm	Density factor = $\frac{\rho_{Material}}{\rho_{PP\text{-}LGF}}$		Stiffness factor = $\frac{E_2 \times (t_2)^{2.2}}{E_1 \times (t_1)^{2.2}}$
Rel. Wall thickness	1.22*	1.39	1.00
Density factor x Wall thickness	1.34	1.52	1.00
Weight of Instrument Panel of 2900 cm3 [kg]	3.97	4.57	3.0

Cost Price Calculation IP - Assumptions

Machine size equal *
Cycle time equal
Energy consumption equal

Mold investment equal

→ Unfavorable assumption for part cost price PP-LGF

Number of operators equal

Assembling cost equal

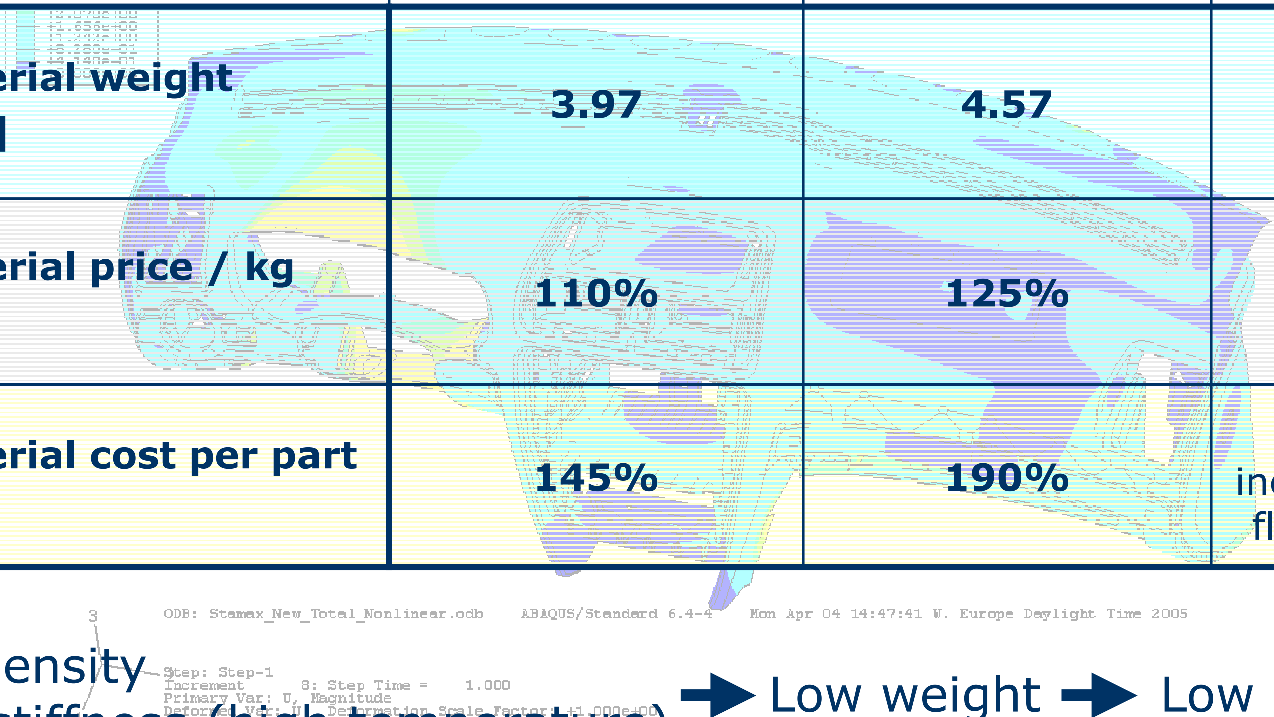
Flame treatment cost for PP-LGF **~ $0.50** / part (incl. investment)

*** Conservative assumptions:**
- Typical PP-LGF clamp force = 1600 ton, amorphous 2500 ton.
- Typically wall-thickness much thinner for PP-LGF, faster cooling/energy.

Material Cost Price IP

Calculated weight factor IP

	mSMA-SGF 12%	PC/ABS unfilled	PP-LGF 20%
Material weight [kg]	**3.97**	**4.57**	**3.0**
Material price / kg [$]	**110%**	**125%**	**100%**
Material cost per part [$]	**145%**	**190%**	**100%** including delta for flame treatment



Low density
High stiffness (high temperature) ➡ Low weight ➡ Low material cost

4. Thin wall design

"Light weight design" has been a topic on all international congresses for years.

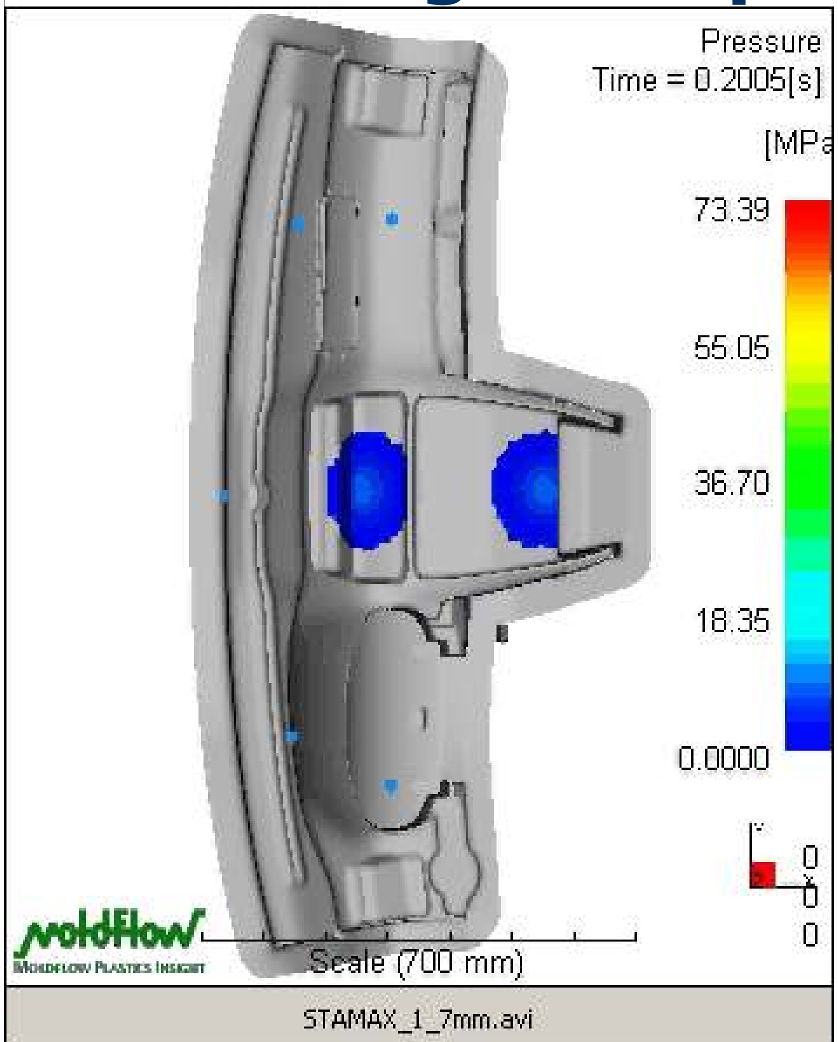
Is it becoming more of a new requirement? Differentiator?

