

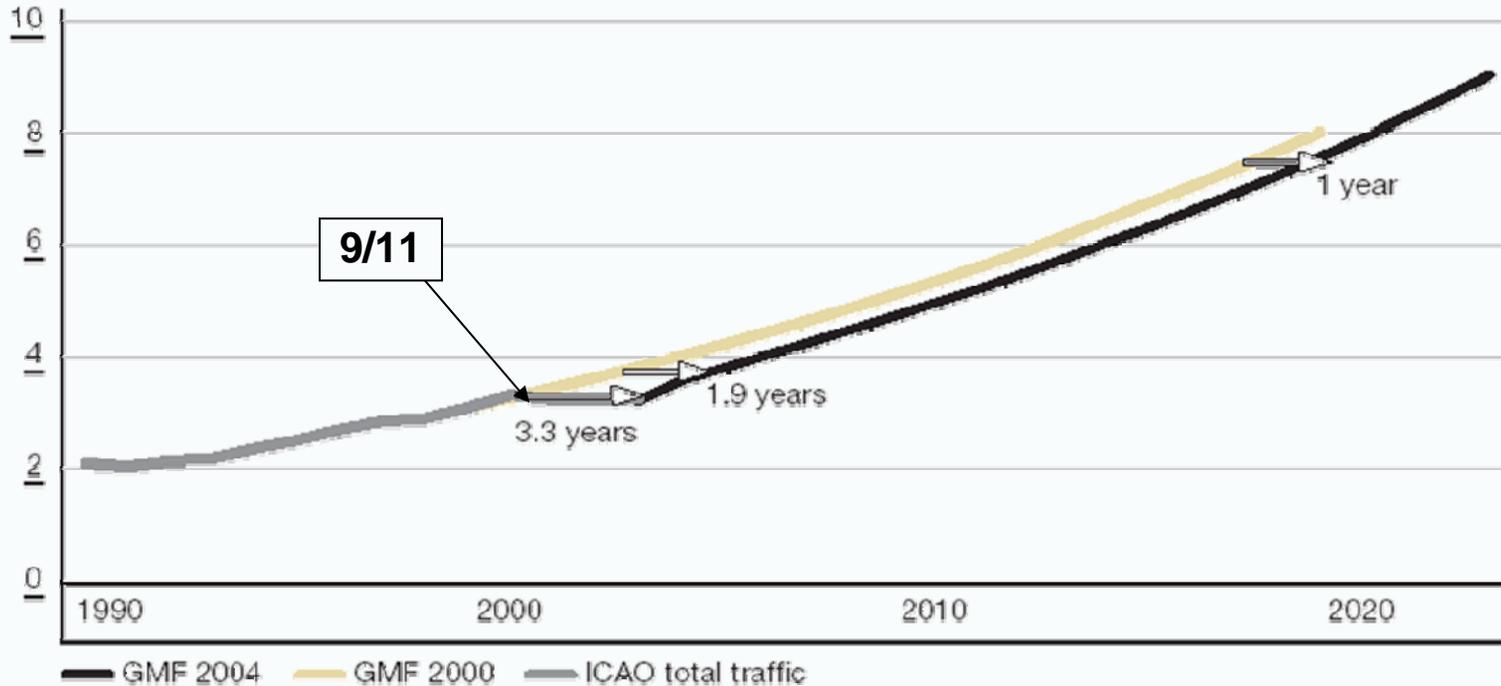
# Hybrid Composite Materials for a Highly Integrated Energy-absorbing Concept for A/C Cabin Interior

## Hybrid Composite Materials for a Highly Integrated Energy-absorbing Concept for A/C Cabin Interior

- Introduction
- Development of energy absorbing support structures
  - State of the art
  - Innovative concept for energy absorbing support structures
    - Concept
    - Test rig
    - Analyzed Materials
  - Simulation with Finite-Element-Methods in LS-Dyna
- Conclusions

## World annual traffic

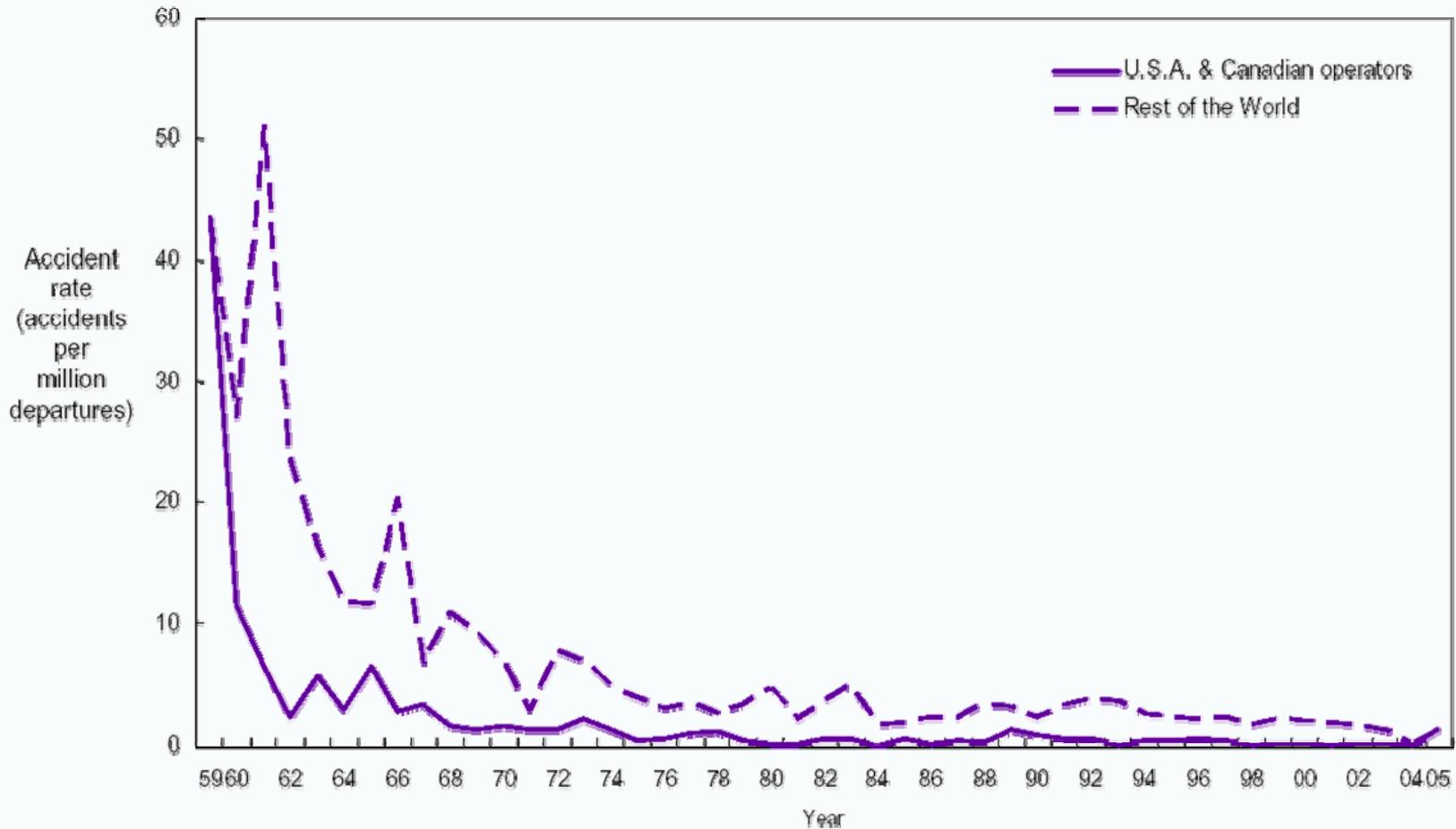
Trillions RPKs



The global market forecast of Airbus predicts an average growth of 5,3% of the global passenger traffic.

