Transport Research Arena
Europe 2008

LITEBUS
MODULAR LIGHTWEIGHT SANDWICH BUS CONCEPT

Contract 031321
TST5 – CT – 2006 – 031321

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- The Project
- The Consortium
- Strategic Importance
- Project Goal
- Research Objectives
- Implementation Plan

The Project

The project

Commencement date : 1st October 2006

Duration: 36 months

Commission Grant : 2 Million Euros

Selected Topic for Call 3B:
Development of advanced, low-mass material structures and systems for vehicles and vessels offering product structural and functional integrity for rated performance at low cost.

The Consortium

The consortium

- INEGI (Coordinator)
- CaetanoBus
- Fibersensing
- CIMNE
- Giugiaro-Italdesign
- UP Milano
- U Oxford
- KTH
- NTET
- Clausthal Univ.
- SUNSUNDEGUI
- MAURI
- UP Madrid

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Strategic Importance

Buses and coaches play a key role in public transport

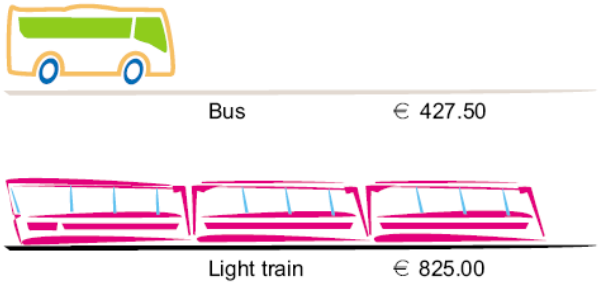
730 000 buses/coaches in the EU
(EU 25, 2005)

7.5 million jobs in industry

Cost-effective

Safe

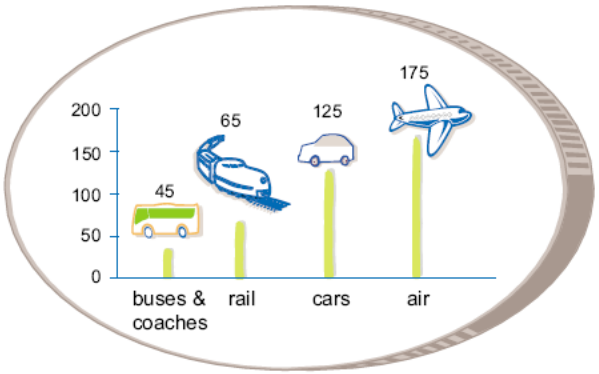
Environmentally friendly



Cost comparison: bus and coach versus light railway
(Total cost/day, based on 60,000 km/yr.)

Buses and coaches – the most cost-effective means of passenger transport!

Carbon dioxide emissions in passenger transport
(EU countries, grammes/passenger-km)

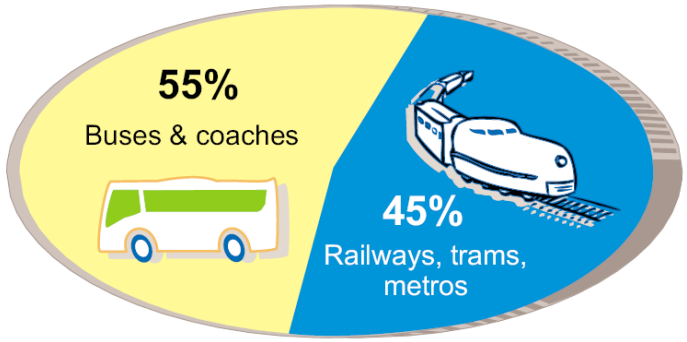


ENERGY & TRANSPORT IN FIGURES 2006 Part 3 : Transport ,EU DG Energy and Transport

International Road transport Union,2000

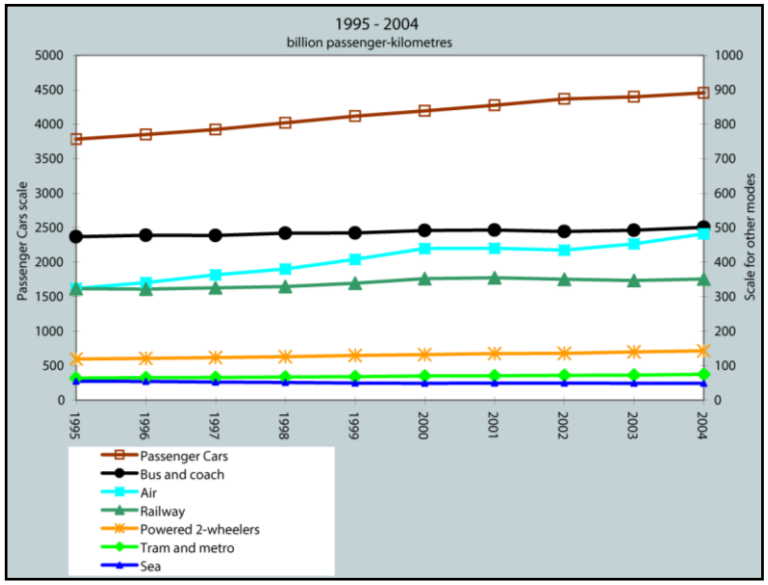
Comparison EU-25 – World : Passenger Transport

	EU-25	USA	Japan	China	Russia
	Passenger transport billion pkm				
	2004	2004	2003	2004	2005
Passenger car (1)	4 458.1	7 165.0	755.0	874.8	
Bus / coach	501.8	226.0	86.0		96.3
Railway	351.7	22.0	385.0	571.2	171.6
Tram + metro	75.2	18.0			71.9
Waterborne	49.0	1.0	4.0	6.6	0.7
Air (domestic / intra-EU-25)	482.5	896.0	83.0	178.2	85.8



Market share in public transport in Europe (passenger-km)

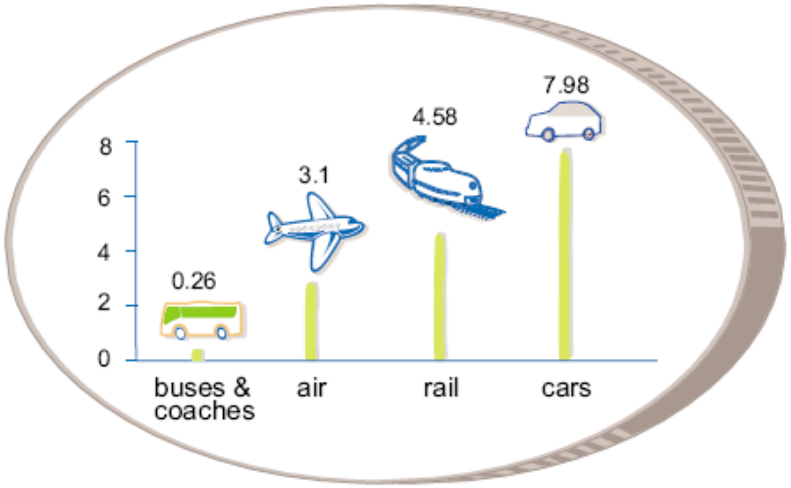
EU-25 Performance by Mode for Passenger Transport



ENERGY & TRANSPORT IN FIGURES 2006 Part 3 : Transport ,EU DG Energy and Transport

International Road transport Union,2000

Road Fatalities by Type of User



Safety in passenger transport
(Fatalities per billion passenger-km, Germany)

	EU15
Total persons killed	32 836
of which:	
driver	21 589
passenger	6 473
pedestrian	4 592
other/not specified	182
by type of vehicle:	
car and taxi	17 698
motor cycle moped	6 464
bus or coach	148
pedal cycle	1 685
agricultural tractor	222
heavy goods vehicle	465
lorry, under 3.5 tonnes	956
other/not specified	5 198

ENERGY & TRANSPORT IN FIGURES 2006 Part 3 : Transport, EU DG Energy and Transport

International Road transport Union,2000

Project Goal

GOAL

- Contribute to reduction of CO2 Emissions
- Reduce Total Cost of Ownership of Buses/Coaches

GROSS BUS WEIGHT REDUCTION OF 20% ALONE WILL RESULT IN AT LEAST 20% IMPROVEMENT IN FUEL EFFICIENCY AT GROSS WEIGHT

Research Objectives

Objectives

The total weight of a "*body in white*"of a Bus/Coach will be 60% lighter than comparable steel bodies.

The stiffness of the body will be equivalent to steel body

Crashworthiness and passive safety performance will be greater than bolted aluminium alloy structures and better than welded steel structures.

20% noise reduction and enhanced vibration properties.

The cost of the structure should be 10% lower than comparable steel body through reduction of production lead time.

Greater corrosion resistance and fire safety (structural and toxicity)

Objectives

Interior space increase (at least 10 %), thus improving quality of journey and increased passenger capacity

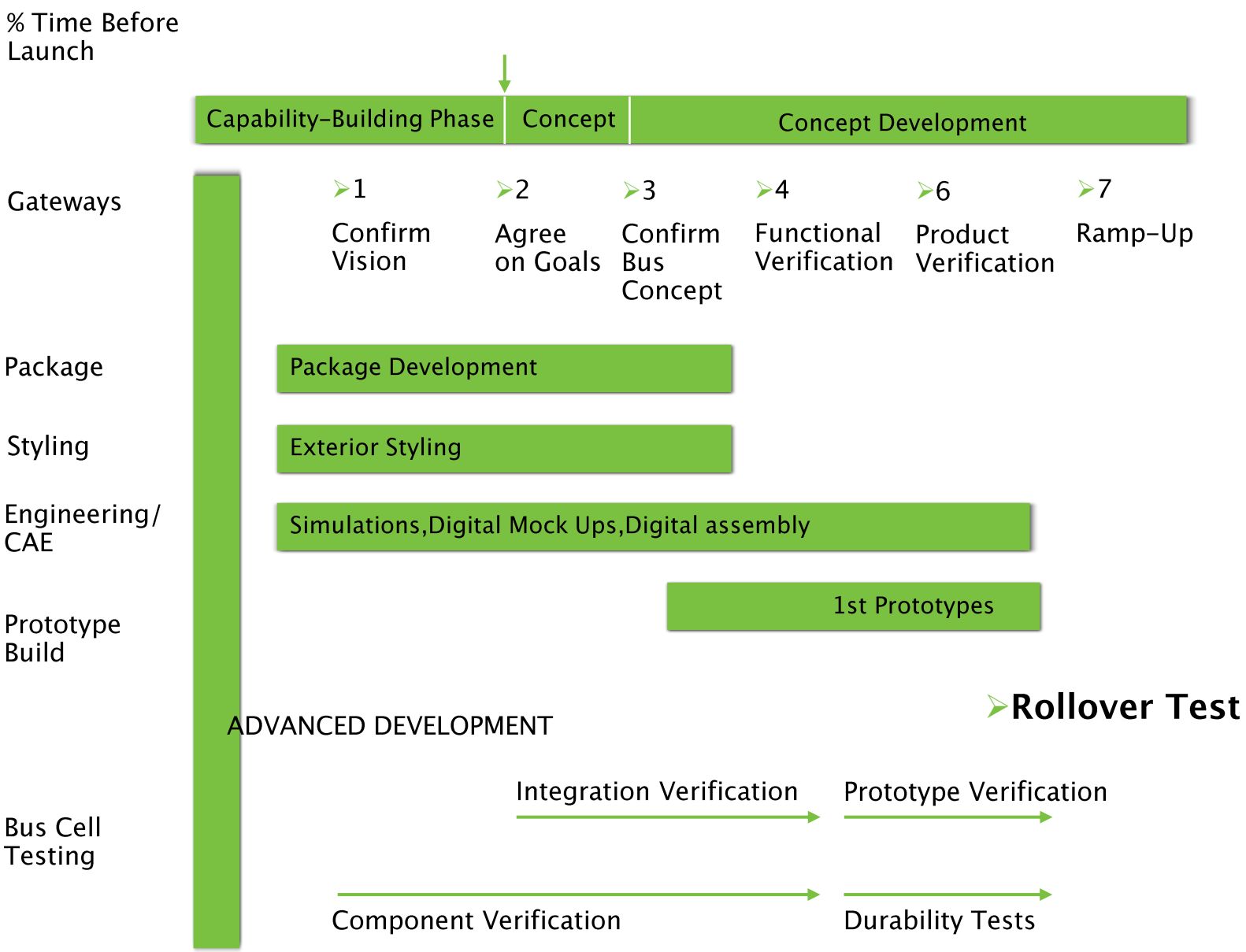
Manufacturing lead time should be reduced 30% through the use of modular large panels, easier and faster to assemble and join together, with built in functions.

Tooling costs will be reduced 50%, since sandwich panel jigs are considerably less expensive than stamping dies or jigs for welded construction.