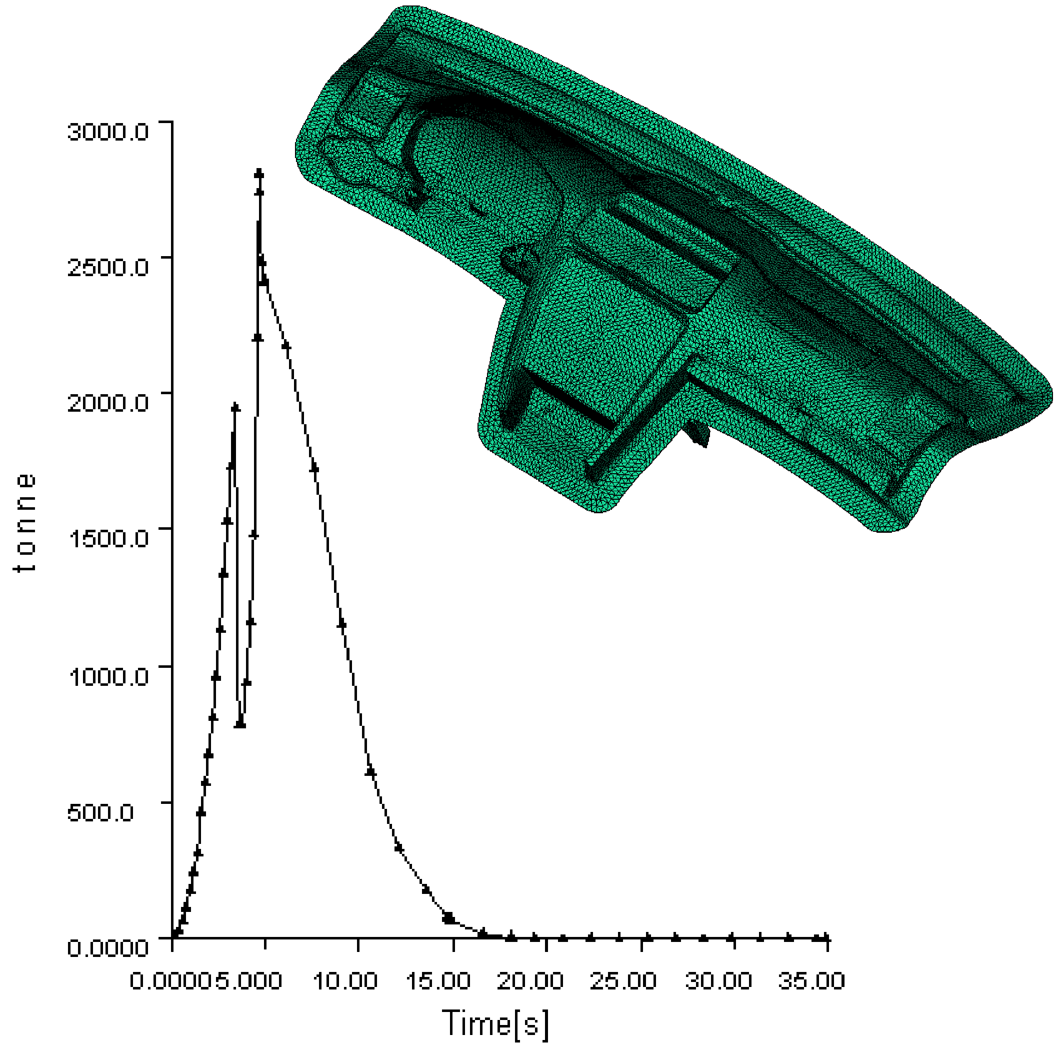
=> Solution: Materials + Engineering

1. Molding thin walls

2. Design optimization

Filling example

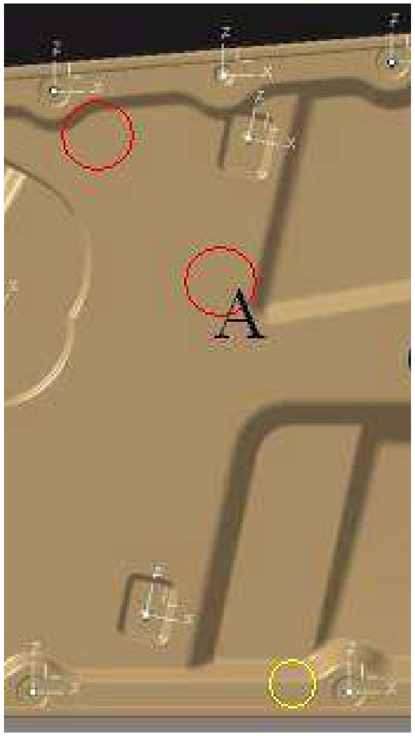




t=1.7 mm

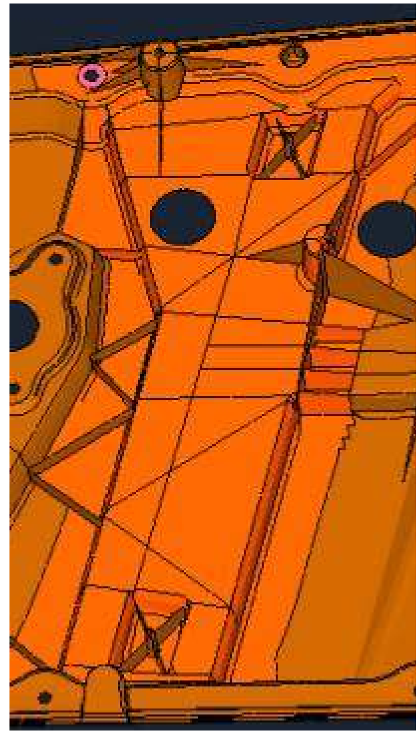
Design optimization – 1 clever design

Example door module



From "metal" design

To plastic