GMF: Global Market Forecast, RPK = Revenue Passenger Kilometre

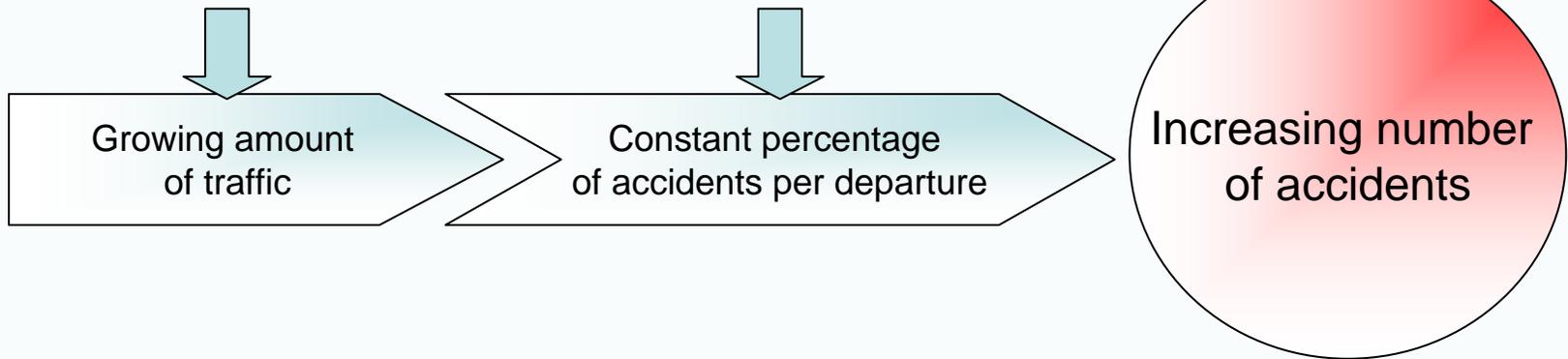
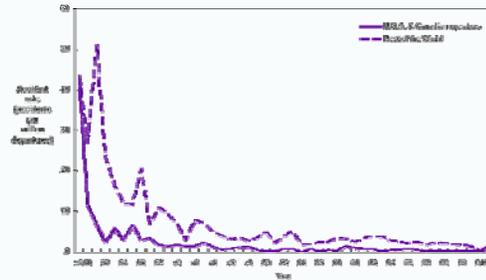
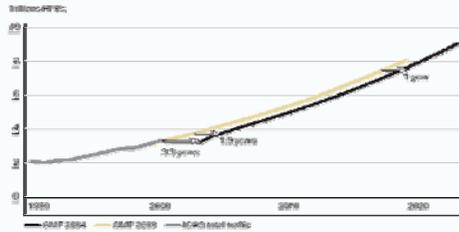
Source: Airbus Global Market Forecast 2004



The accident rate (accidents p. mill. Dep.) is nearly constant on a low level along the last decades.

Source: Boeing Homepage, Statistical Summary of Commercial Jet Airplane Accidents, 2005