Implementation Plan

LiteBus "Front-loaded" Development Schedule

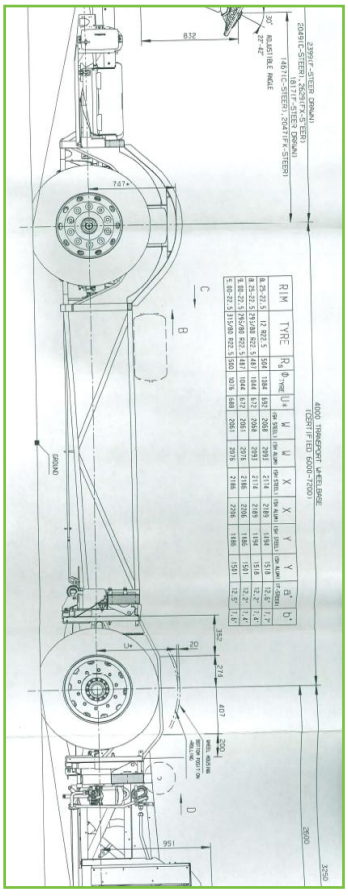
Project Schedule – Time = 36 Months

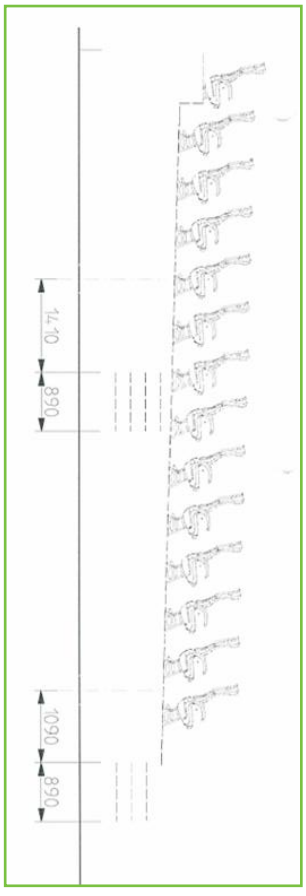


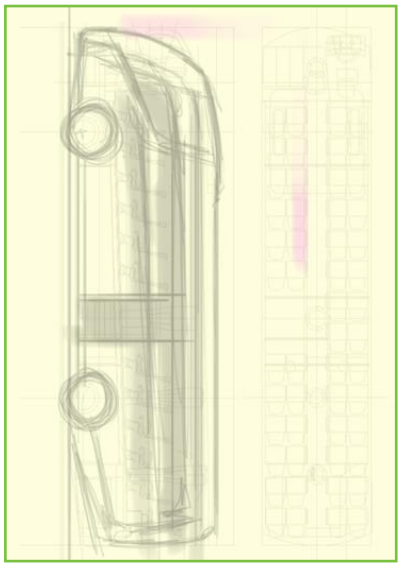
Adapted from S HThomke,2007

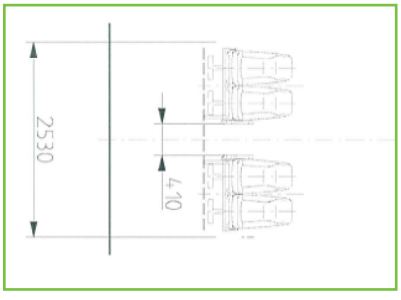
Generation of new concept vehicle architecture