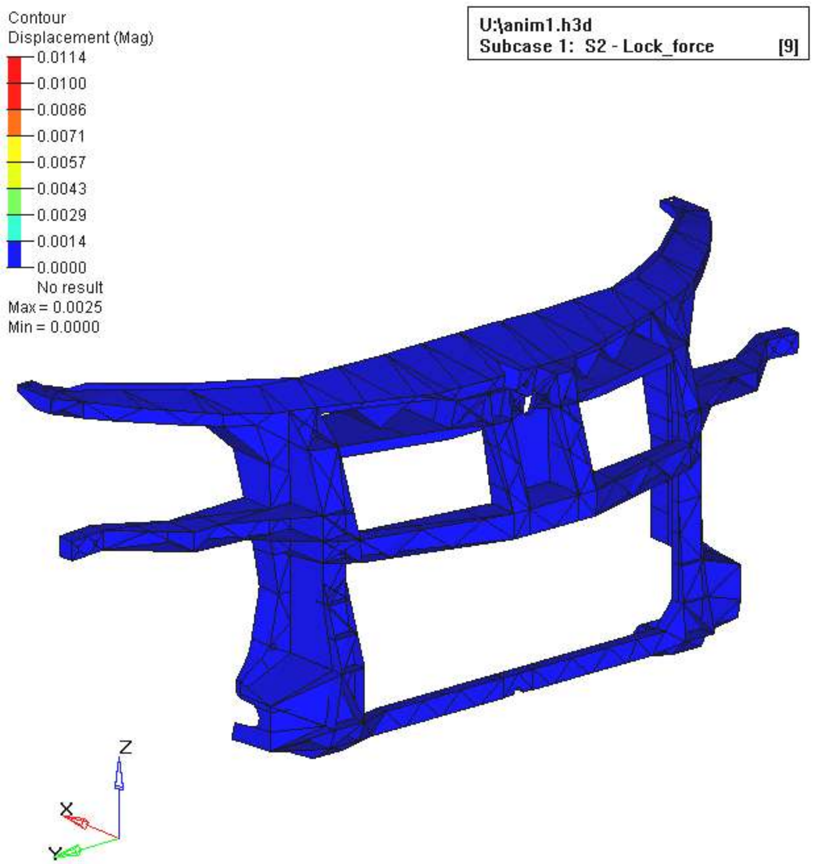


+ Wall-thickness optimization
typical 1.0-1.5 to max. 3-4 mm

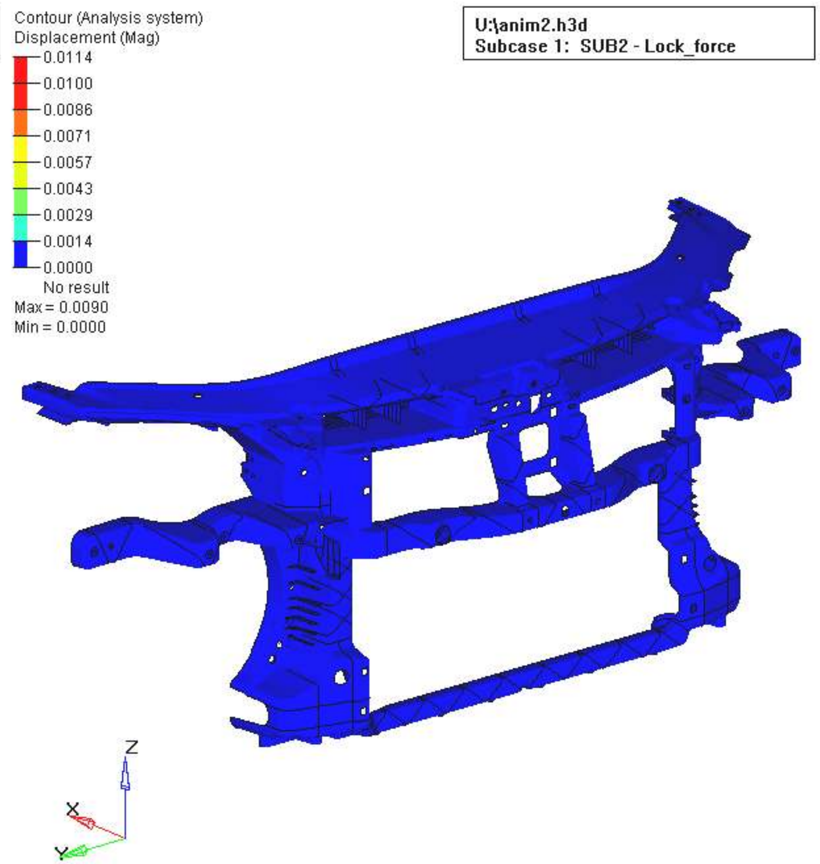
Effect clever design

Front-end structure

Clever design



Standard design

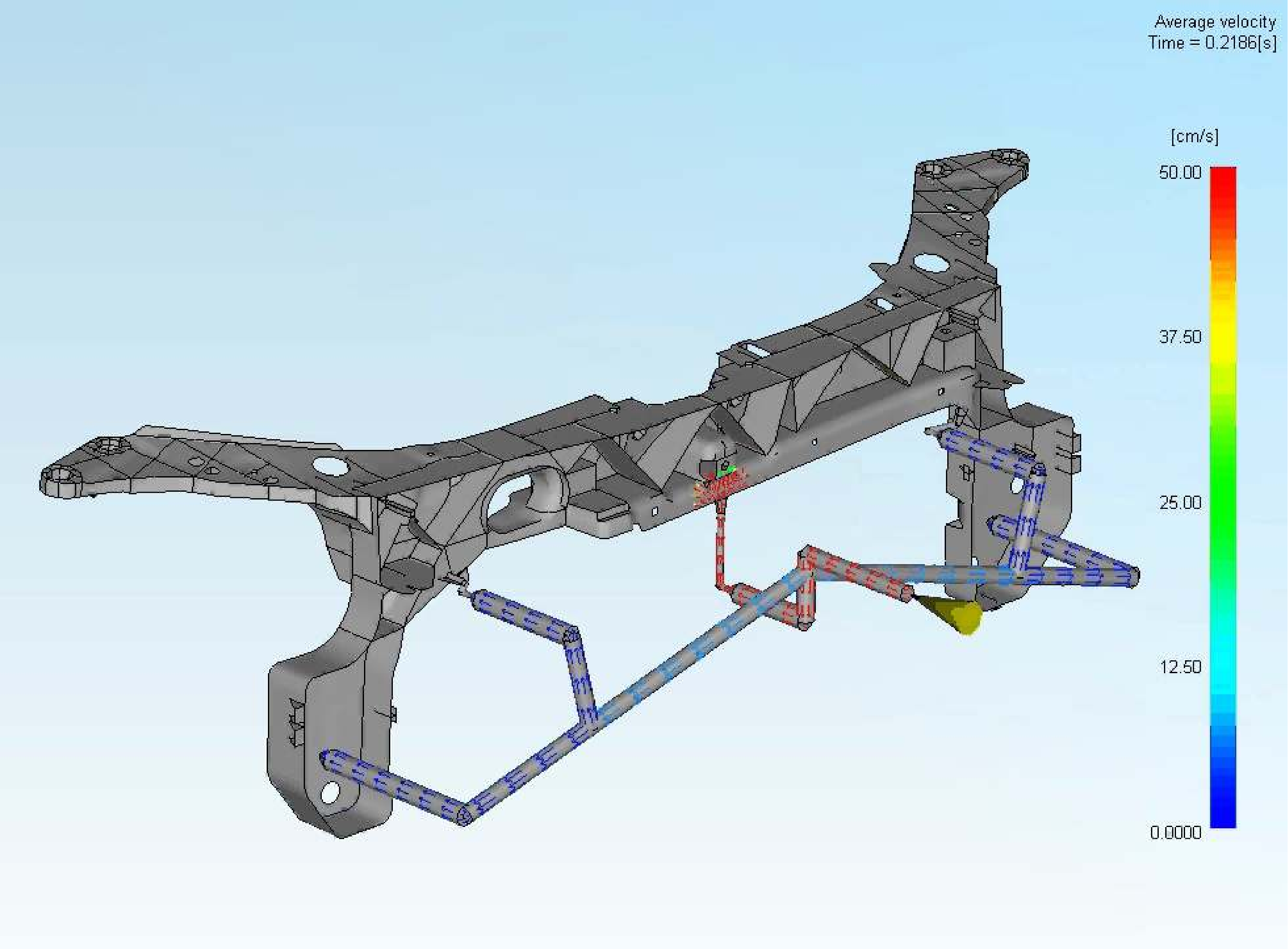


Factor 4 increase in stiffness, just by design.

Or **2 kg** = 33% weight + cost saving on total front-end.