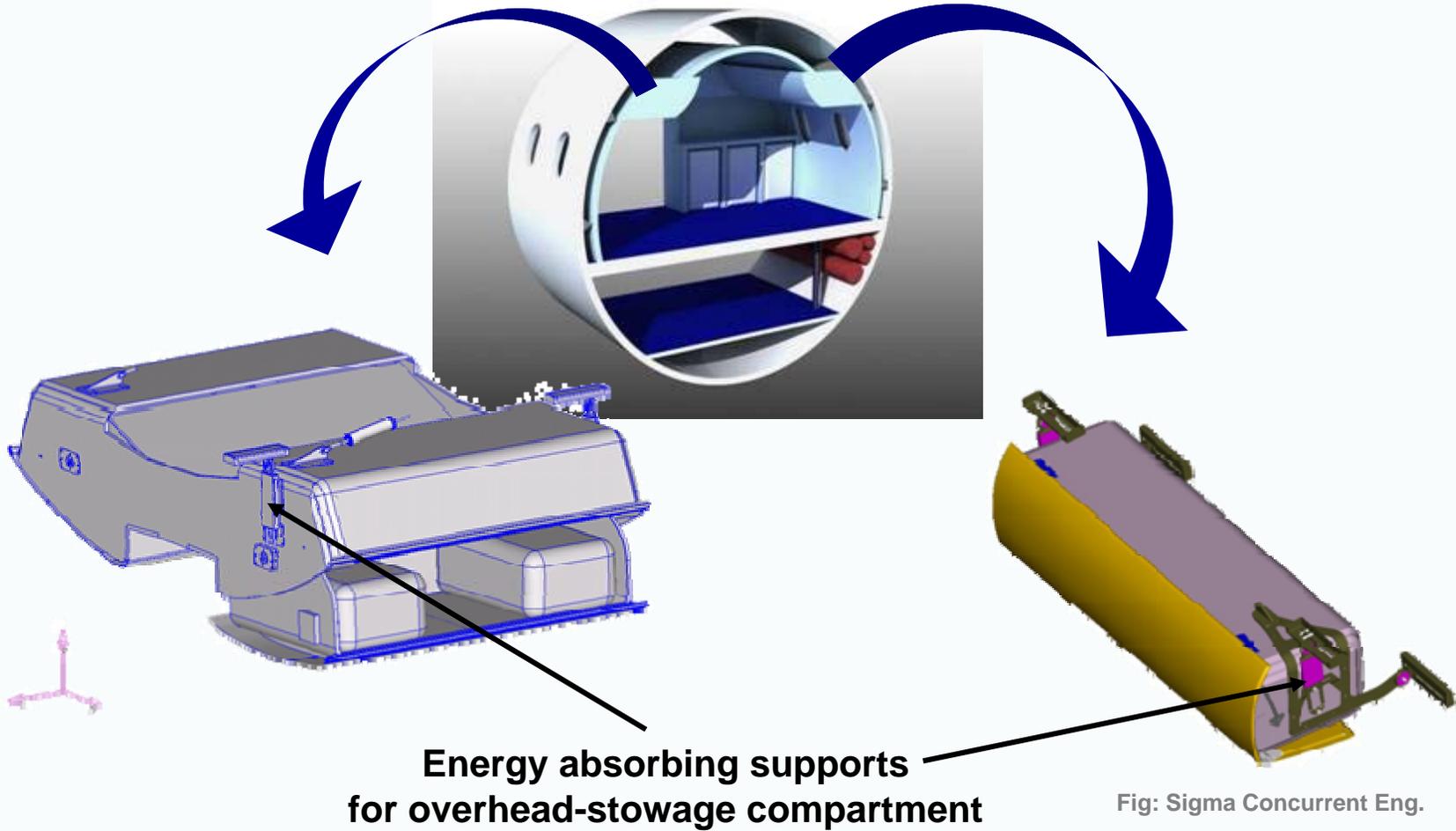
World annual traffic



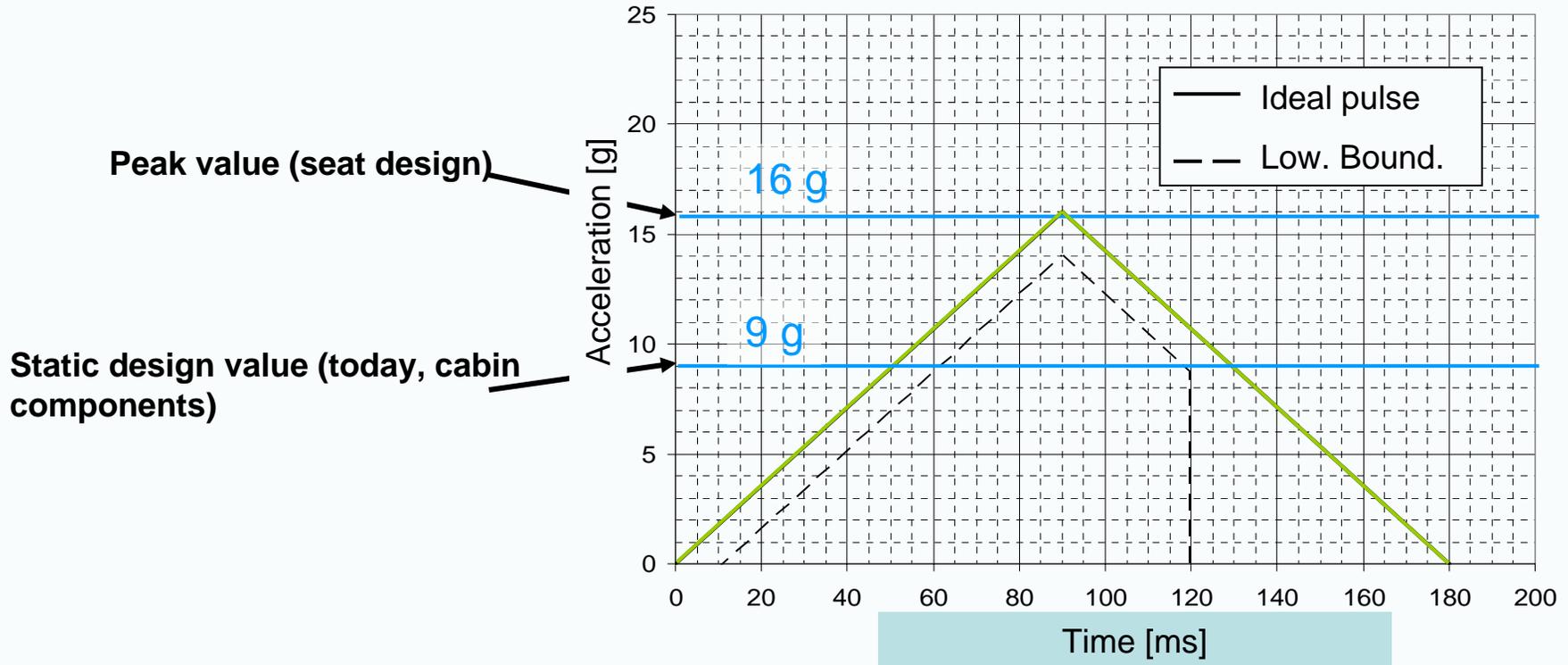
R & D on the topic of active and passive safety systems has to be conducted to reduce the amount of accidents in the future and lessen the consequences of the mishap.

The growth of safety has to be aligned with the growth of air traffic. Therefore concepts have to be developed to optimize A/C cabin passive safety but without or low weight gain!

The focus of the joint research project “InTeck”\* of Airbus, EADS and TUHH is to develop new supports with an integrated energy absorber for hatracks.



\* funded by the Ministry of Economy and Labour Affairs of the Free and Hanseatic City of Hamburg in cooperation with Airbus and EADS

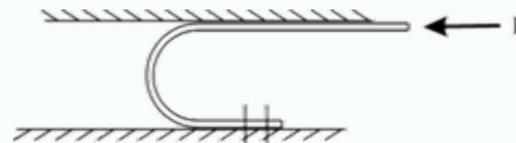
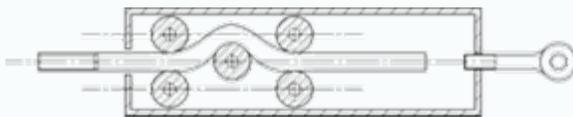
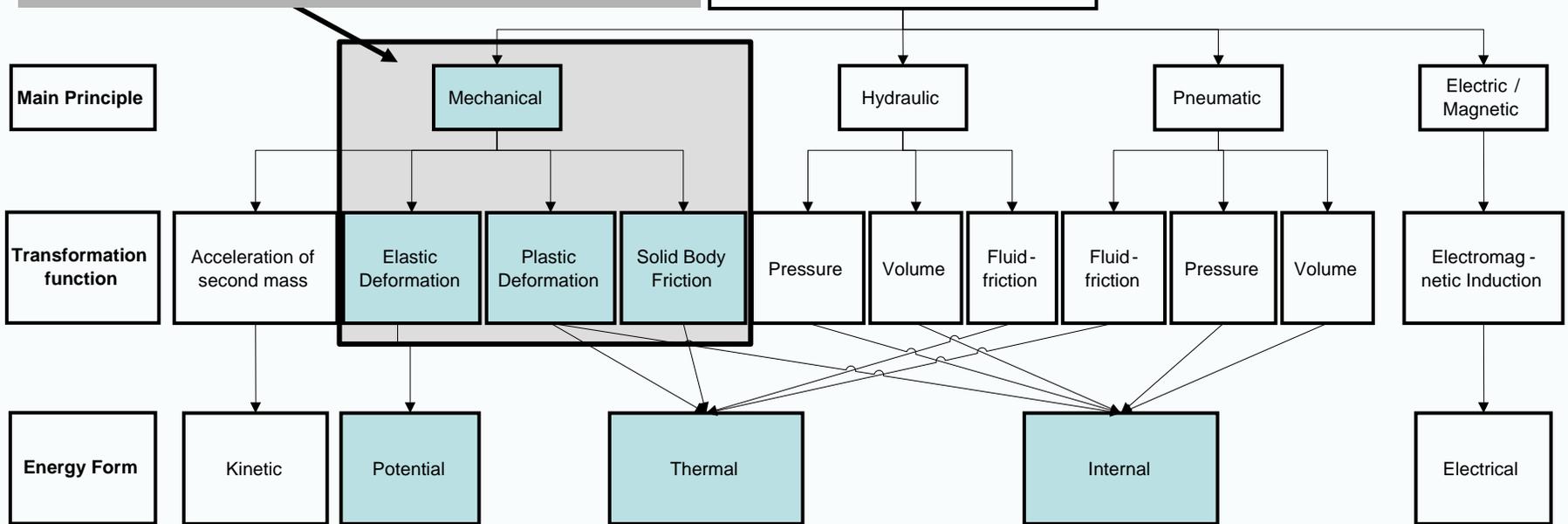