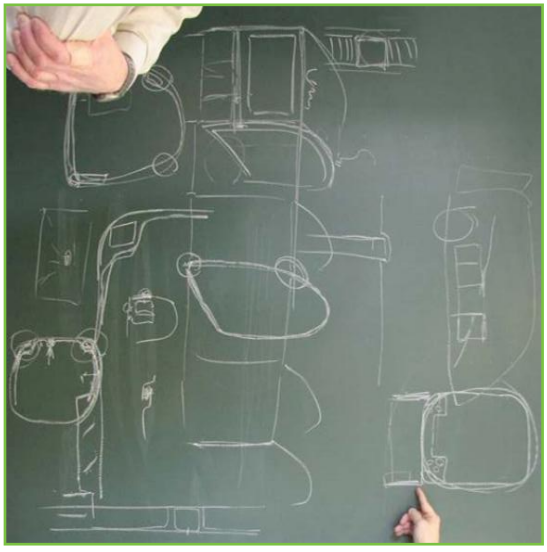
Current State of the Art

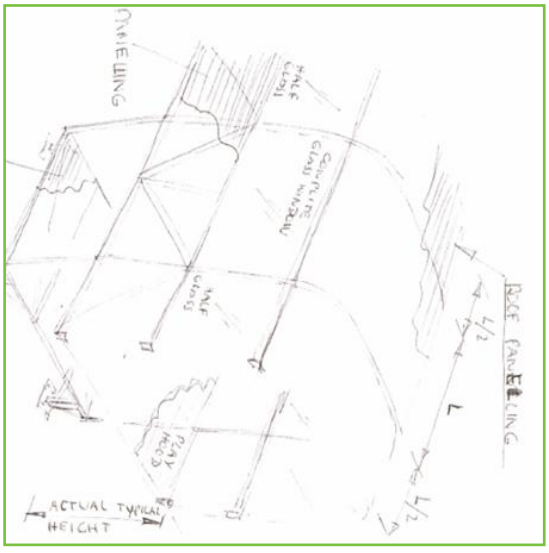




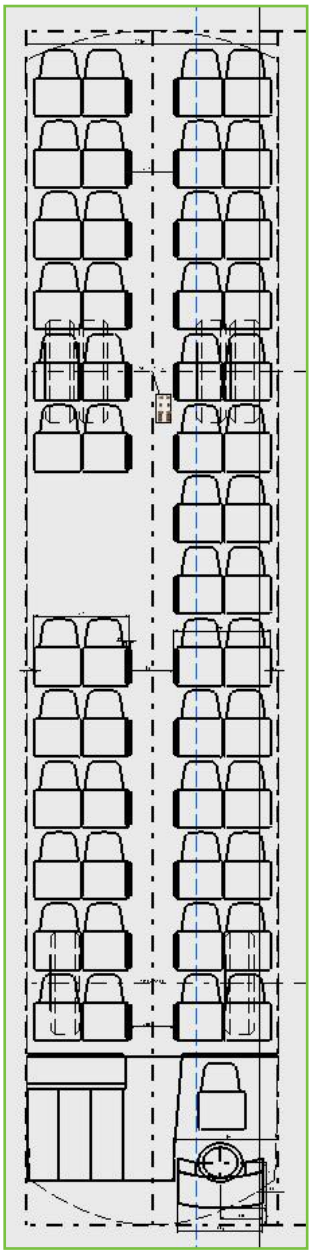


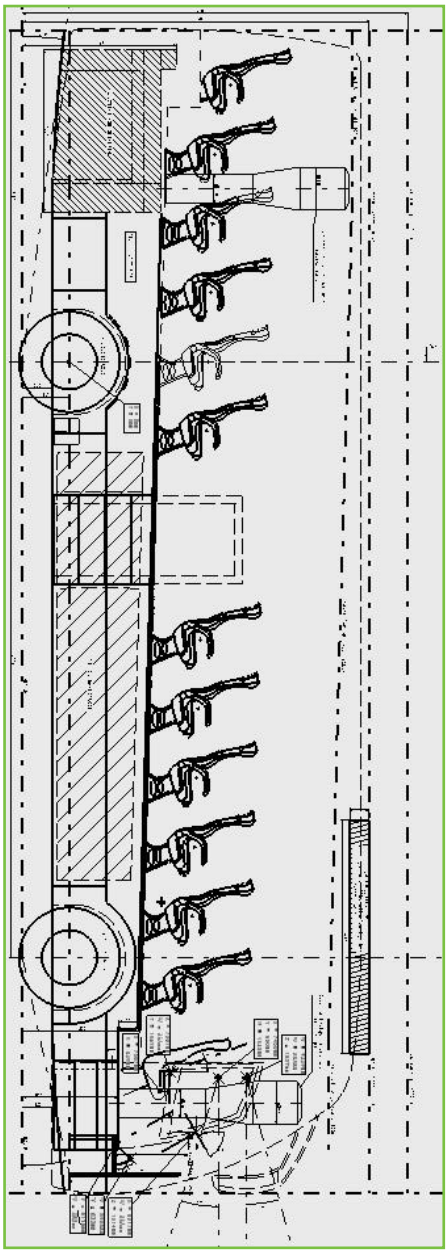


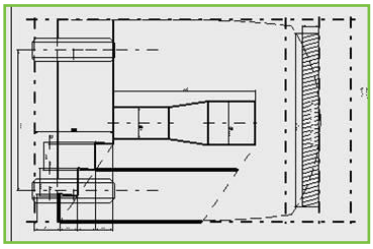


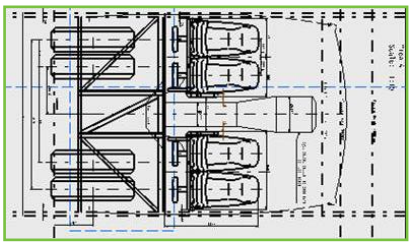


Package 2D

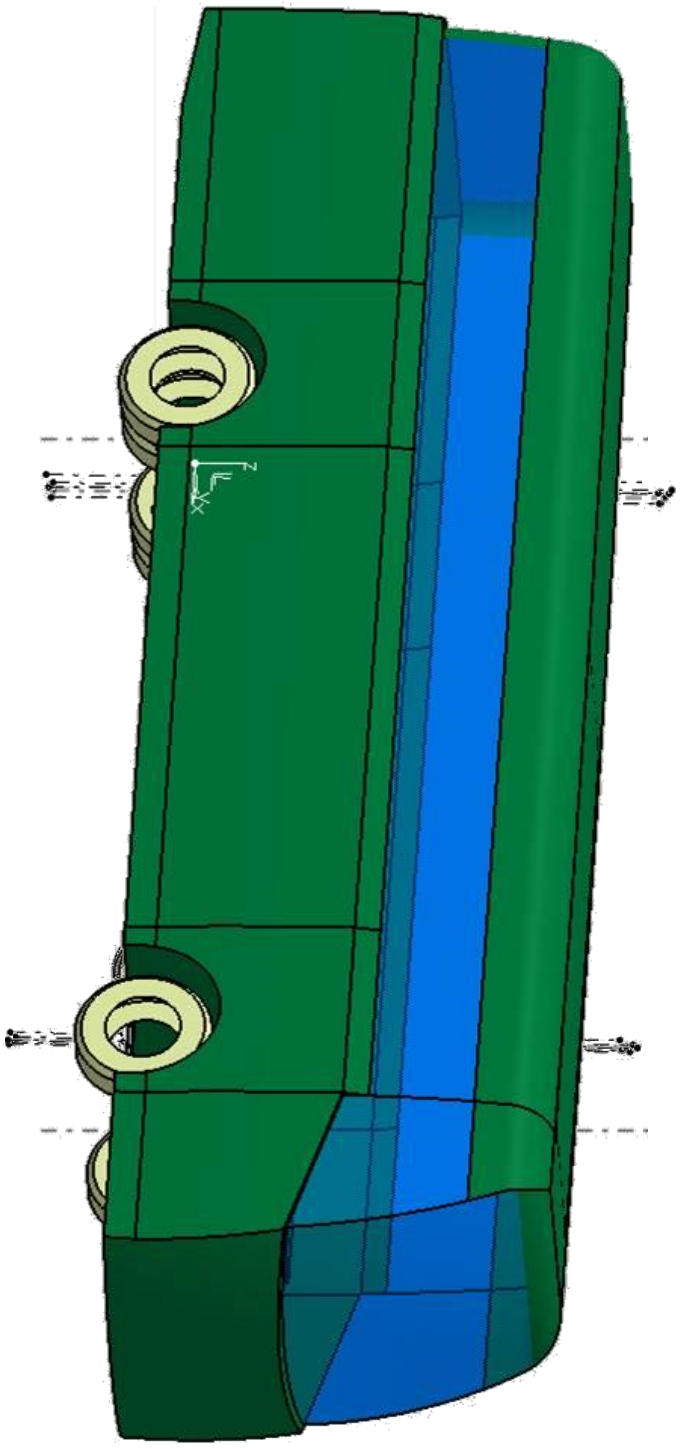




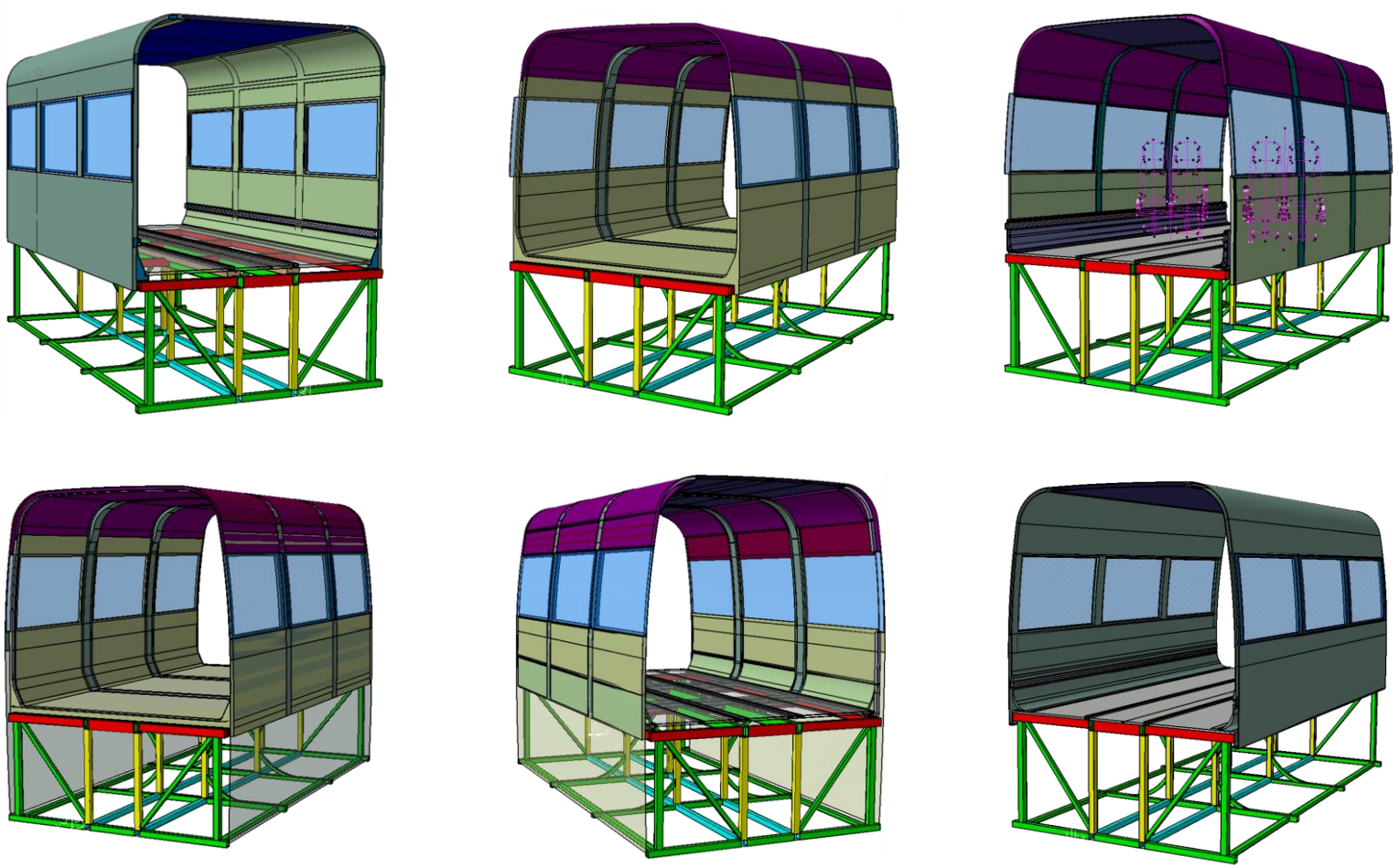




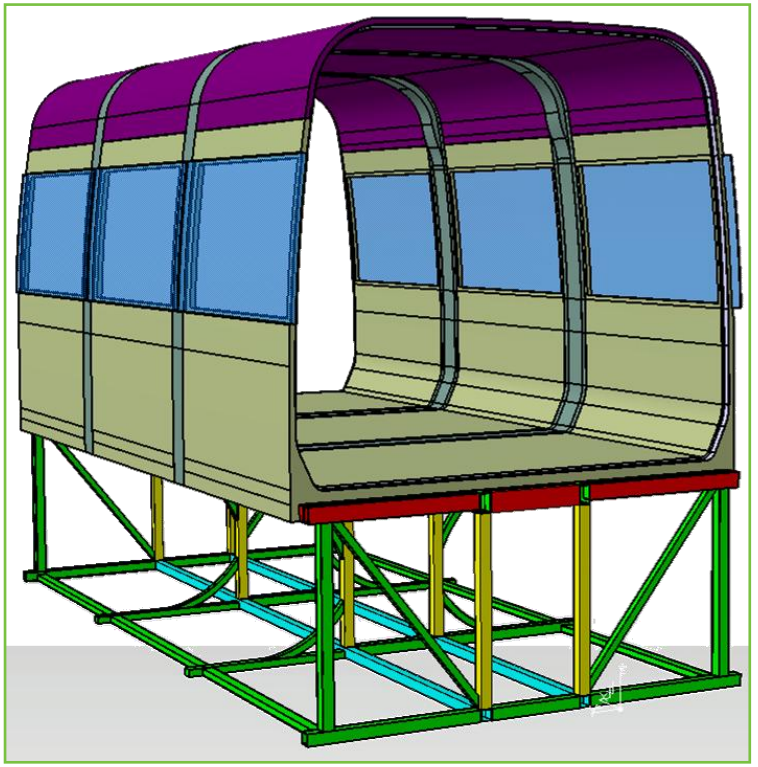
Package 3D

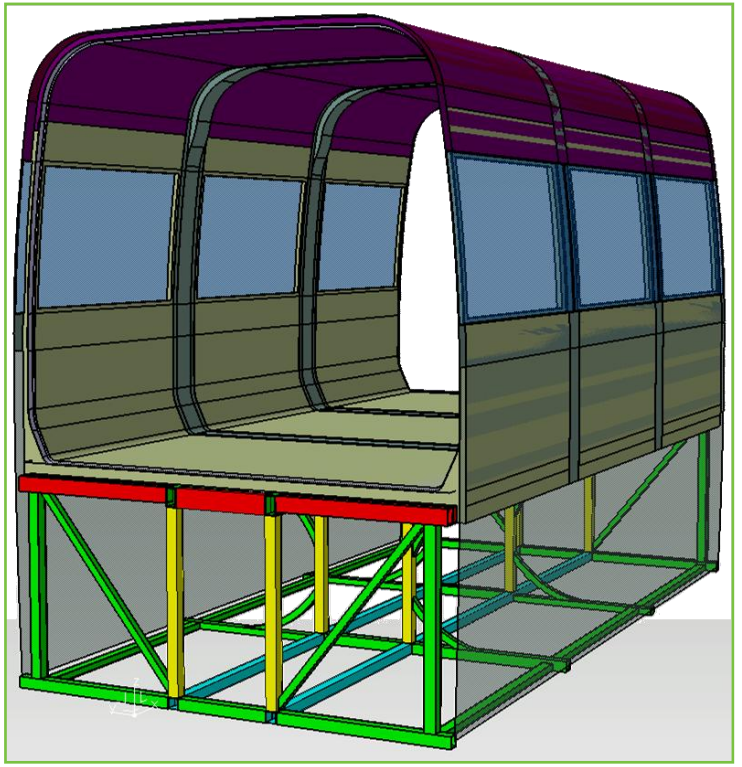


Idea Generation

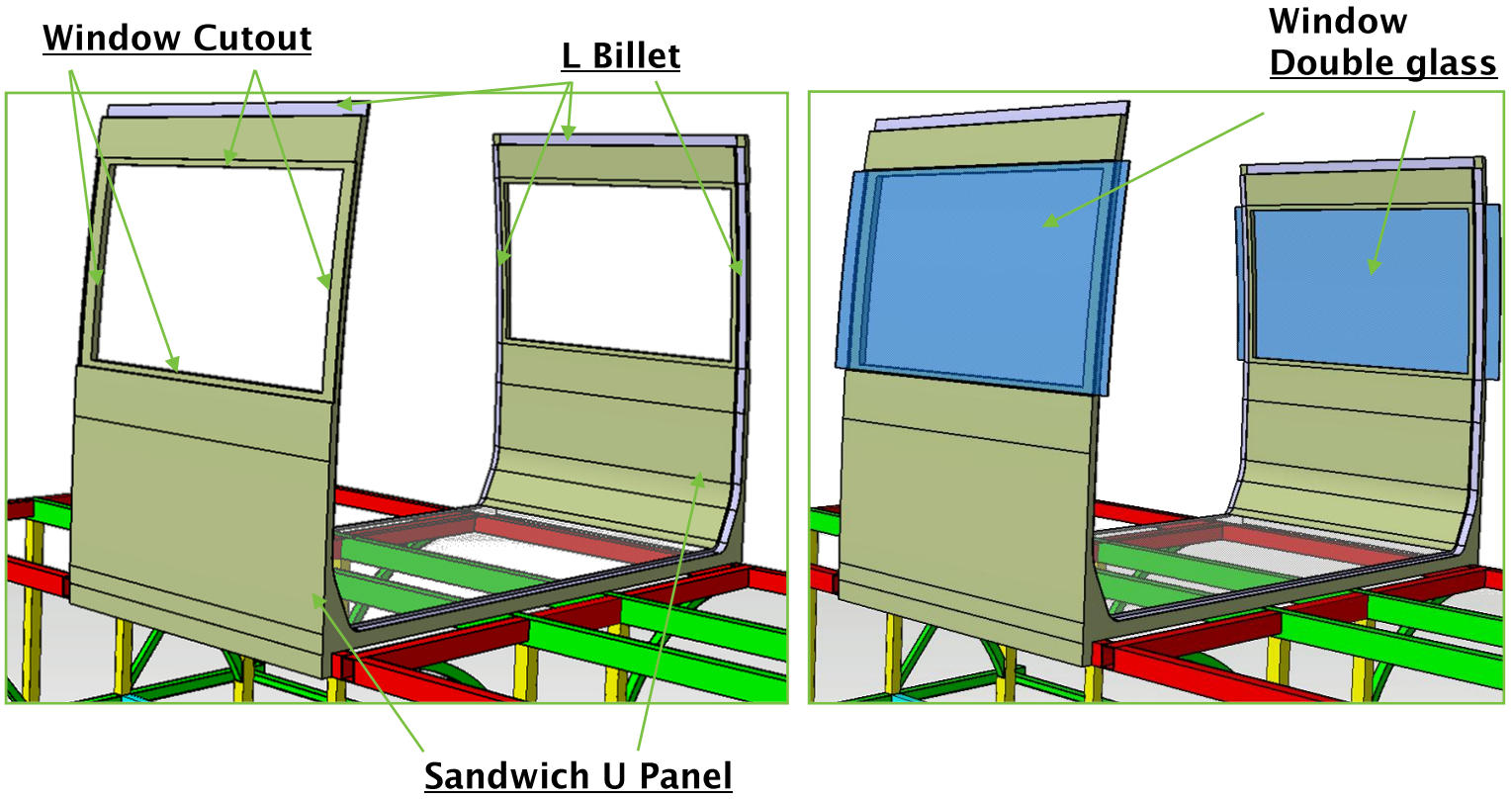


Isometric Views