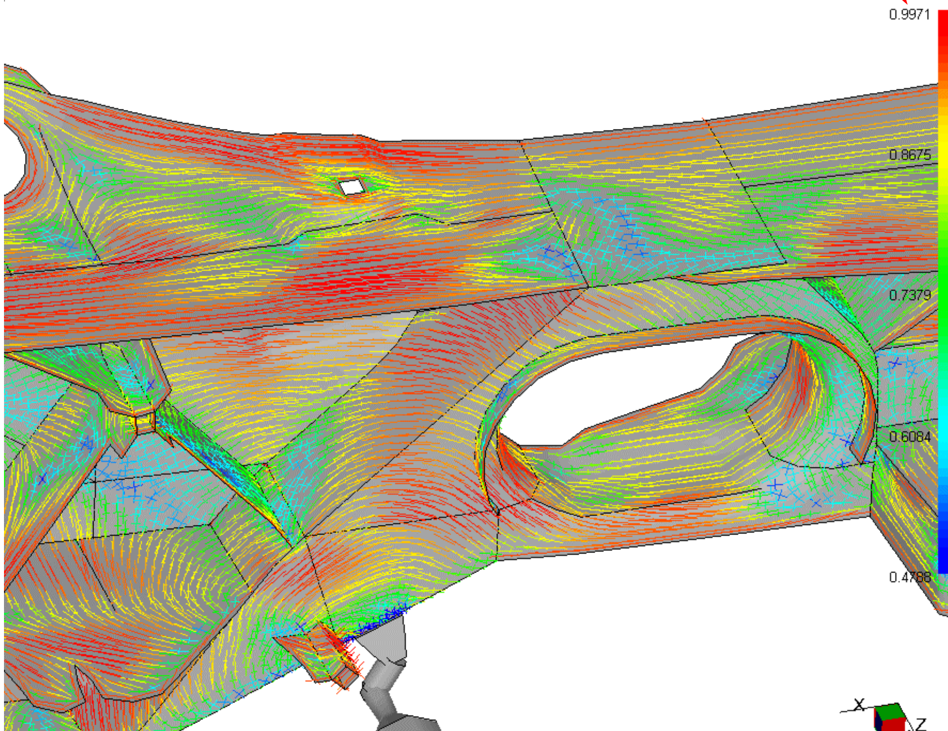
Design optimization, Anisotropic

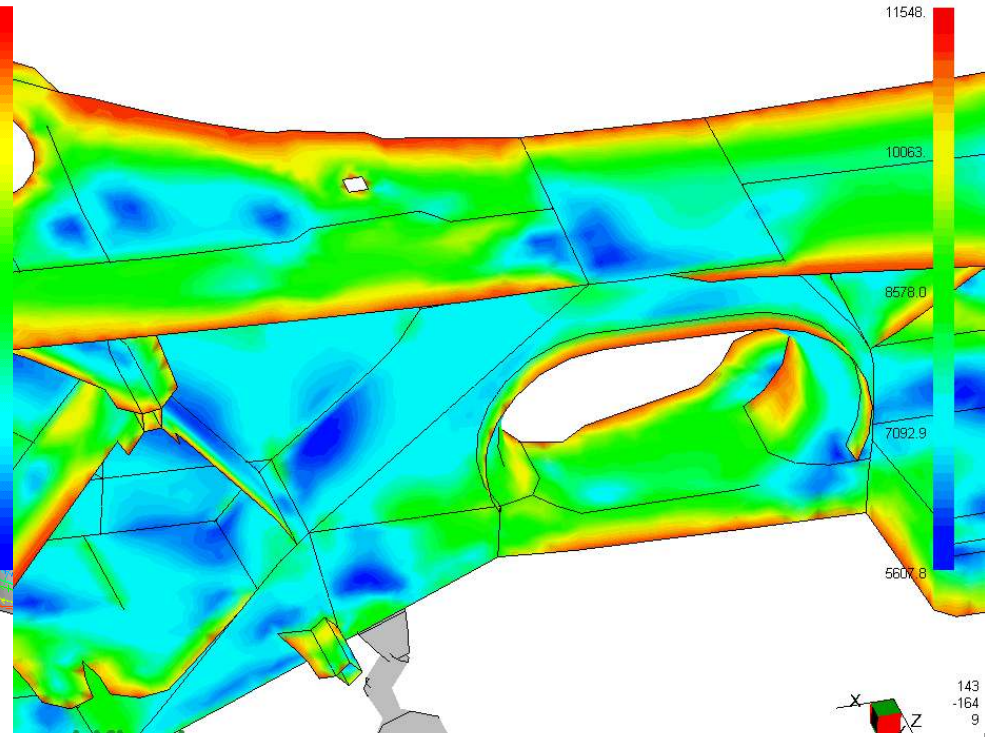
***Use fiber orientation from flow*.**



Design optimization, Anisotropic

Using anisotropy! Up to **20%** weight saving compared to isotropic.





example fiber orientation core layer

example E-modulus distribution

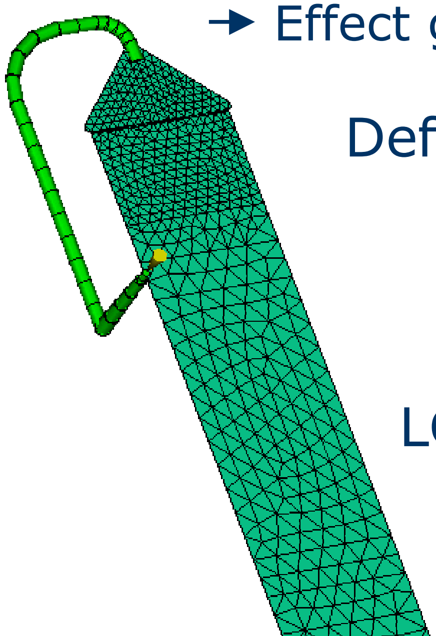
But still hardly used for IP/door modules

5. Warpage control

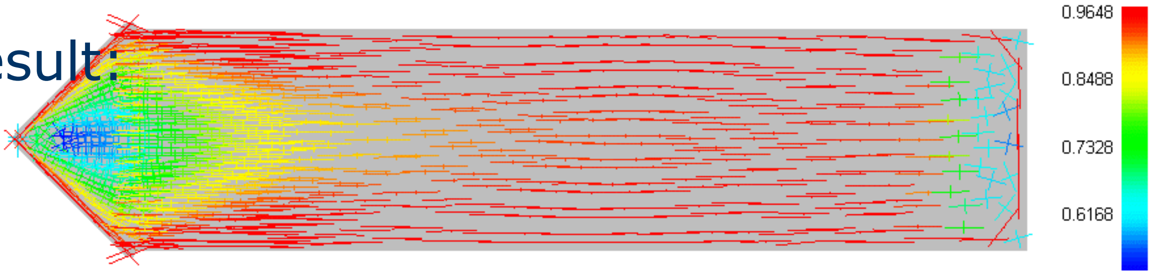
Filling is not the issue, large IP can be filled with one gate!

=> One important issue: **Warpage control**.

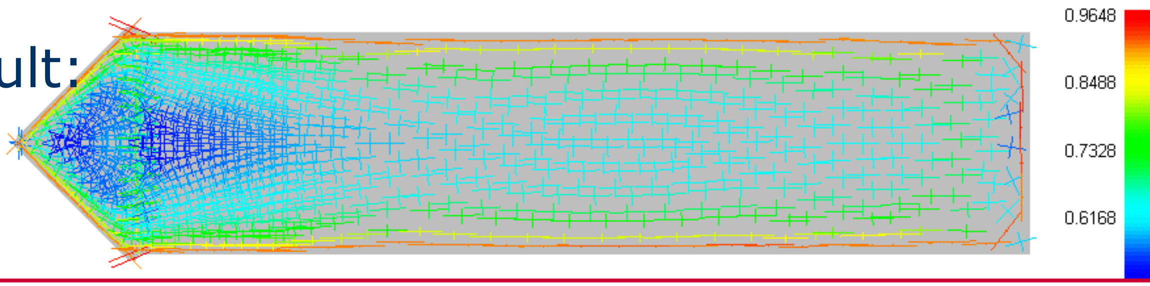
- ➜ Effect fiber length on fiber orientation.
- ➜ Long fiber Ci/Dz/λ coefficients as f(glass%, length, thickness)
- ➜ Effect gating strategies, spring-forward predictions, etc.