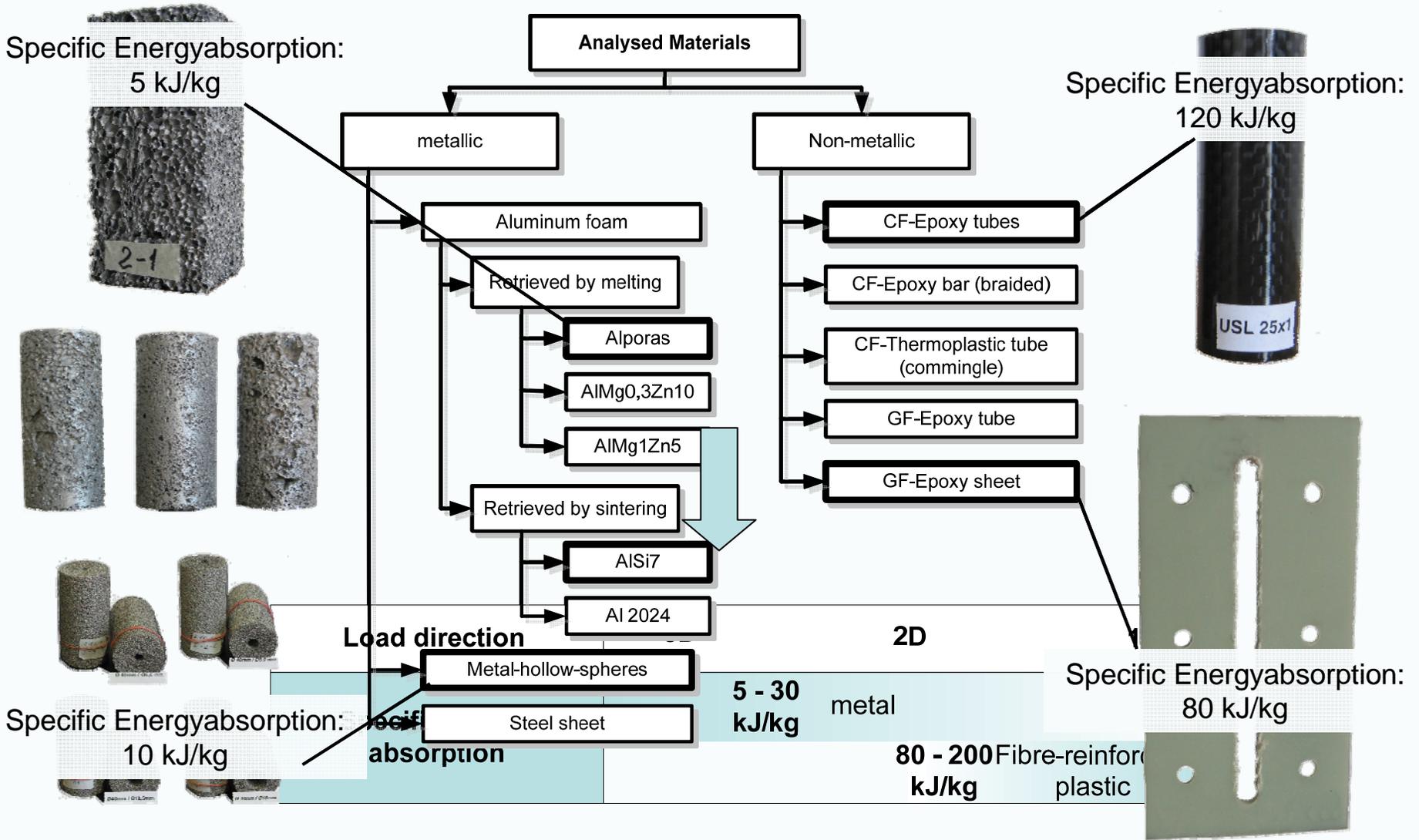
Taking only the peak values for design would lead to high forces.  
The use of force limiters (energy absorbing supports) could possibly solve this problem.

## Physical principles for energy absorption

### Applicable principles

### Dissipation of kinetic energy





## Drop tower and hydraulic shaker

- ➔ Analysis of impact behavior and influence of different deformation velocities on the force-deformation-curve on various materials (Drop tower)
- ➔ Vibration testing of materials and concepts

The hydraulic shaker allows vibrational loading of materials and concepts for replicating the loads during taxiing or windmilling (fan-blade-off event).

- ➔ Verification of function after simulation of service life loads

### Technical data of drop tower

Maximum impact force:	25 kN
Maximum drop height	6 m
Maximum impact velocity	7,5 m/s