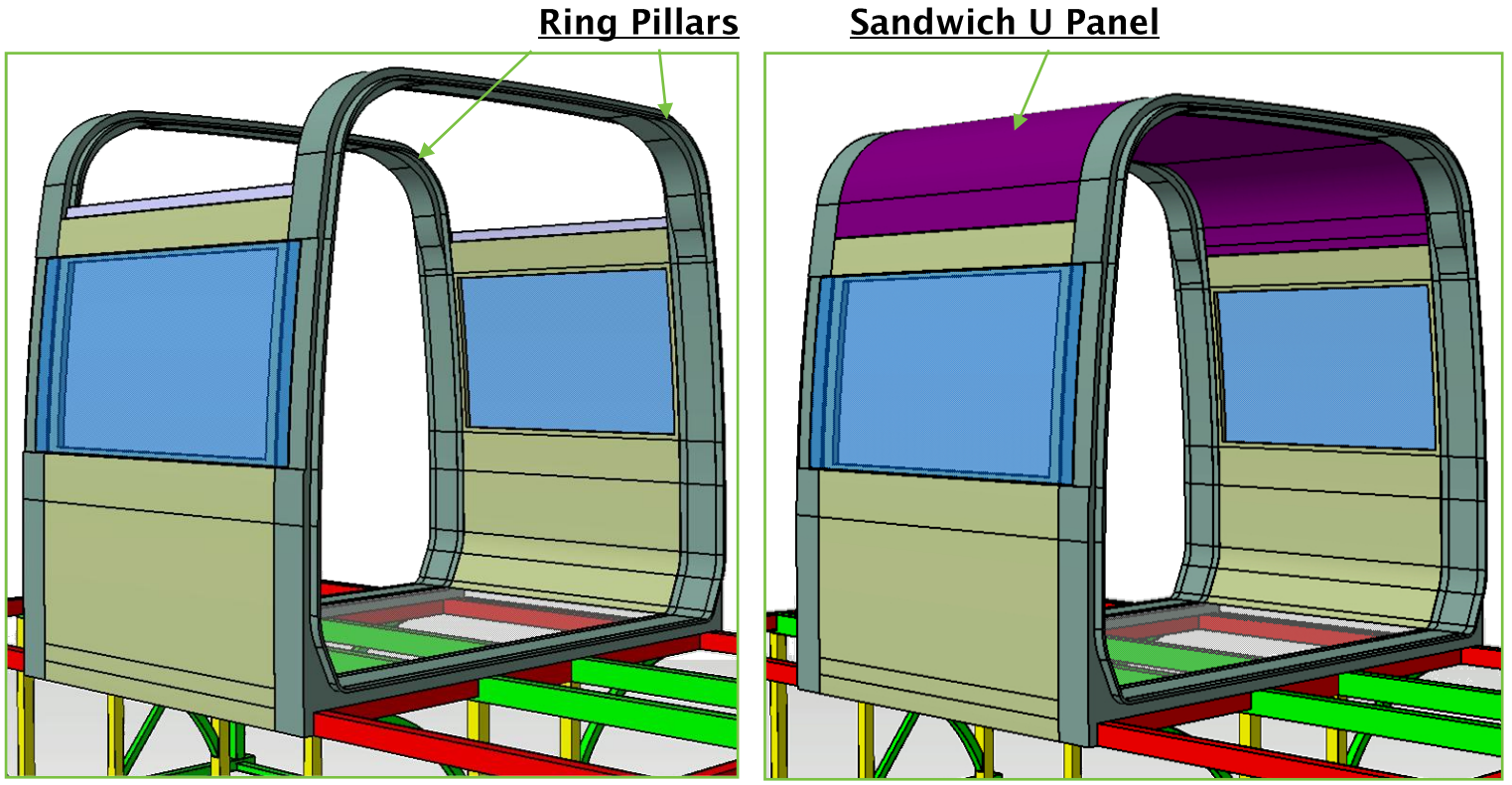




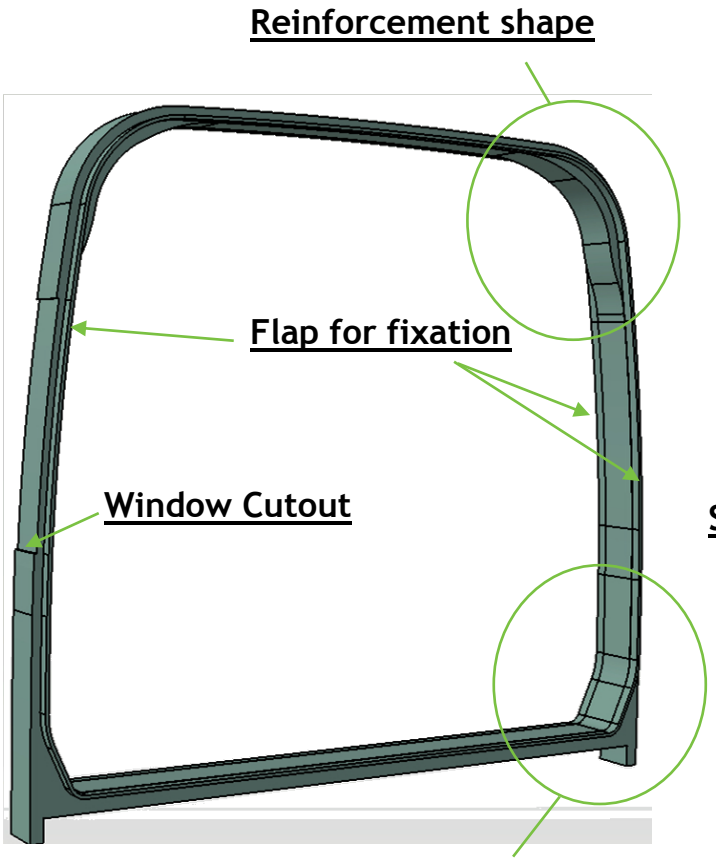
Isometric Views

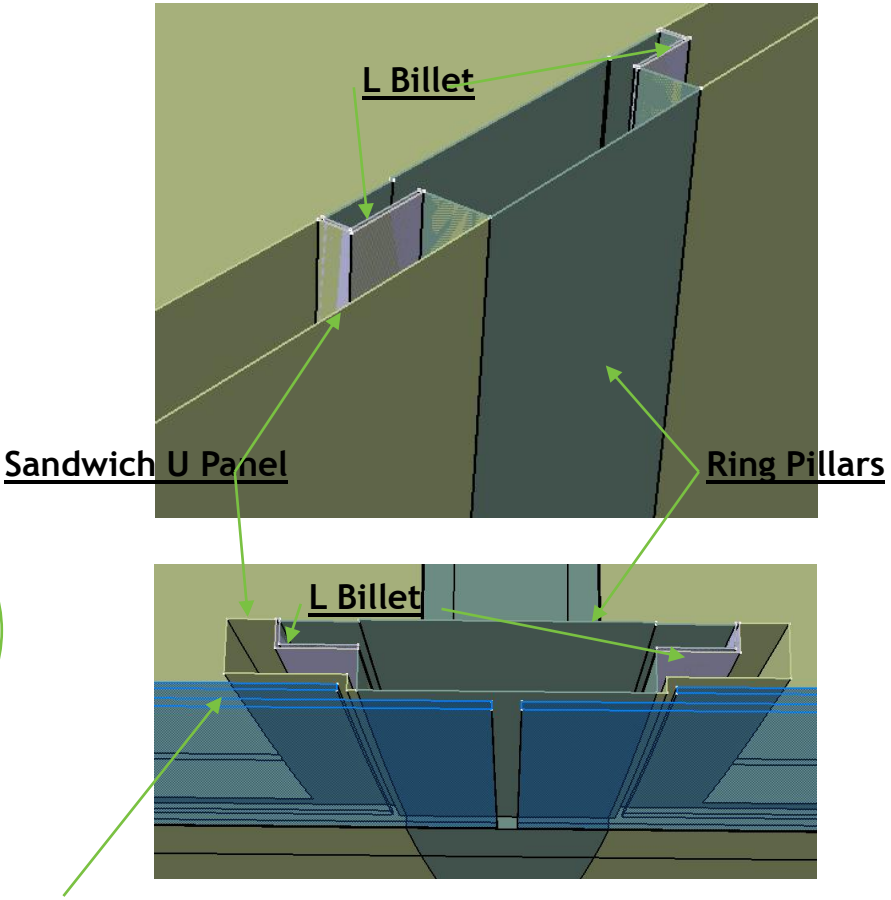


Isometric Views

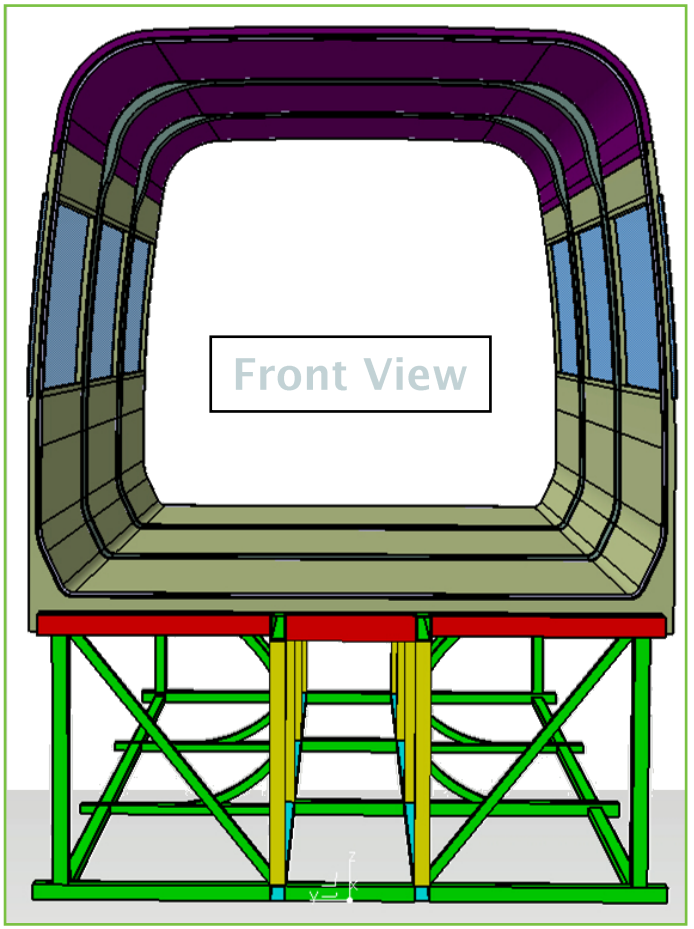


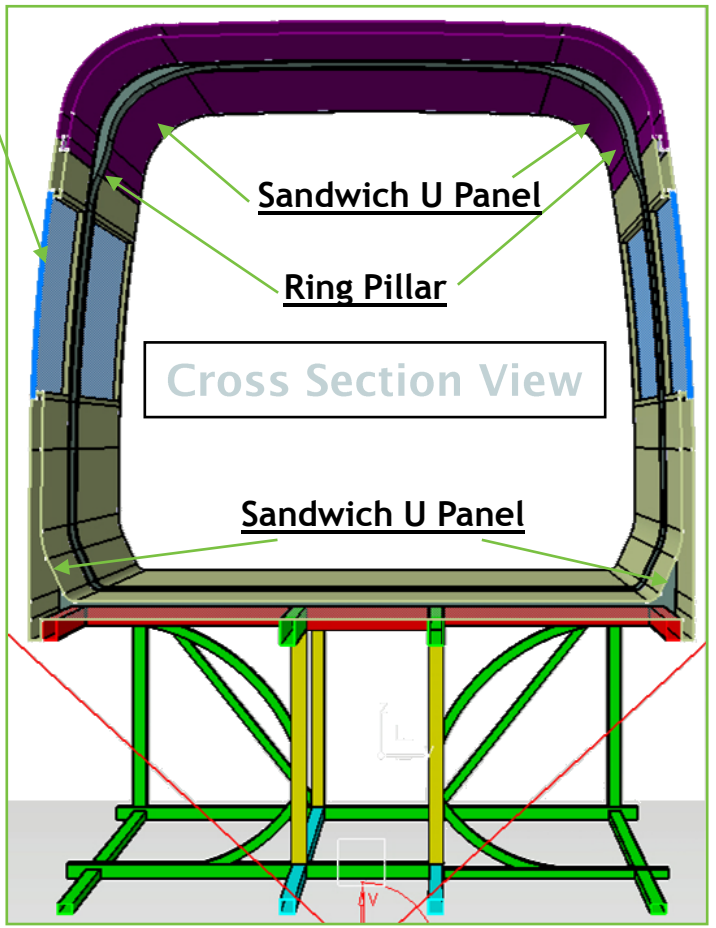
Isometric Views



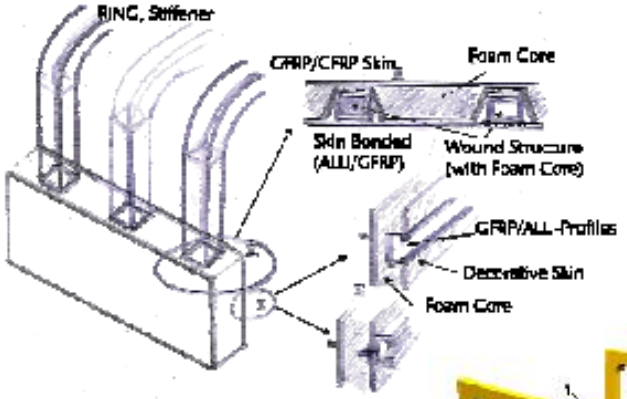


Isometric Views





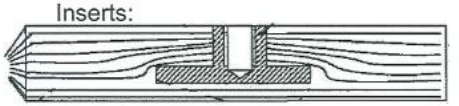
Materials & Assembly Process



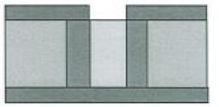
Joints for disconnection: riveting, screwing

Joints for durable connections: bonding, welding

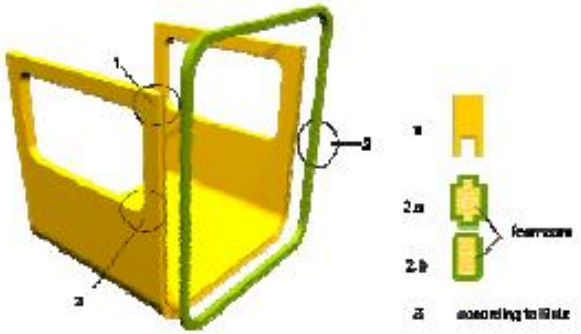
Inserts:

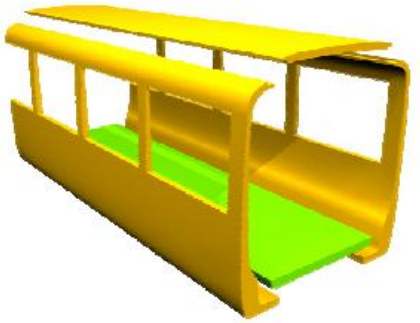


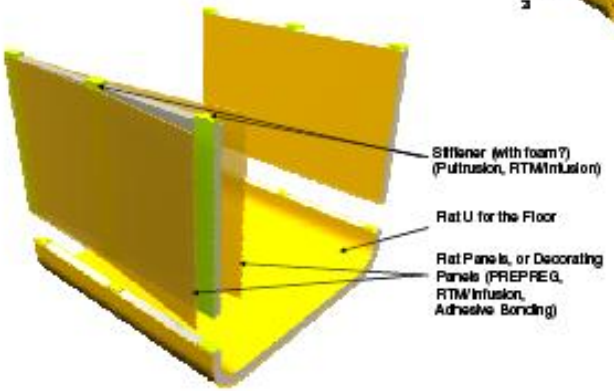
Solid laminate

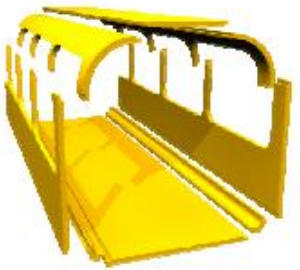


sandwich

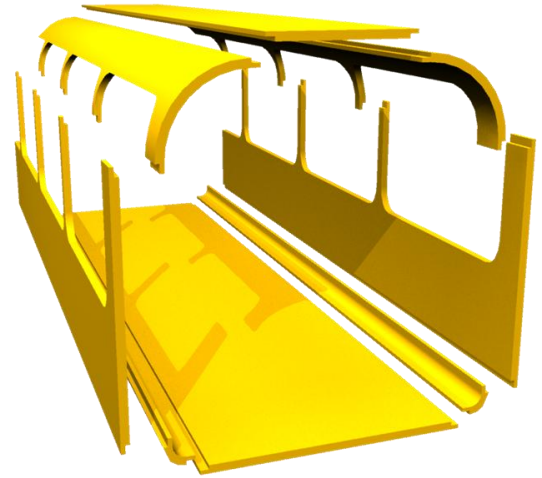


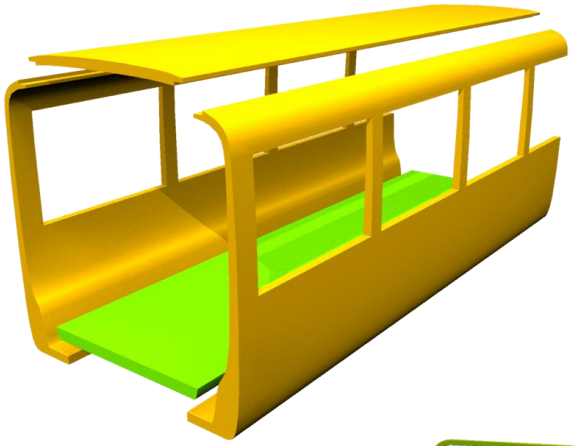


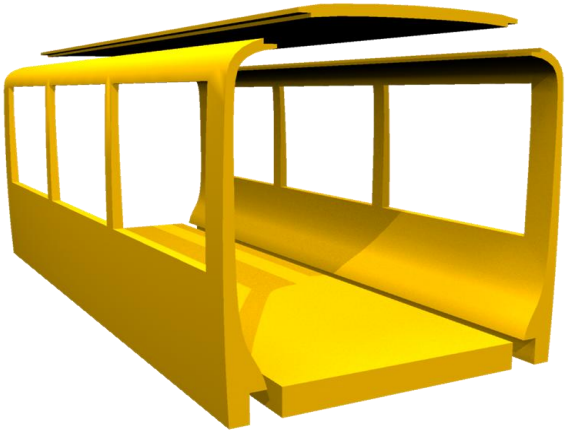


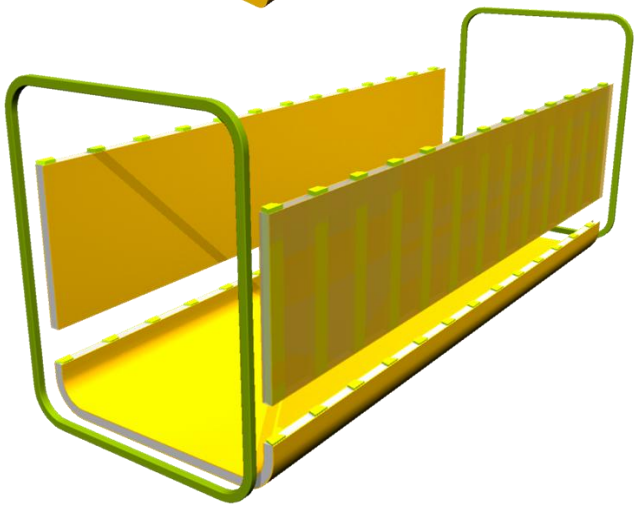


Different possible Assembly Concepts



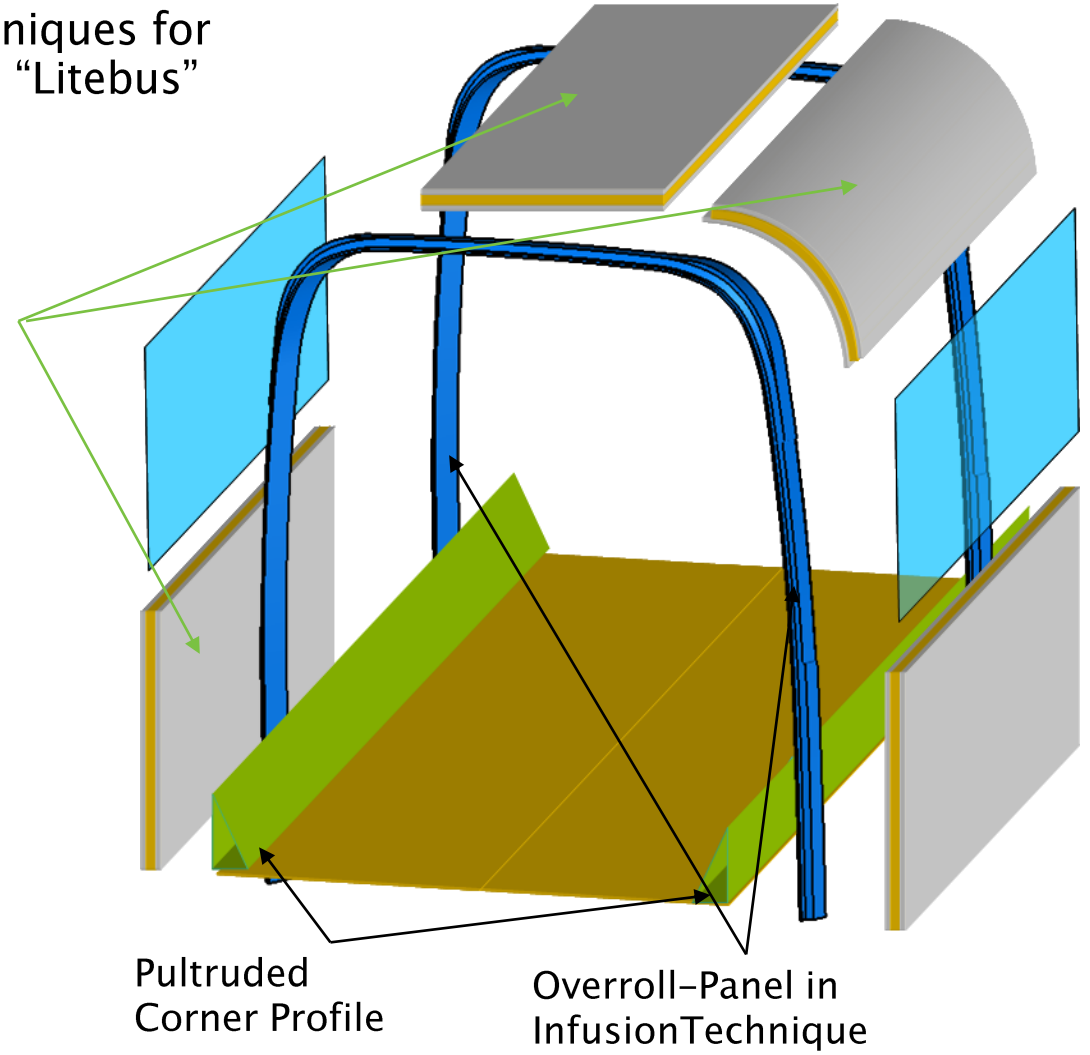






Selected Assembly Concept

With processing techniques for different parts of the “Litebus”

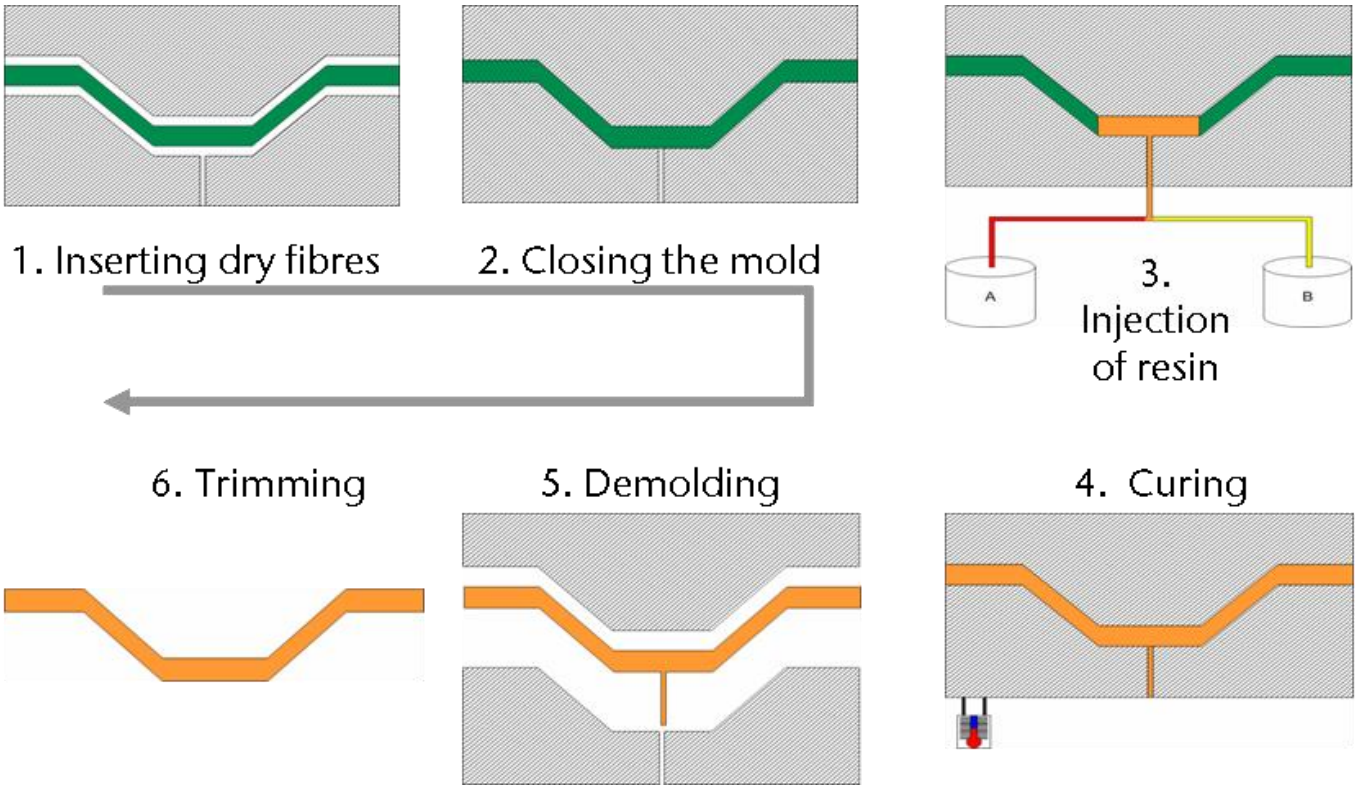


Processing Technique: Infusion Techniques

LCM

- RTM
- VARTM
- VARI
- VAP
- SCRIMP

RTM:



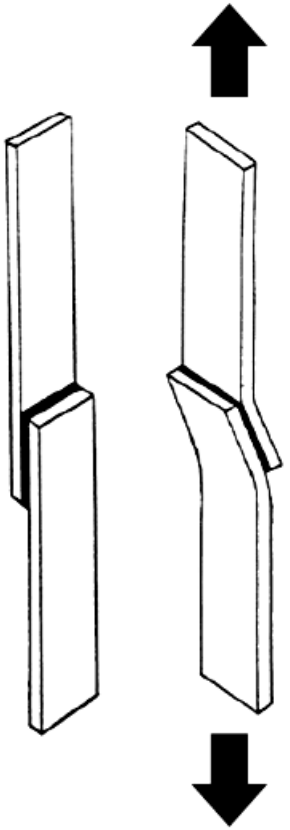
Adhesive Bonding Experiment

AV118

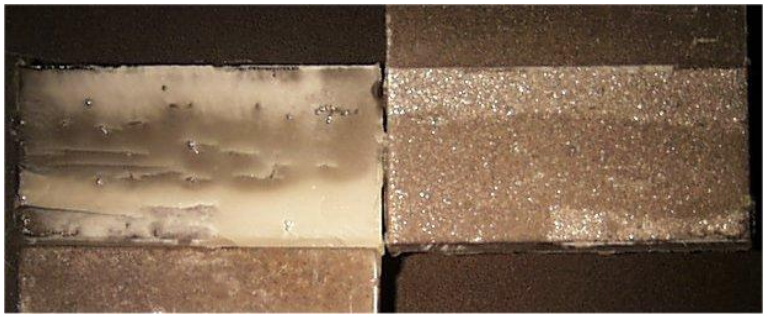
- High strength steel
- 12.5mm overlap
- Adherend thickness 2mm
- Adhesive thickness 0.2 and 0.5mm