Default result:



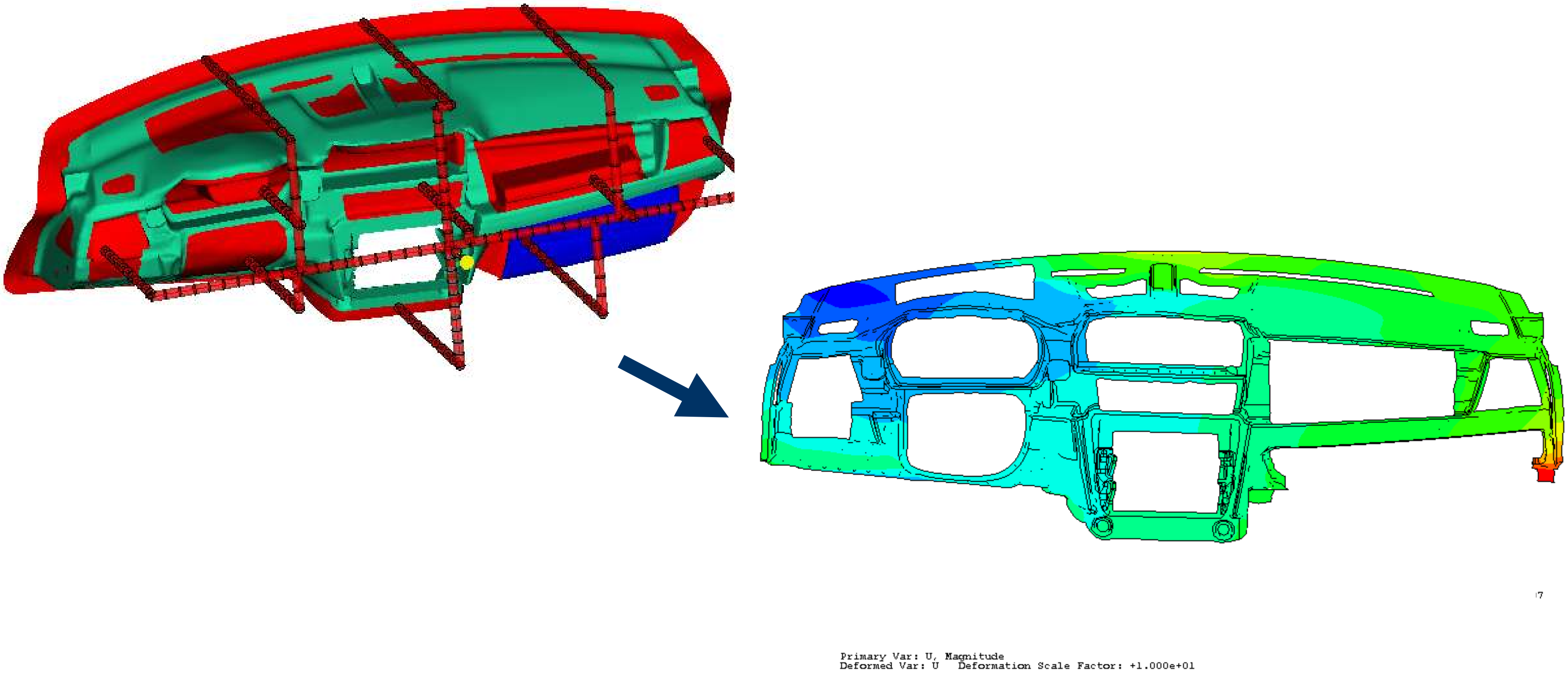
LGF result:



Own SABIC Moldflow version and knowledge developed and still ongoing.

Developments in simulations
Dashboards/IP-carriers

1. Warpage of both "as molded" and "trimmed" dashboard.



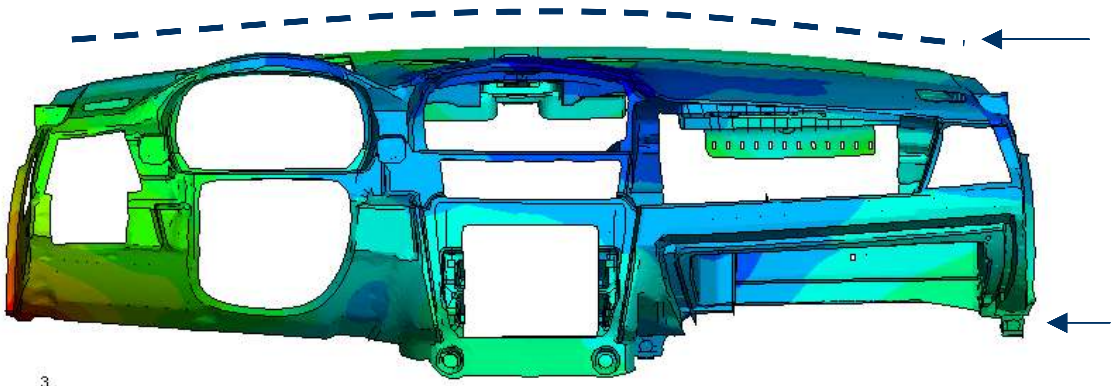
Developments in simulations

Dashboards/IP-carriers

2. Warpage of **assembly** in car:

+ vibration welded air ducts, glove box, etc.

How does it fit into the car and when mounted?



z-deflection, nice fit

y-deflection, OK in assembly

Thin-wall dashboard is flexible. Out of the mold shape may be quite different compared to assembled shape.

Note:
Special method developed for vibration welded assembly warpage.

6. Trends

1. Only recently first examples of weight and wall-thickness optimization in door modules.

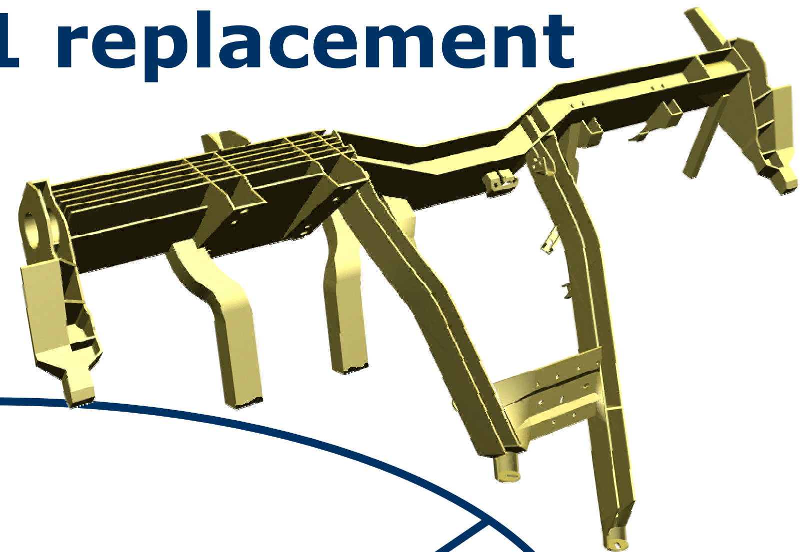
2. Structural upgrade of dashboard carriers