### Technical data hydraulic shaker

Force:	25 / 120 kN
Frequency	30 / 15 Hz
Power	70 kW



Drop tower / shaker in test bay

Glass fiber reinforced epoxy plate, drilled



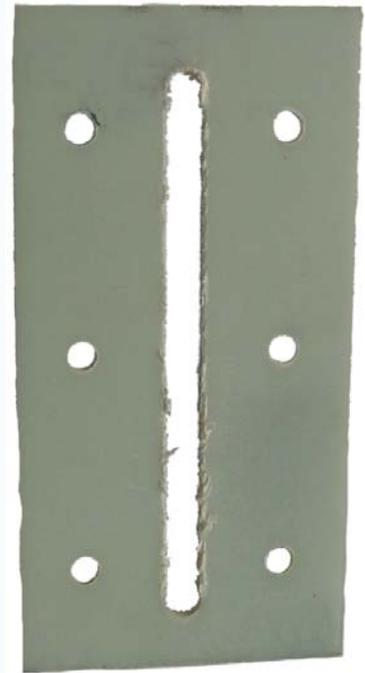
Before test



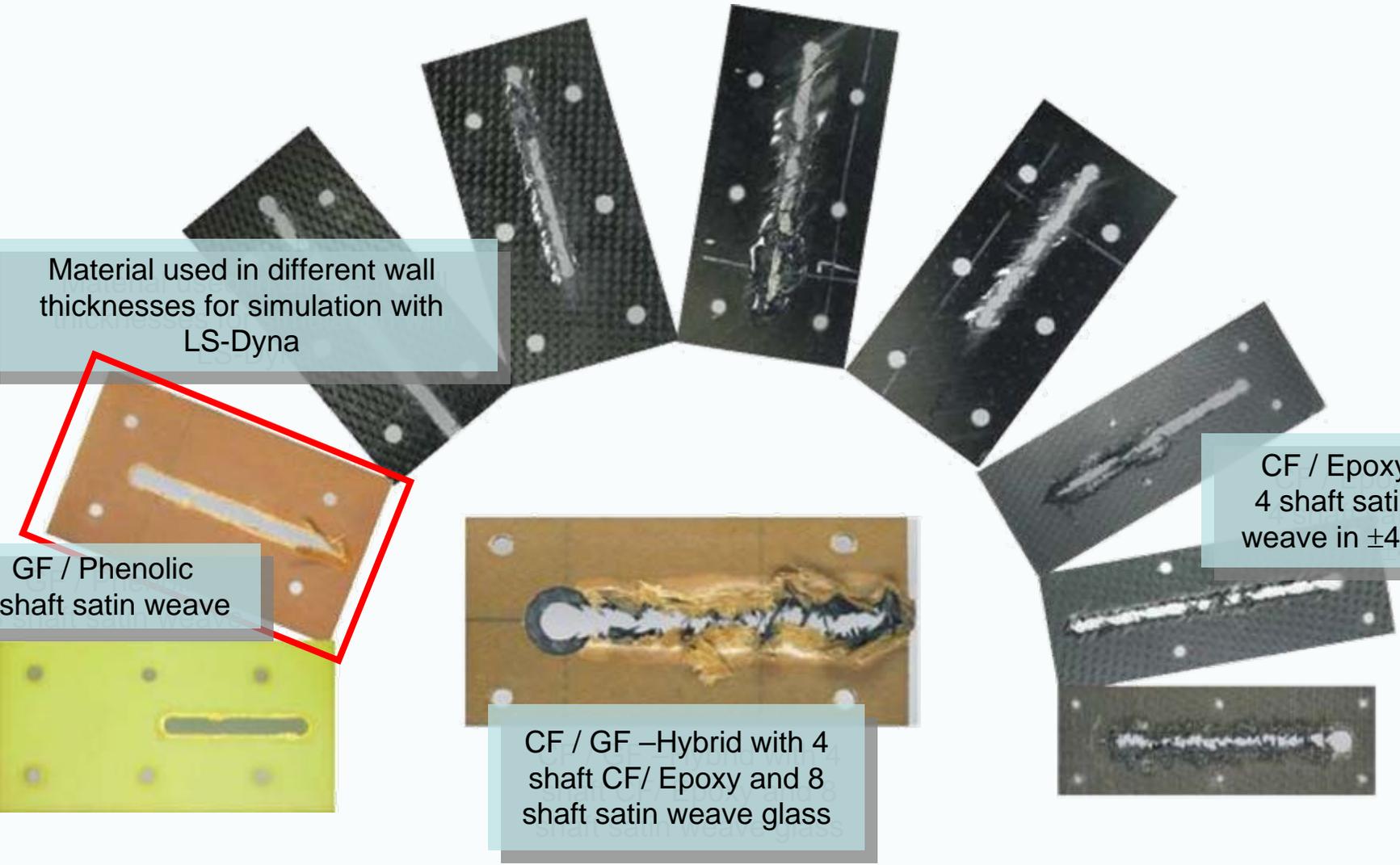
Test device



A stable, progressive crush front was established, little damage penetration lateral to the tear direction was observed.