Sikaflex 552

- Mild steel
- 25mm overlap
- Adherend thickness 2mm
- Adhesive thickness 0.2

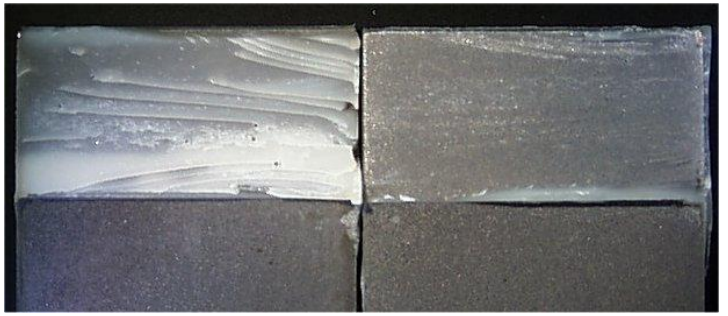


Experiments
Failure Mode – AV118

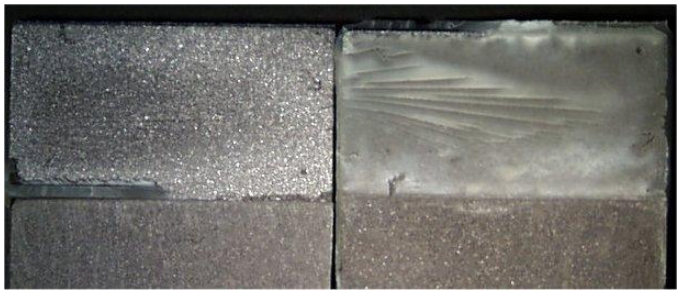


a) RT–mixed mode failure

b1) –40°C–mixed mode failure



b2) –40°C– cohesive failure



c) 80°C – adhesive failure

Engineering CAE

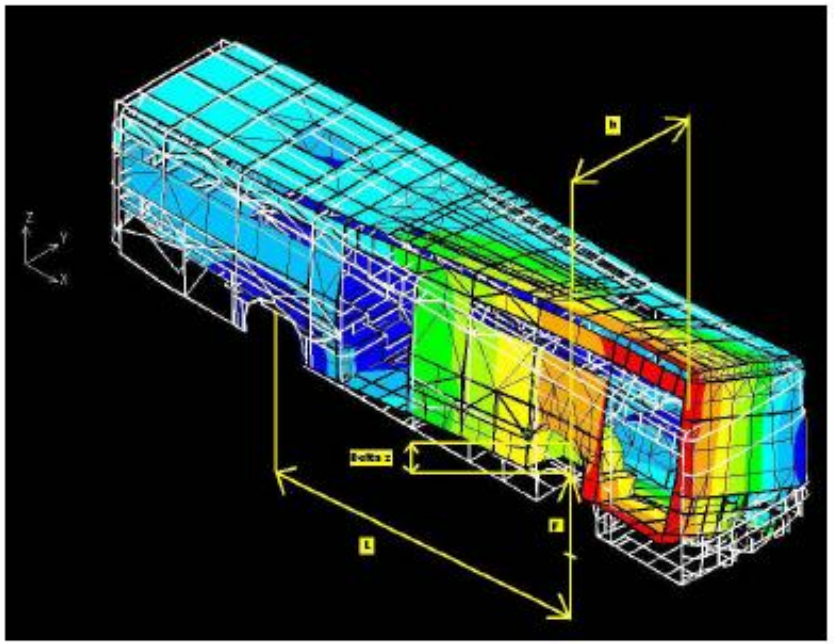


Fig. 1: Bus model torsional deformation test

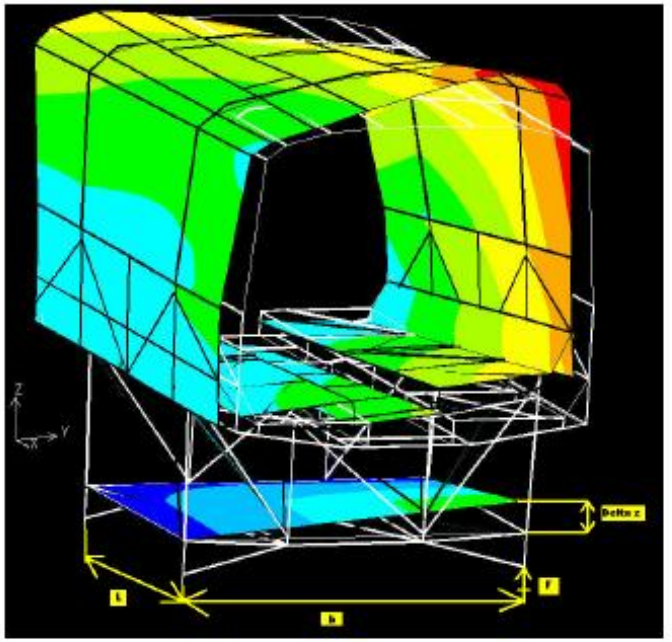
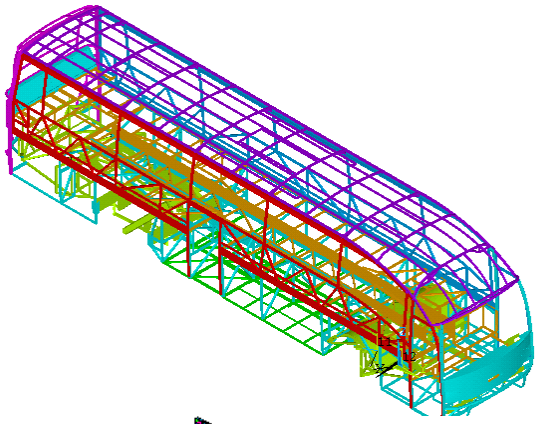
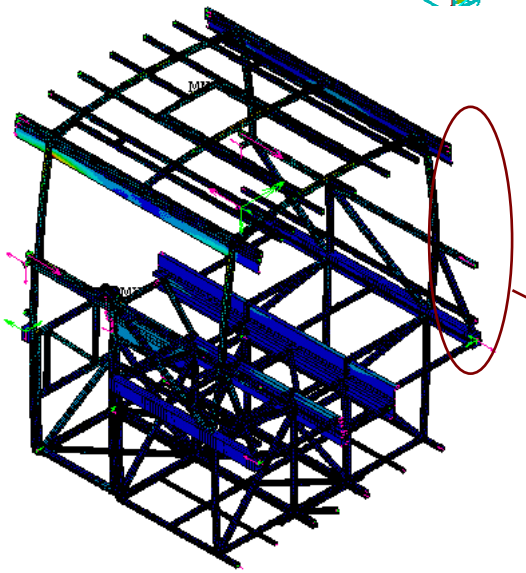
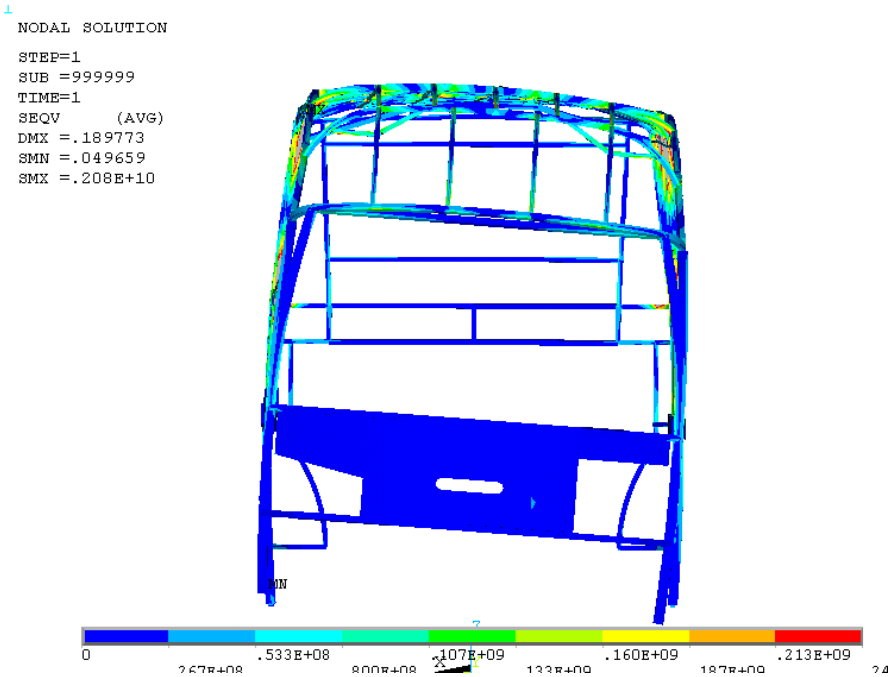


Fig. 3: Coach Cell model torsional deformation test

First model, worst case (with SUNSUNDEGUI)

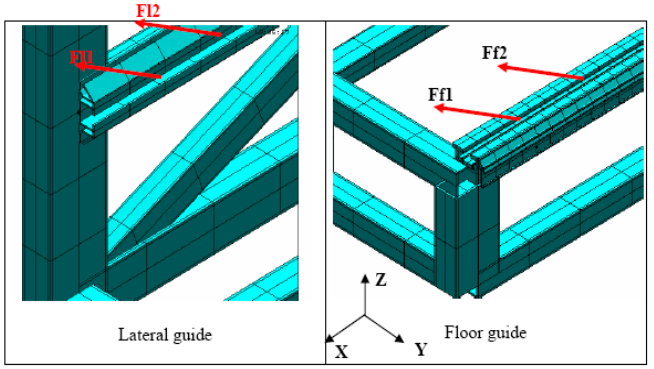




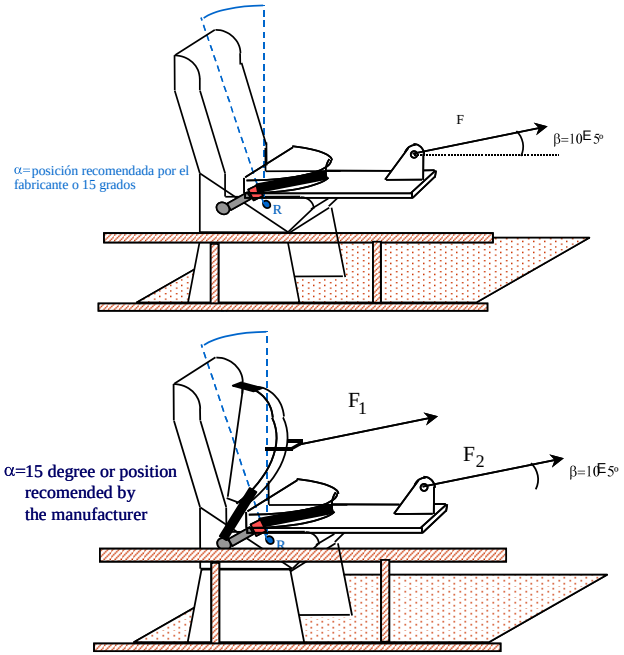


We can obtain the efforts in a section in normal conditions

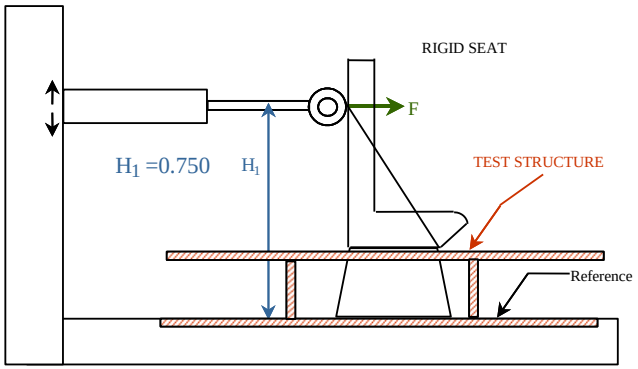
Efforts on rail and guide of seat's anchorage



(N)	FZ	FY	FX
Fl1 –front screw lateral-	-5750	-1900	6275
Fl2 –rear screw lateral-	14800	2850	300
Ff1 –front screw floor-	-22000	195	5000
Ff2 –rear screw floor-	26350	-390	4440