   Cross car beam

3. Other light weight alternatives?

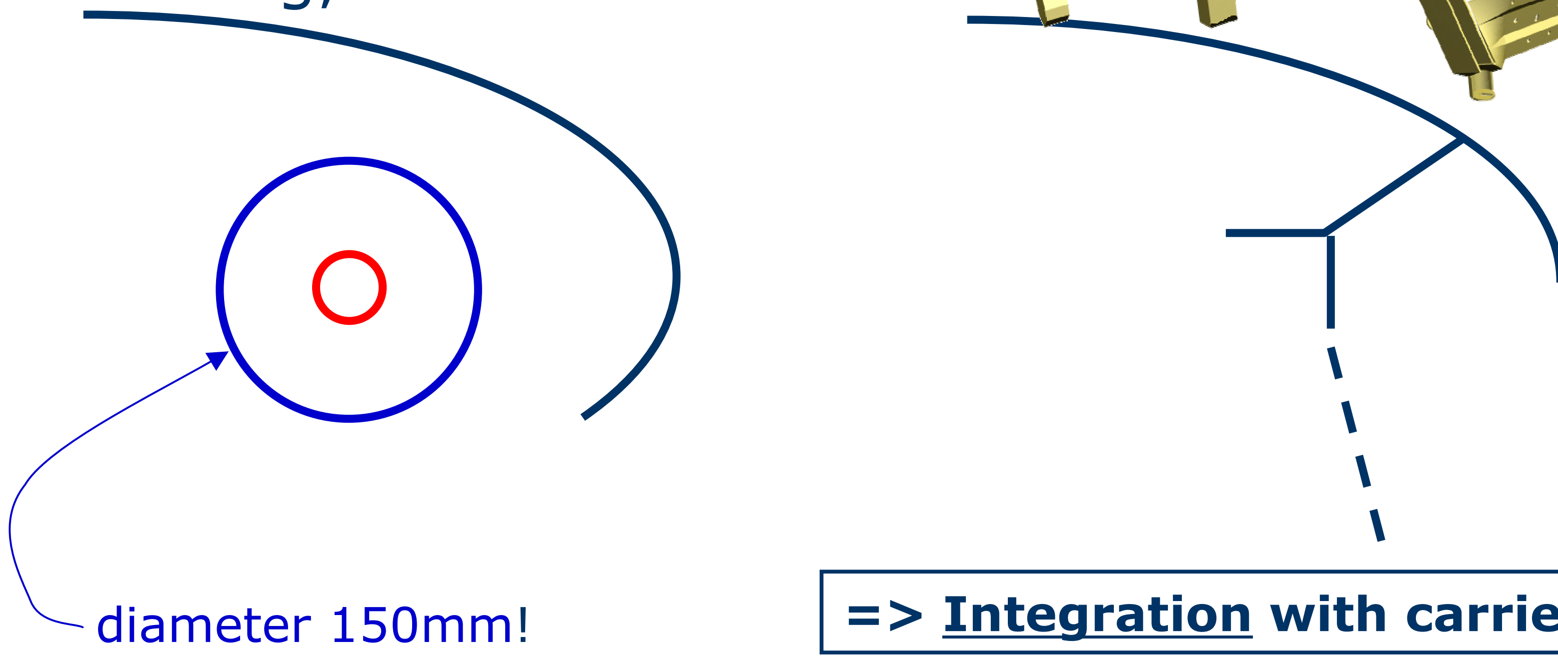
   Foaming?
   Injection-compression?

Cross car beam 1 to 1 replacement



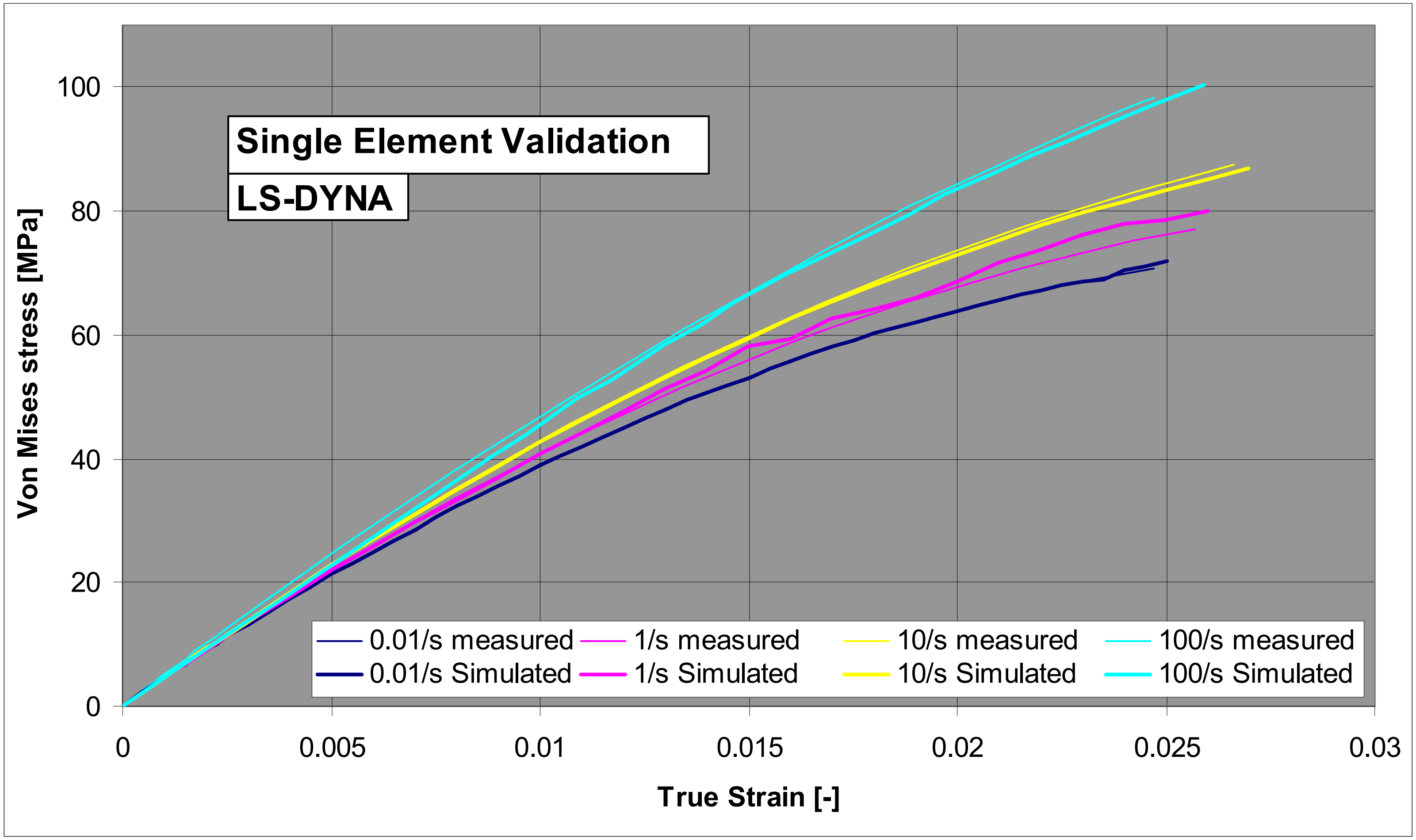
Steel -> STAMAX:

STAMAX beam only weighs
ca. 2 kg, at t=3mm.



=> <u>Integration</u> with carrier.