After test

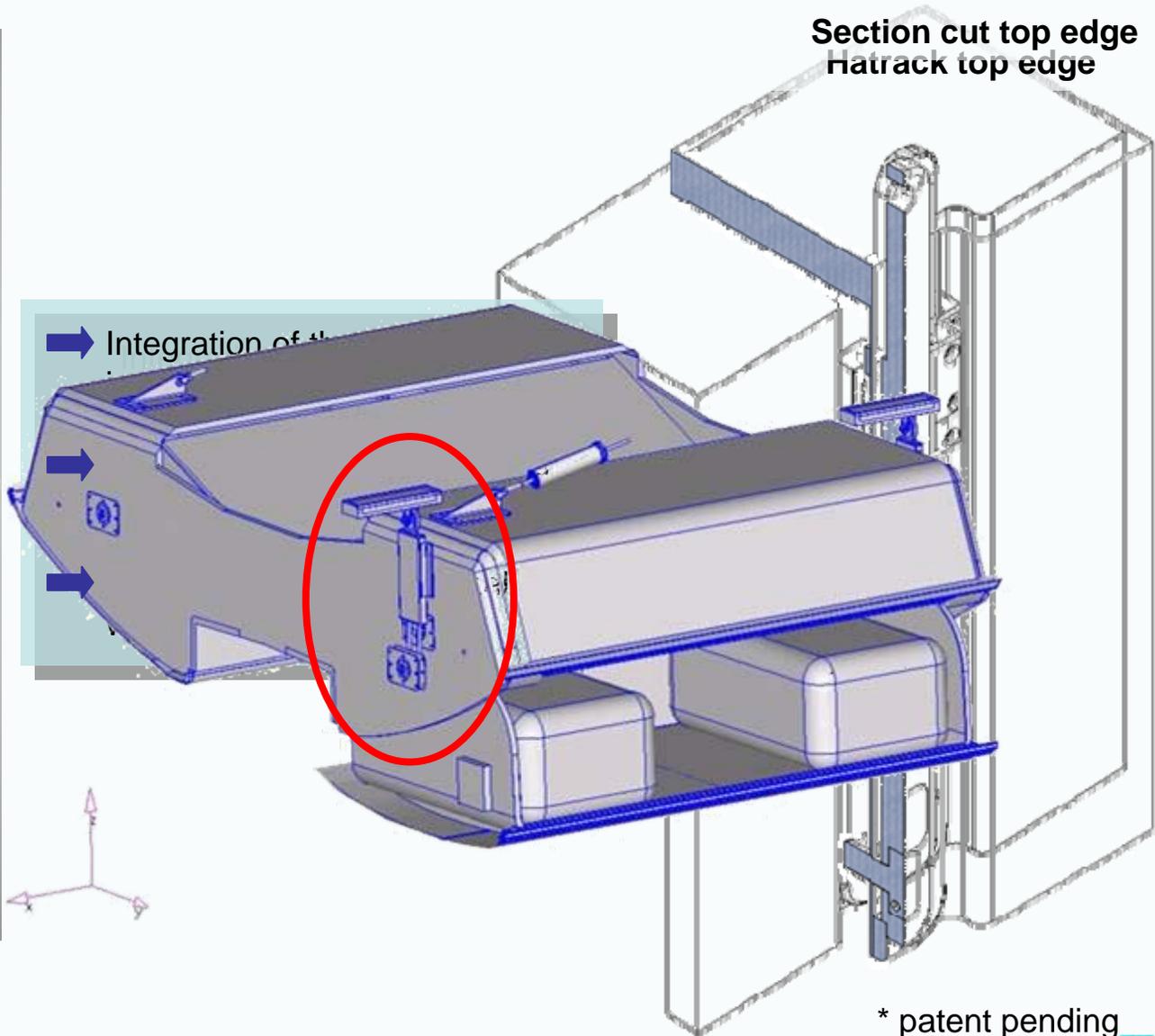


Material used in different wall thicknesses for simulation with LS-Dyna

GF / Phenolic  
8 shaft satin weave

CF / Epoxy  
4 shaft satin  
weave in  $\pm 45^\circ$

CF / GF –Hybrid with 4  
shaft CF/ Epoxy and 8  
shaft satin weave glass



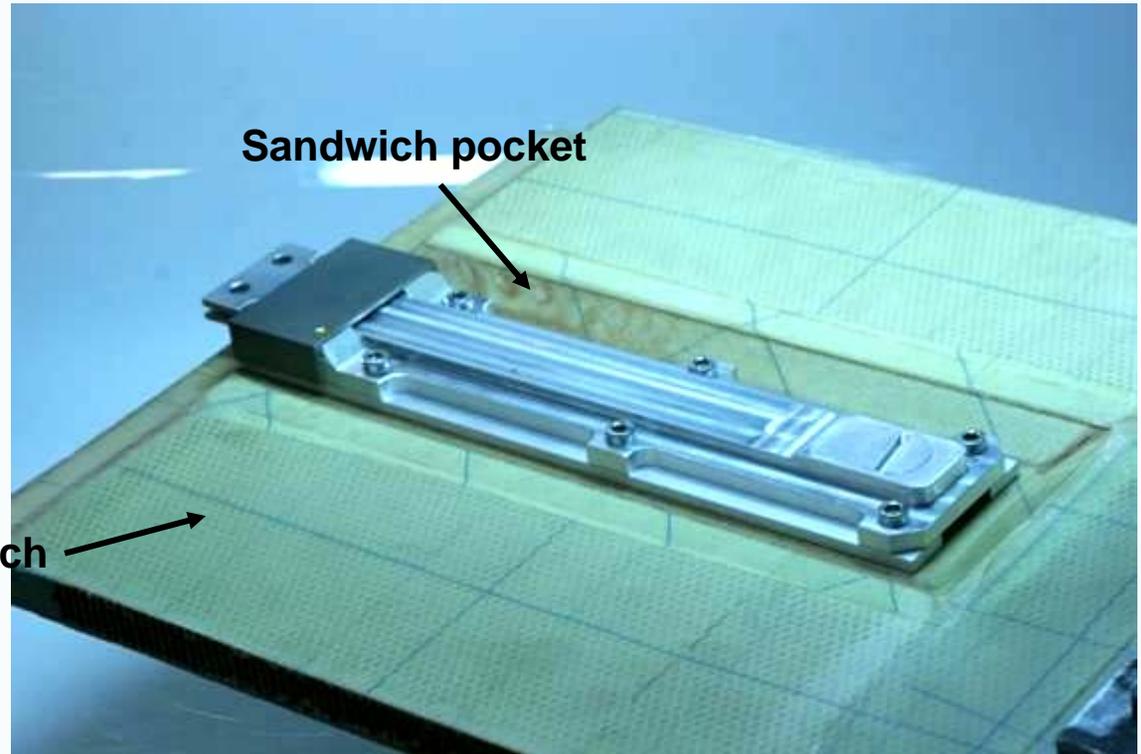


Sandwich

Absorber

Tear pin

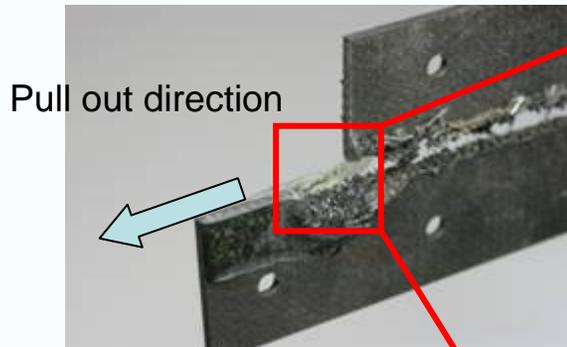
Positioning same as in A/C



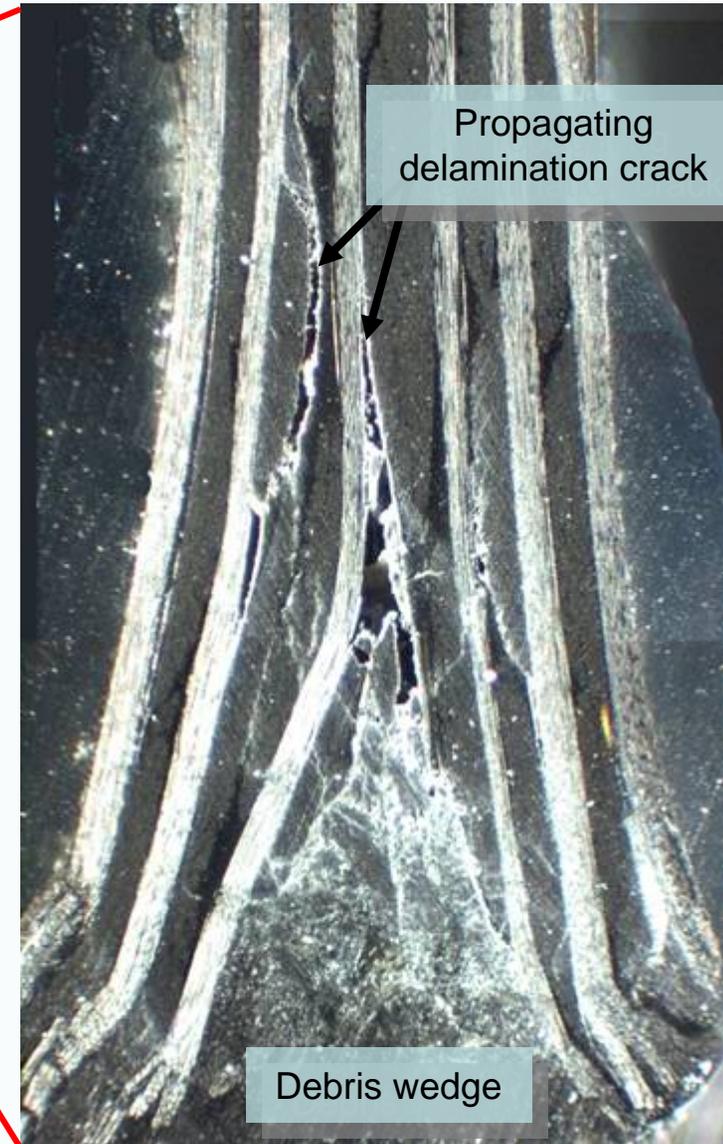
Sandwich pocket

## Advantages

- ➔ light weight design with integration of function
- ➔ small design space
- ➔ weight reduction of the surrounding structure is possible



0/90° satin weave CF/EP

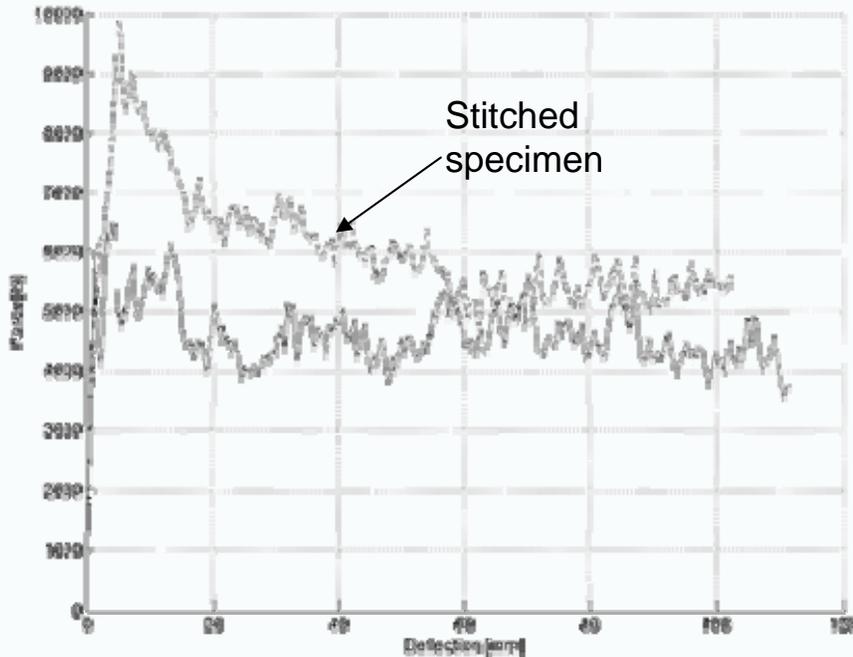


- ➔ Micrographs taken from the crush zone indicate a debris wedge on top of the pin, similar to crush tubes.
- ➔ The wedge pre-damages the laminate due to cracks protruding from the tip of the wedge.
- ➔ Different damage modes render analytic description of the failure problematic.