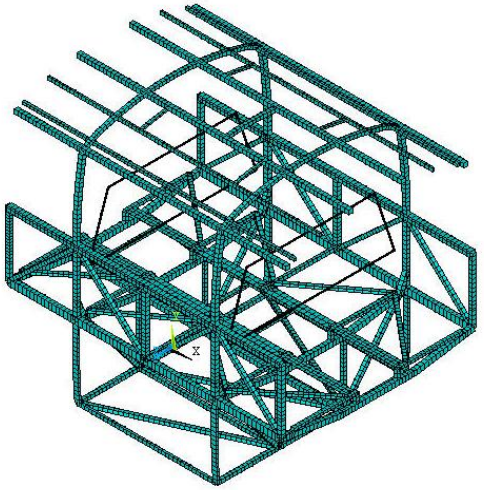
RESTRAINT SYSTEMS:
SEATS, ANCHORAGES AND SAFETY BELTS



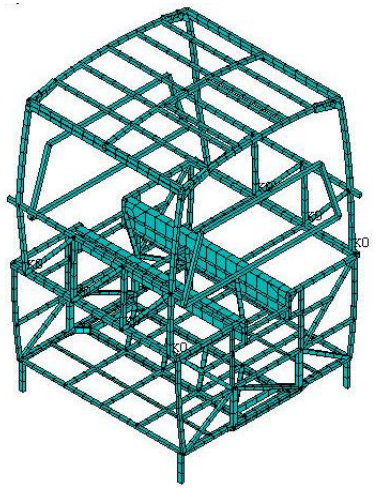
Static for the anchorages of seats

Benchmark FEM Analysis

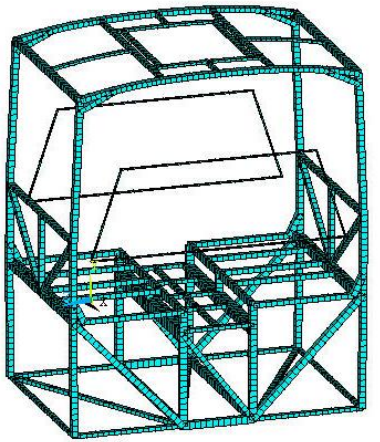
FEM analysis of sections with the initial dimensions (only one window)



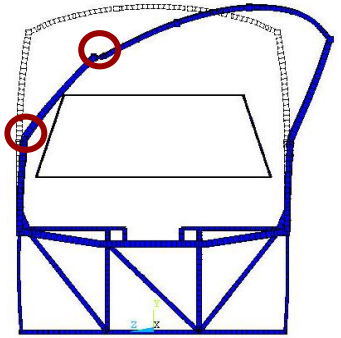
CAETANO BUS

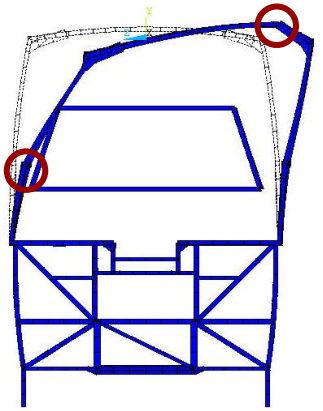


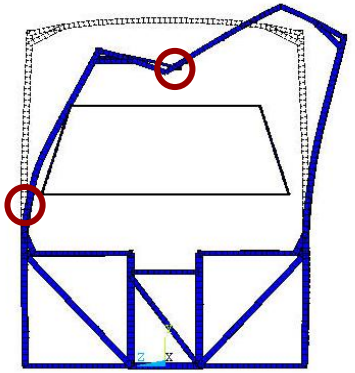
SUNSUNDEGUI



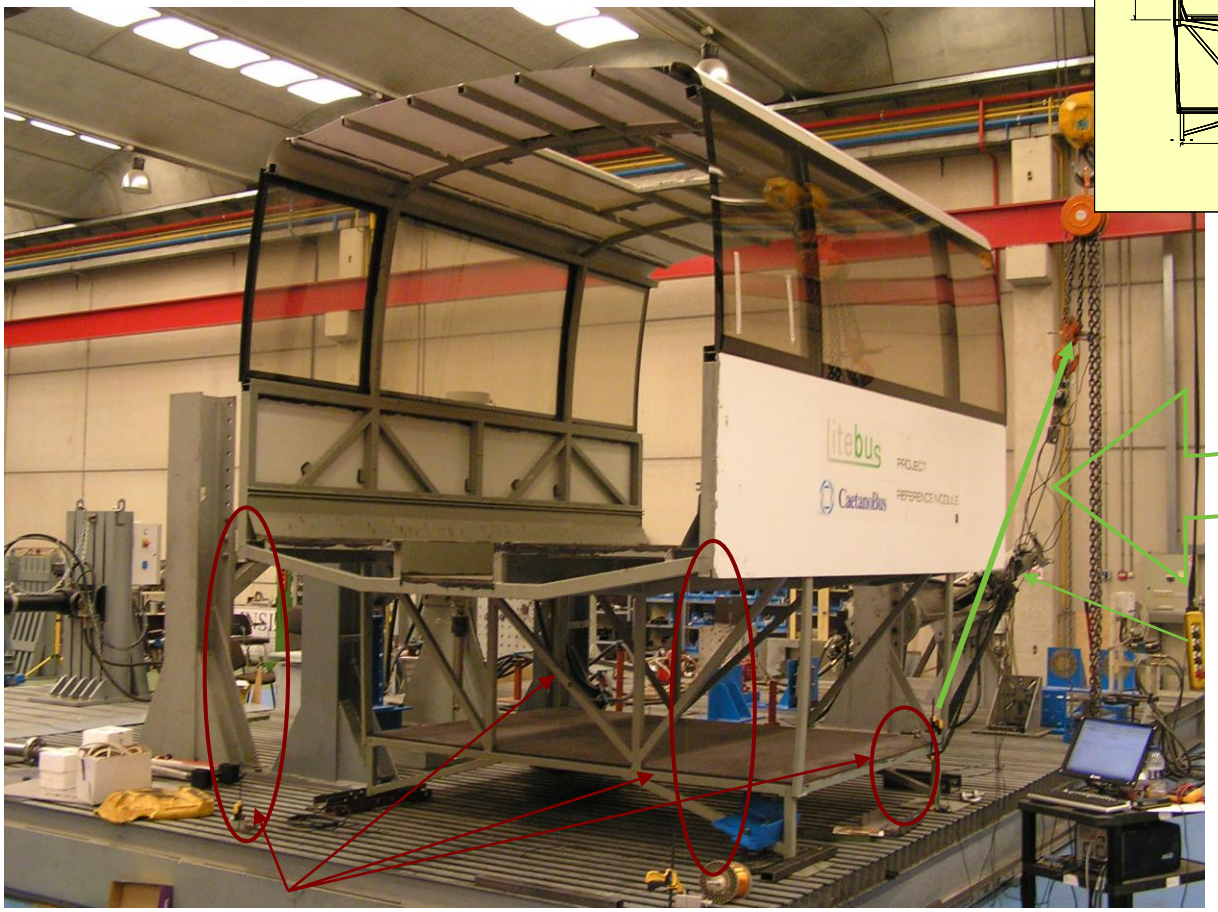
MAURI

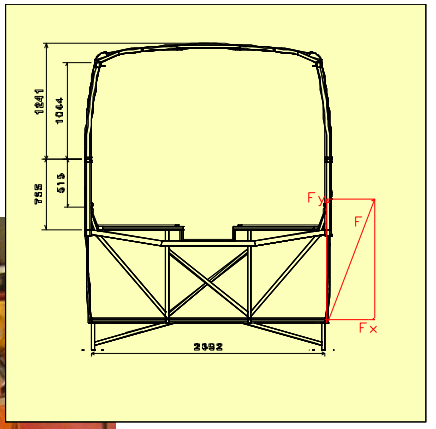






Tests on CAETANO's section





Inclinometer

Load Cell

Threat sensor

Rollover Test – Current Structure

CRASHWORTHINESS Studies

WP2. – FEM first models for collapse properties under rollover

EXTERIOR:

Pultrution whit Carbon/Epoxi

SHELL 99

Two Layer

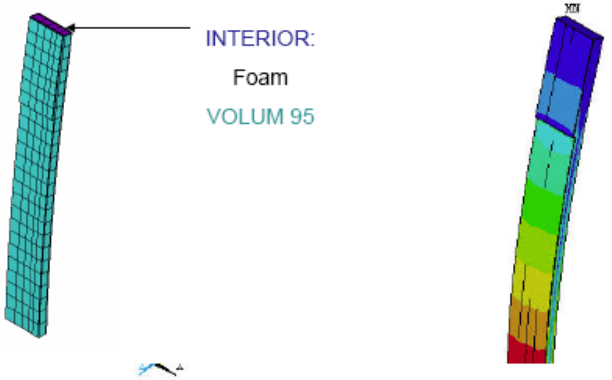
Matrix:
YOUNG=4.e+3 POISS=0.35
Glass fibre

YOUNG=86.e+3 POISS=0.22
EYY=86.e+3 EZZ=86.e+3 /

INTERIOR:

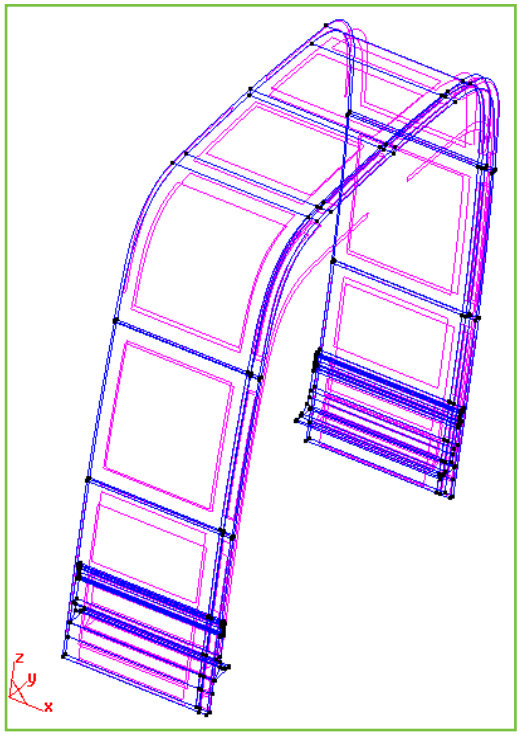
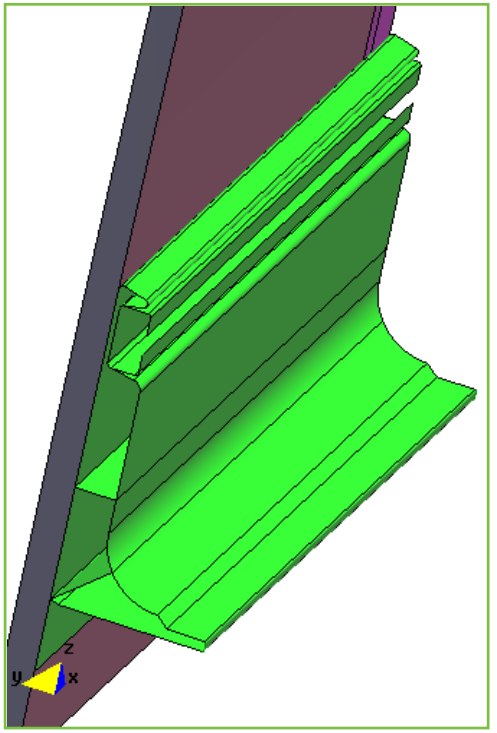
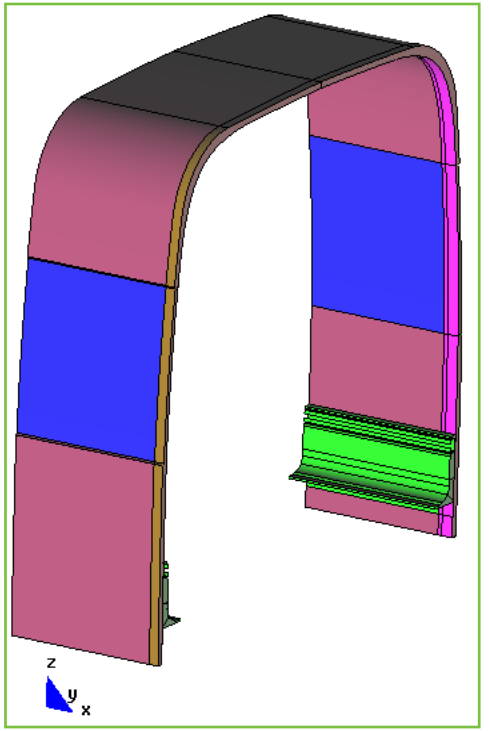
Foam