Needs validated impact simulation

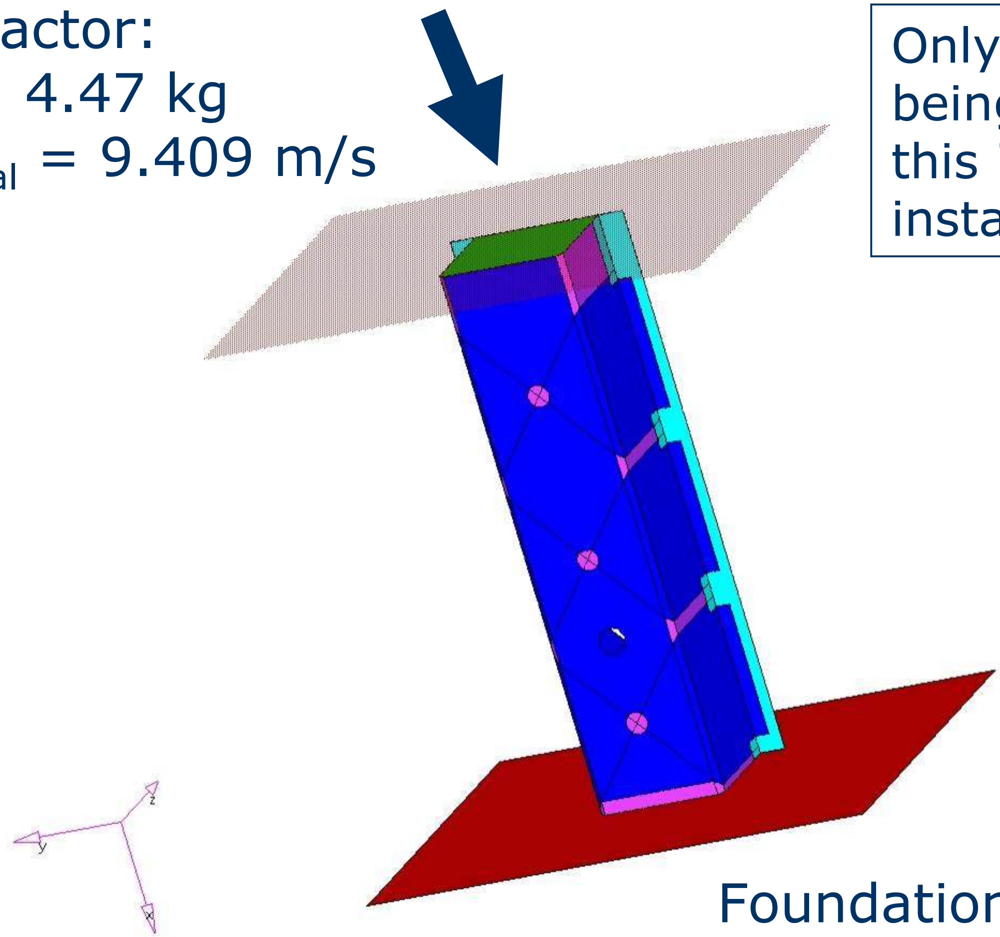


+ test bar validation
+ component validation

Example of dynamic validation

Component test, beam compression

Impactor:
m = 4.47 kg
$v_{initial}$ = 9.409 m/s

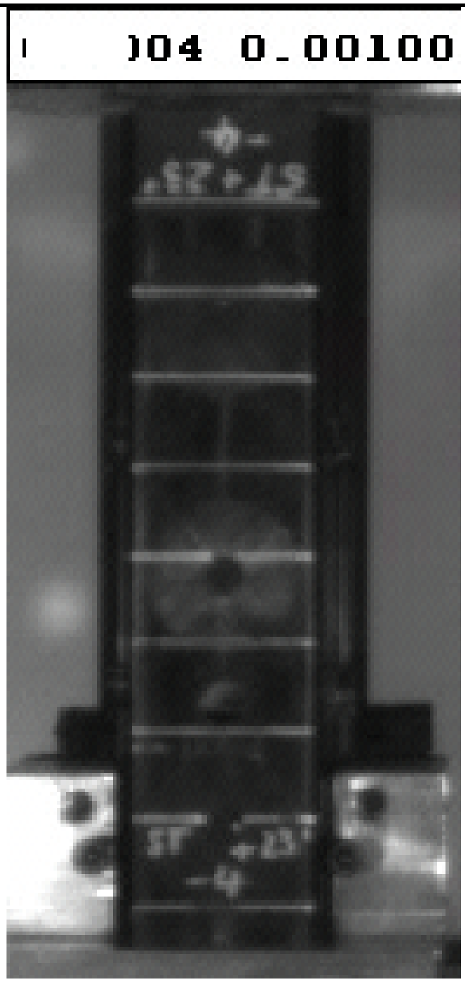


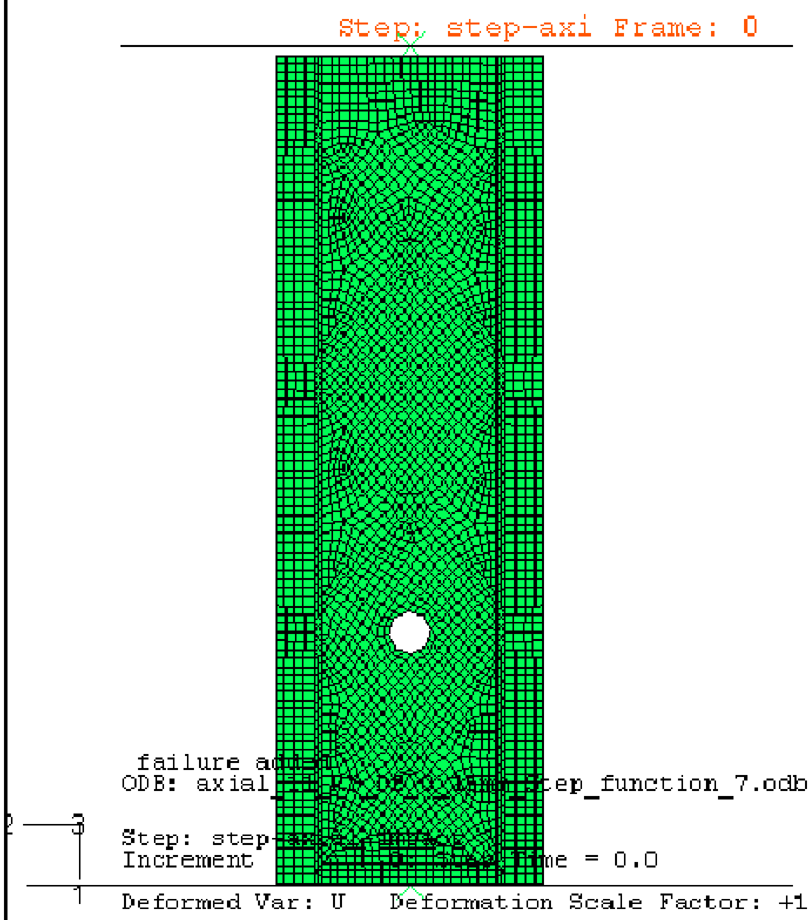
Only half of the beam is being tested ,
this is done to prevent instable collapse