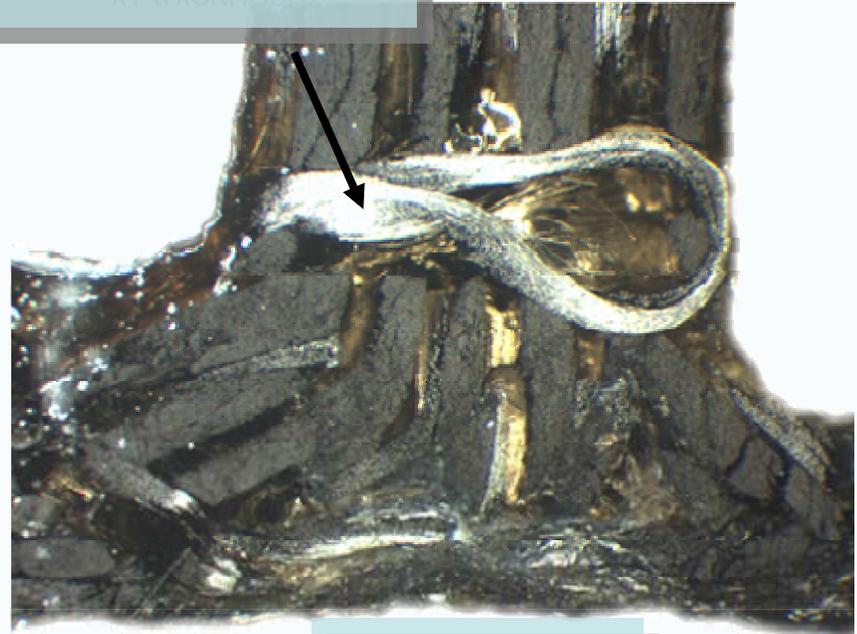
The influence of in-thickness direction reinforcements were analyzed by stitching the plate with aramid yarn.

As can be seen, the debris wedge is comparatively small.

An increase of the mean crush force by approx. 20 % was observed.



Aramid reinforcement \*  
(in-thickness)

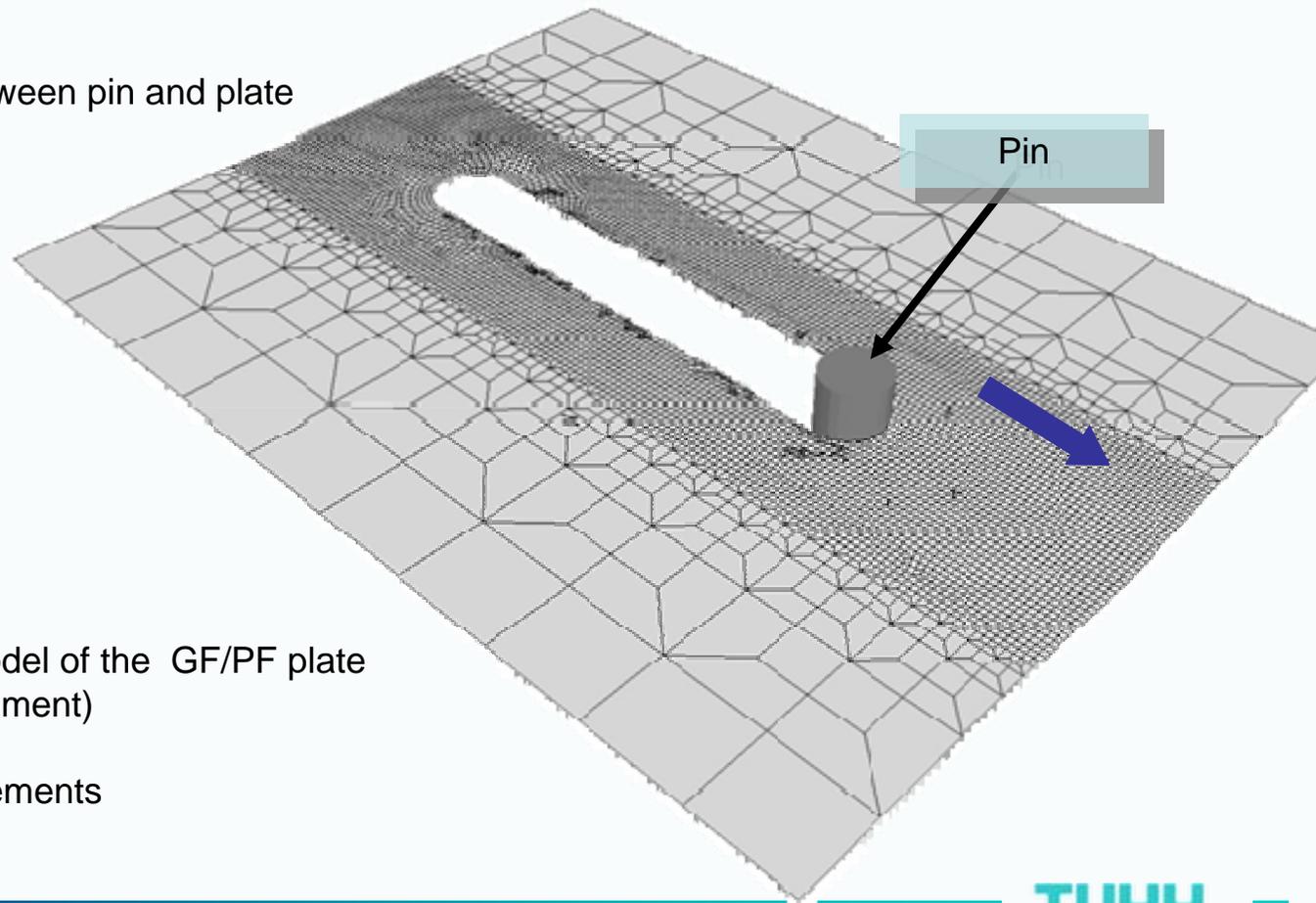


Debris wedge

\* patent pending

The influence of the following parameters were investigated:

- ➔ material model
- ➔ mesh refinement
- ➔ crash front parameters
- ➔ coefficient of friction between pin and plate



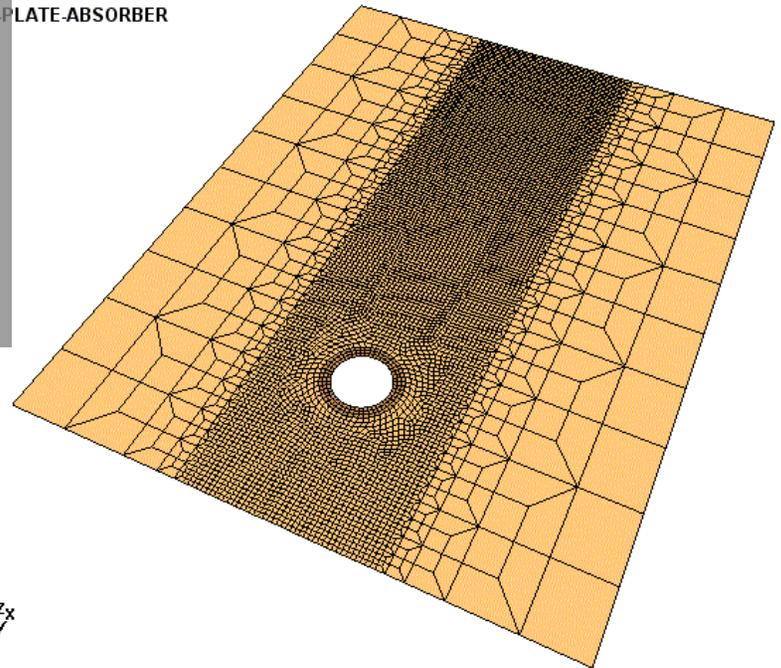
LS-Dyna model of the GF/PF plate  
(mesh refinement)