VOLUM 95

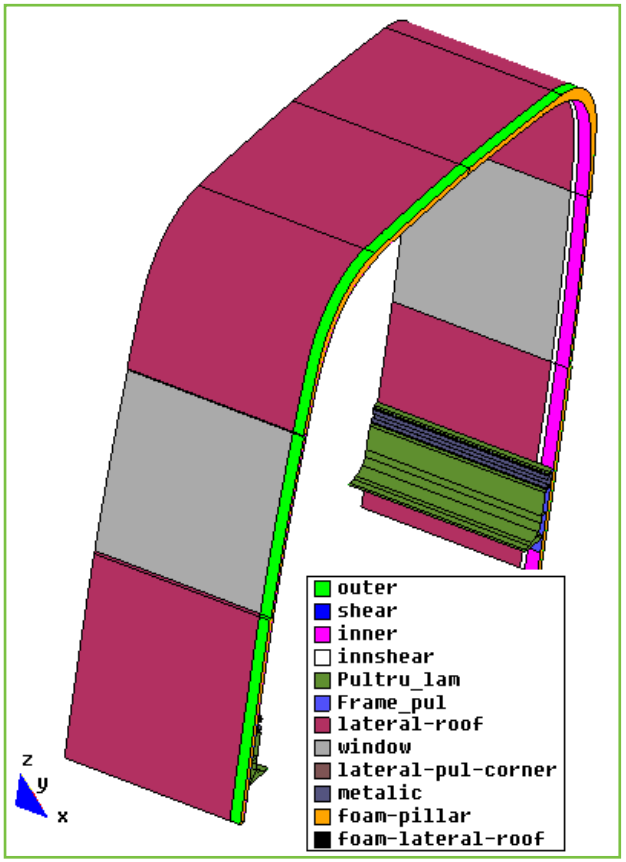


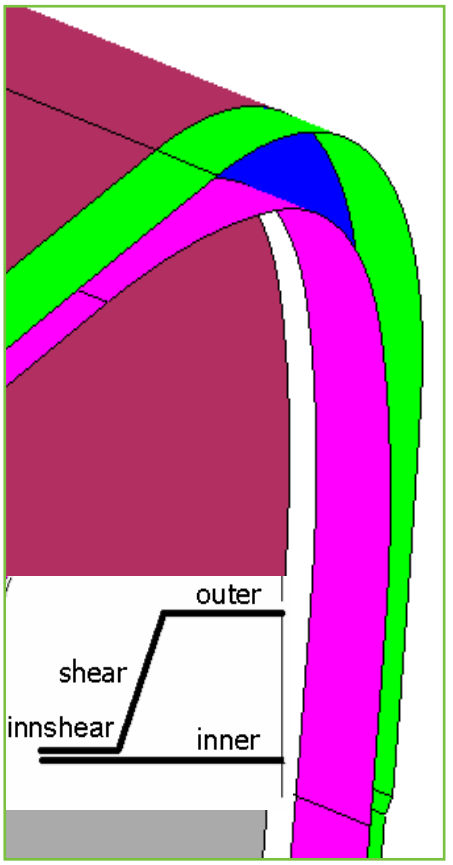
New geometry for analysis including :

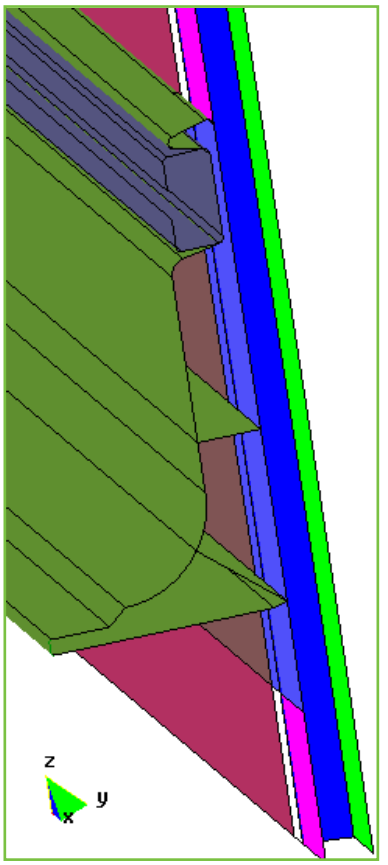
- New low-corner pultrusion profile
- Lateral and roof panels
- Lateral metallic rail
- Windows
- Foams (rough approx.)

Materials

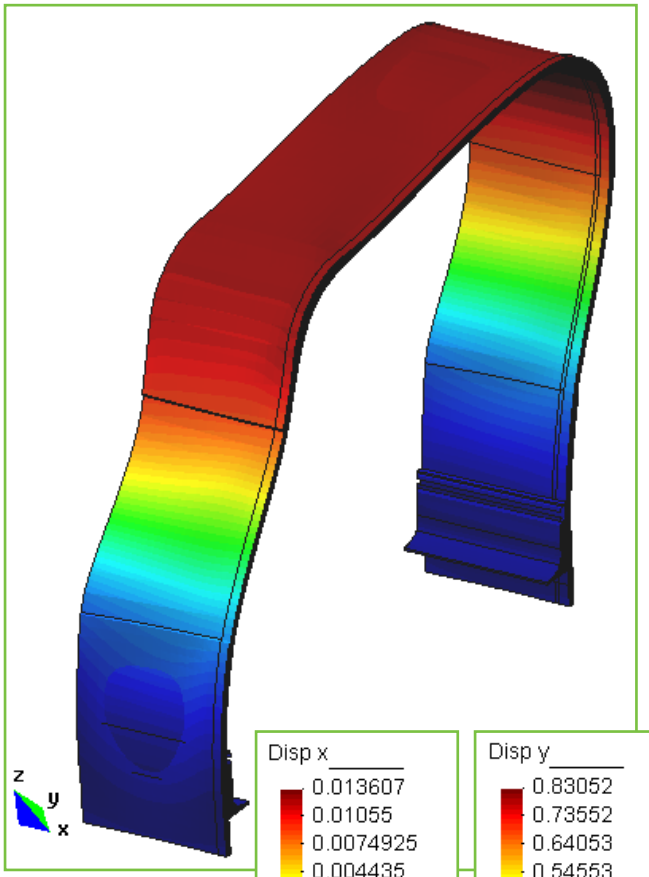


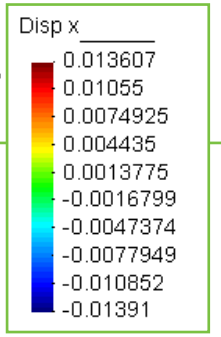


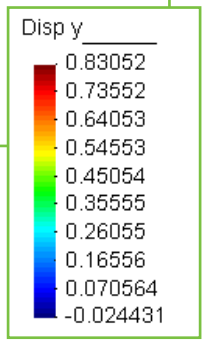


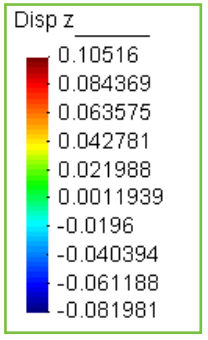
inner [80%_0°, 20%_ 45°]
shear [80%_ 45, 20%_0°] ; outer = shear
Innshear = inner + shear (10.mm)

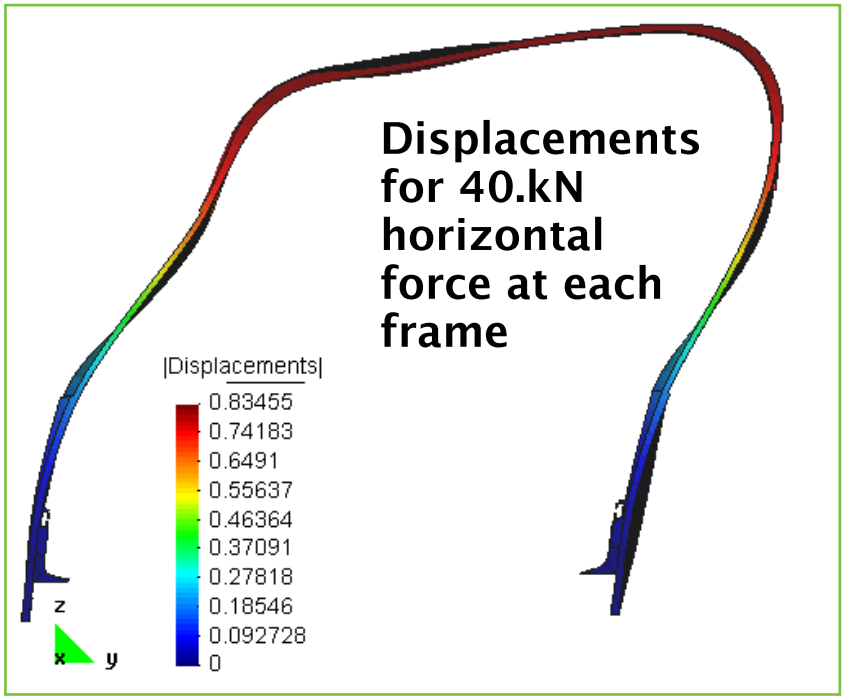
Analysis results







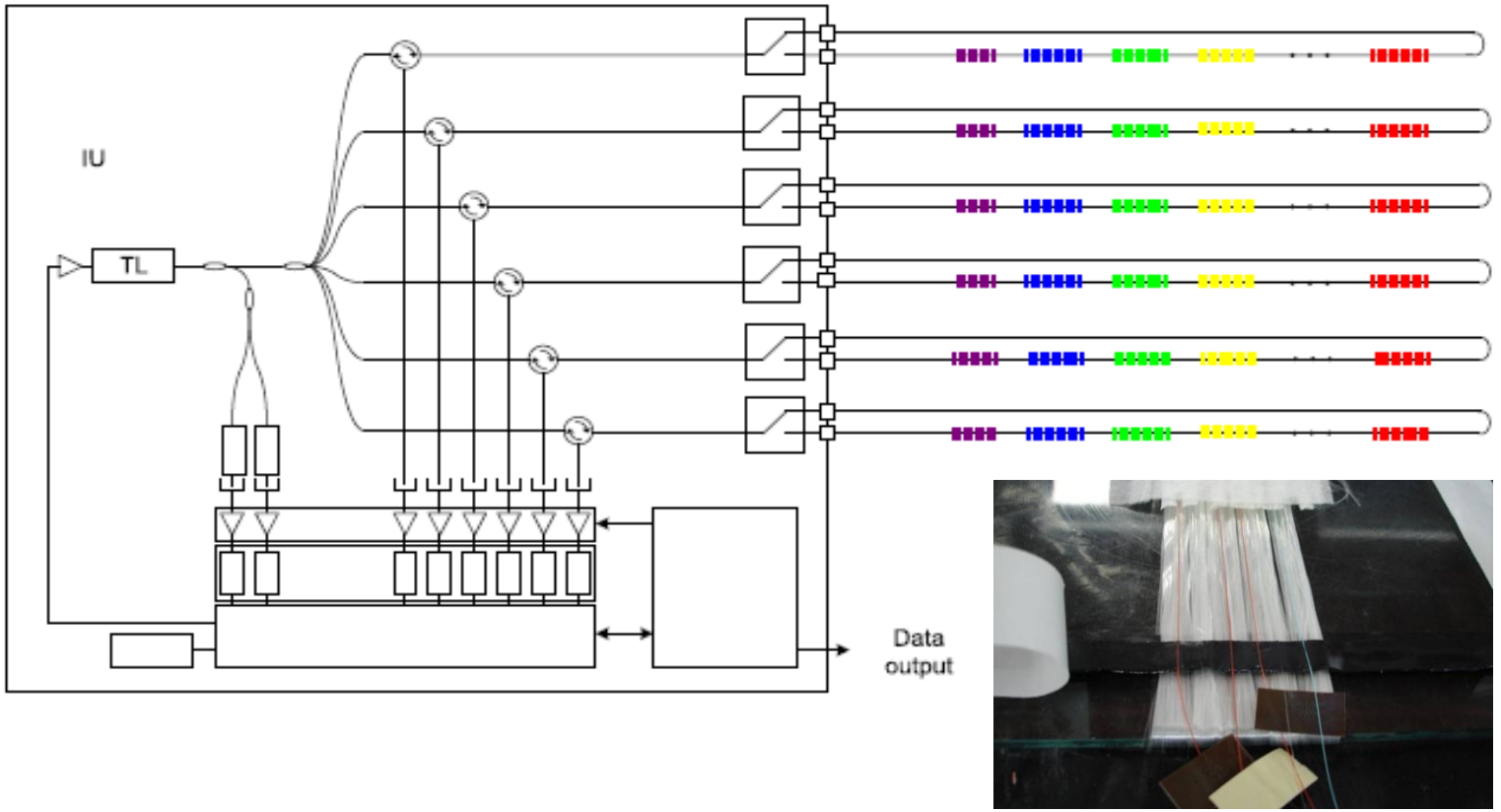




Material parameters (mechanical characterisation) must be updated according to experimental tests

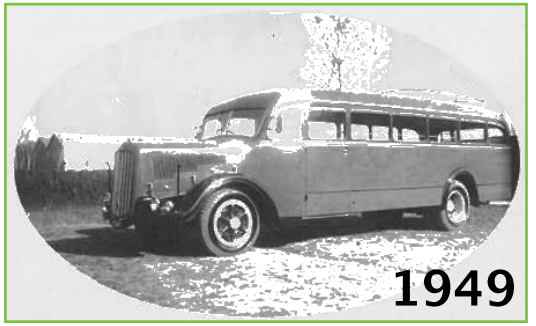
updated glass-fibre and matrix mechanical properties

Health Monitoring – Fiber Optic



Nervous system architecture providing 30 sensors on each fibre and fibre failure

Evolution



litebus

The future

litebus

end

thank you