Foundation:
beam fully constrained

Example of dynamic validation

Component test, beam compression

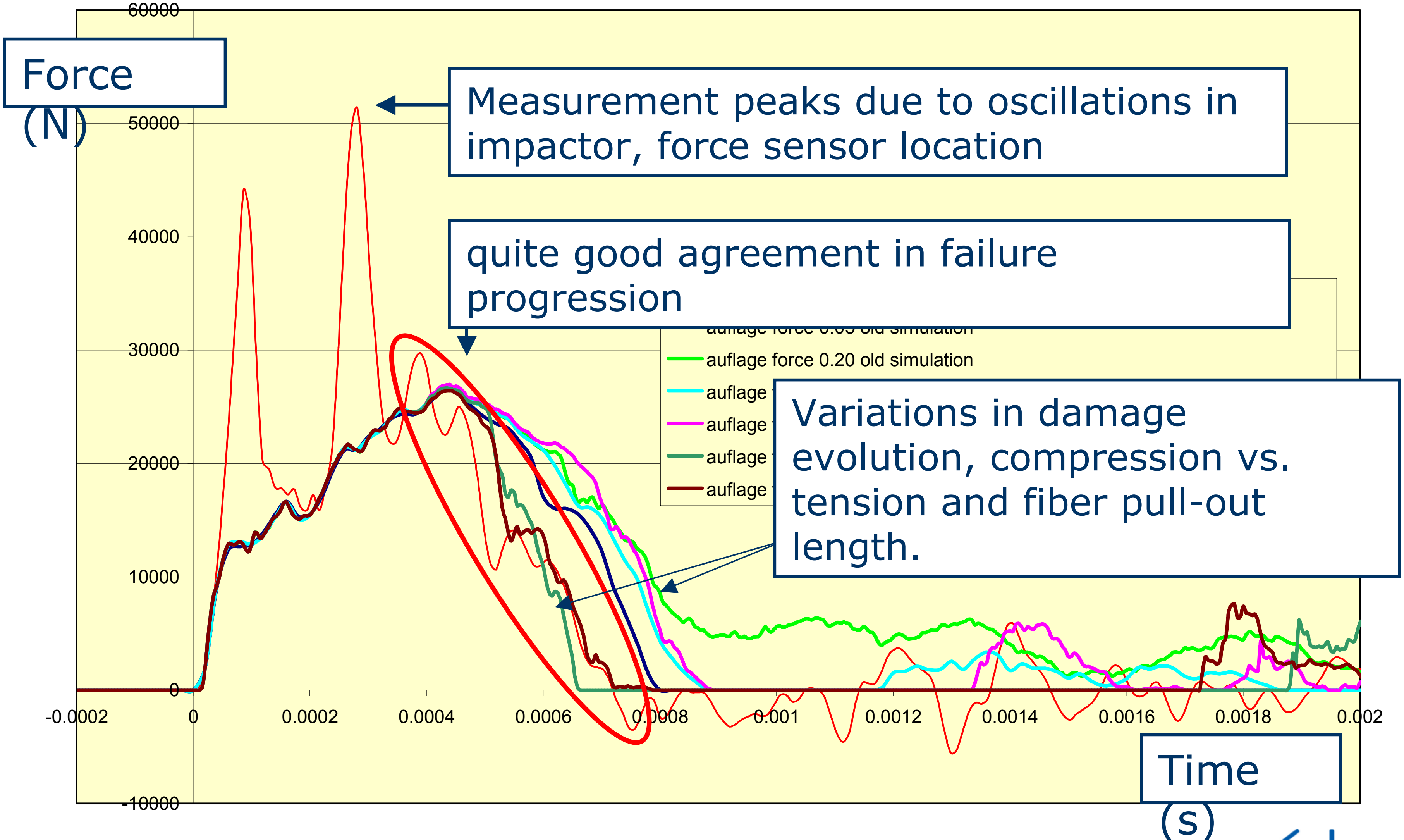




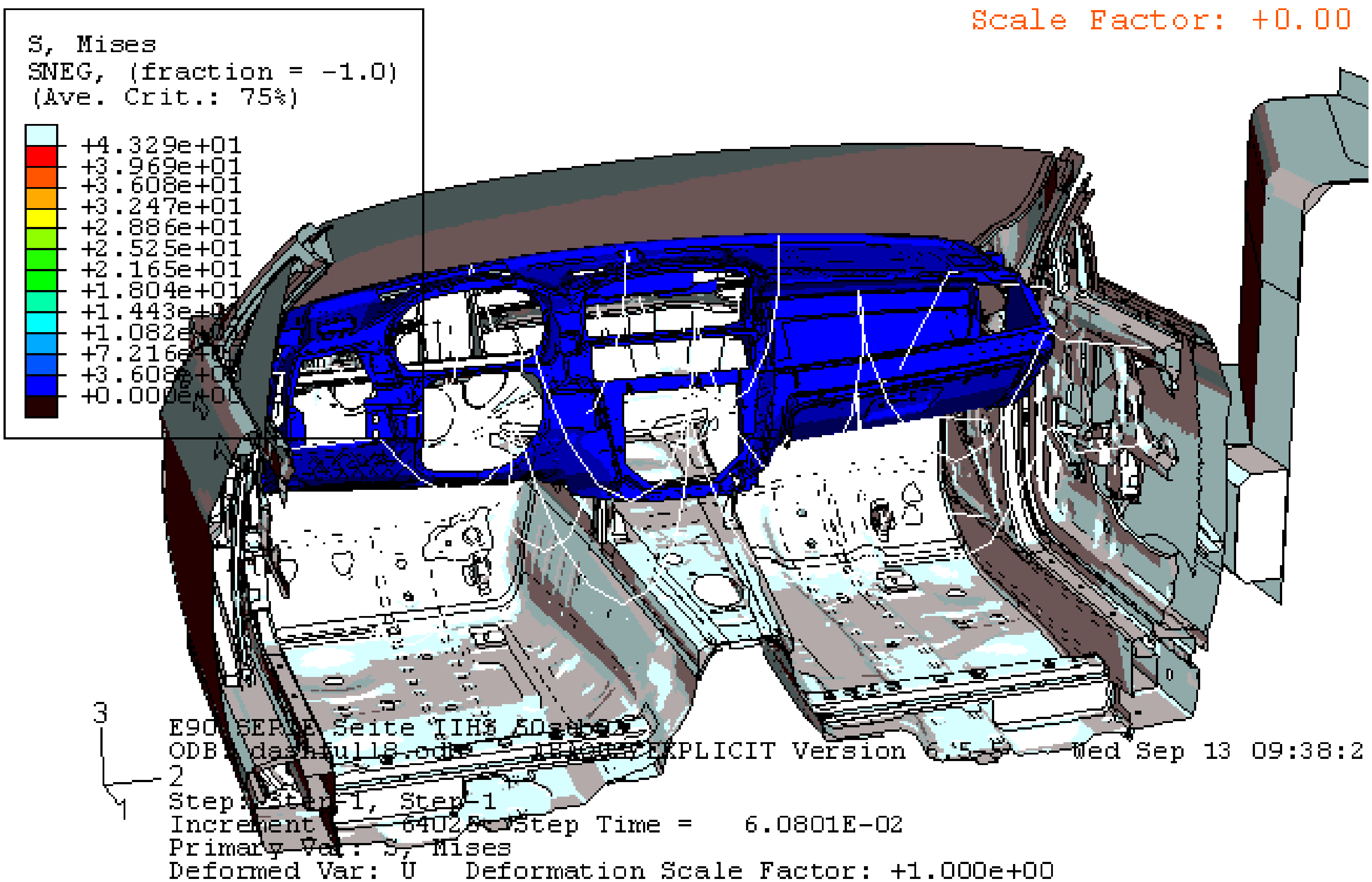
test data supplied by faurecia

sabic

Measurement vs. calculation unfiltered



Side impact crash simulation



Conclusions

- Door modules/IP-carriers in LGF-PP have become common practice.
  Reasons: Low weight, low cost.

- Thin wall molding is state of the art, but weight optimization is just getting accepted.
  => large cost/weight saving potential.

- Warpage control knowledge key to success for LGF-PP.

- Trends for more structural dashboard carriers.