2D-Shell-Elements

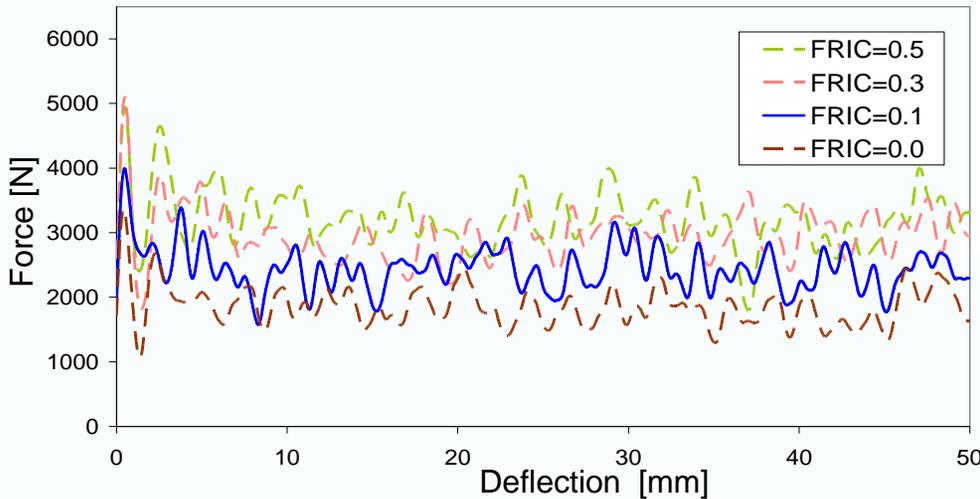
## Influence of different model parameters on average crush force

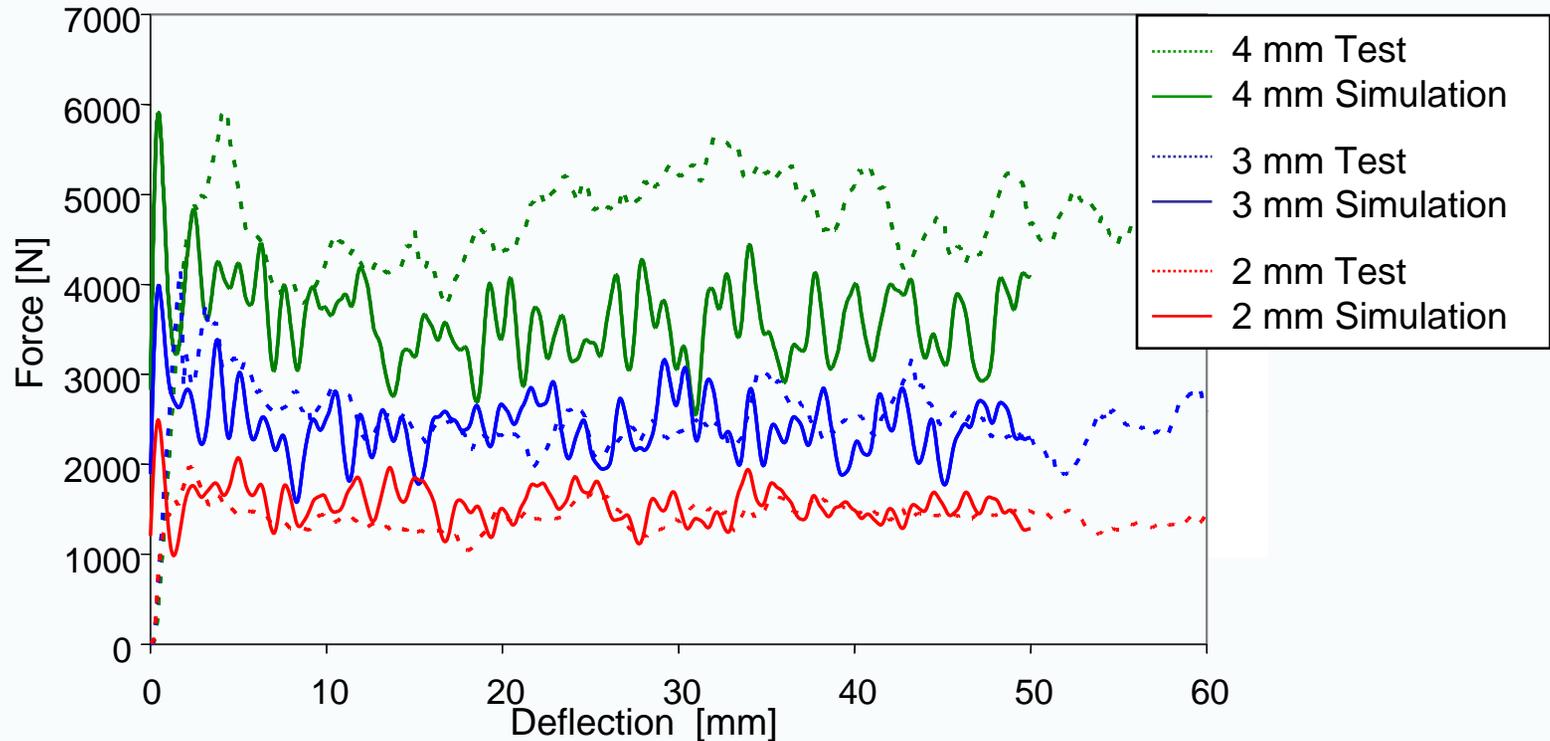
Parameter	High	Low
Material model	<b>X</b>	
Mesh refinement		<b>X</b>
Crash front parameters	<b>X</b>	
Coefficient of friction	<b>X</b>	

PIN PLATE-ABSORBER



GF/PF, 3 mm, MAT54, SOFT=0.5, TFAIL=0.3





### Comparison between test / simulation

- ➔ Post-test simulations with one parameter set for different plate thicknesses had a relatively good correlation between test results and simulation
- ➔ Tuning of non-physical simulation parameters was required
- ➔ Pre-test simulation is limited due to non-physical parameters

- ➔ Plastic deformation as the chosen principle of energy absorption promises high efficient force limiters with low weight.
- ➔ The research showed that the integration of force limiting support structures in A/C cabins comprising innovative energy absorbing materials is possible.
- ➔ The derived design method for *Integration of Functions*, which will be further developed, makes it possible to reduce the A/C cabin weight especially combined with special lightweight materials, like sandwich panels.
- ➔ Simulation of the absorber with LS-Dyna shows a limited capability for pre-test prediction. Experimental tests are inevitable.

The utilization of the force limiter makes it possible to use dynamic boundary conditions as used for seats for certification, with (today) low weight gain.

Thank you for your attention!