production group

VERY HIGH-SPEED TRAINS
SIDE SKIRTS
COMPOSITE BUILD

JEC FORUM ITALY 2025
Business Meetings & Conferences
June 11-12, 2025 | CERNOBBIO, LAKE COMO ITALIA

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ASSOCOMPOSITI
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Very High-Speed Trains Side Skirts - **Composite Build**

Foreword

When it comes down to the design and construction of trains' underframe, especially for Very High-Speed Train (VHST), rarely do the designers choose to use composite materials. In the last decade, the Technical Specifications issued by train builders for said components convey the choice towards metals, such as aluminum alloy.

When questioned on this topic, engineers explain that the orientation is based upon the application of service proven solutions and upon the satisfaction of required recyclability levels.

Whilst carrying out maintenance operation on Side Skirts of a VHST fleet, Production has collected returns of experience (REX) and food for thoughts on the real conditions of components after very few years of service. Production has eventually finalized them in a complete project: to re-engineer a Side Skirt in composite materials, from Technical Specification to the construction of a prototype.

In this presentation, we'll see the results of this work.

Let us firstly, and briefly, introduce Production Group.

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Introducing Production Group

Production Group is an Italian company founded in 1989.

Its five plants are located in Southern Italy, close to Caserta.

Production Group holds an IRIS Certification, and it is leader in the design, development, manufacturing, maintenance of train sub-systems for very high-speed, high speed, regional trains and mass-transit rolling stock.

Production Group employs 500 people.

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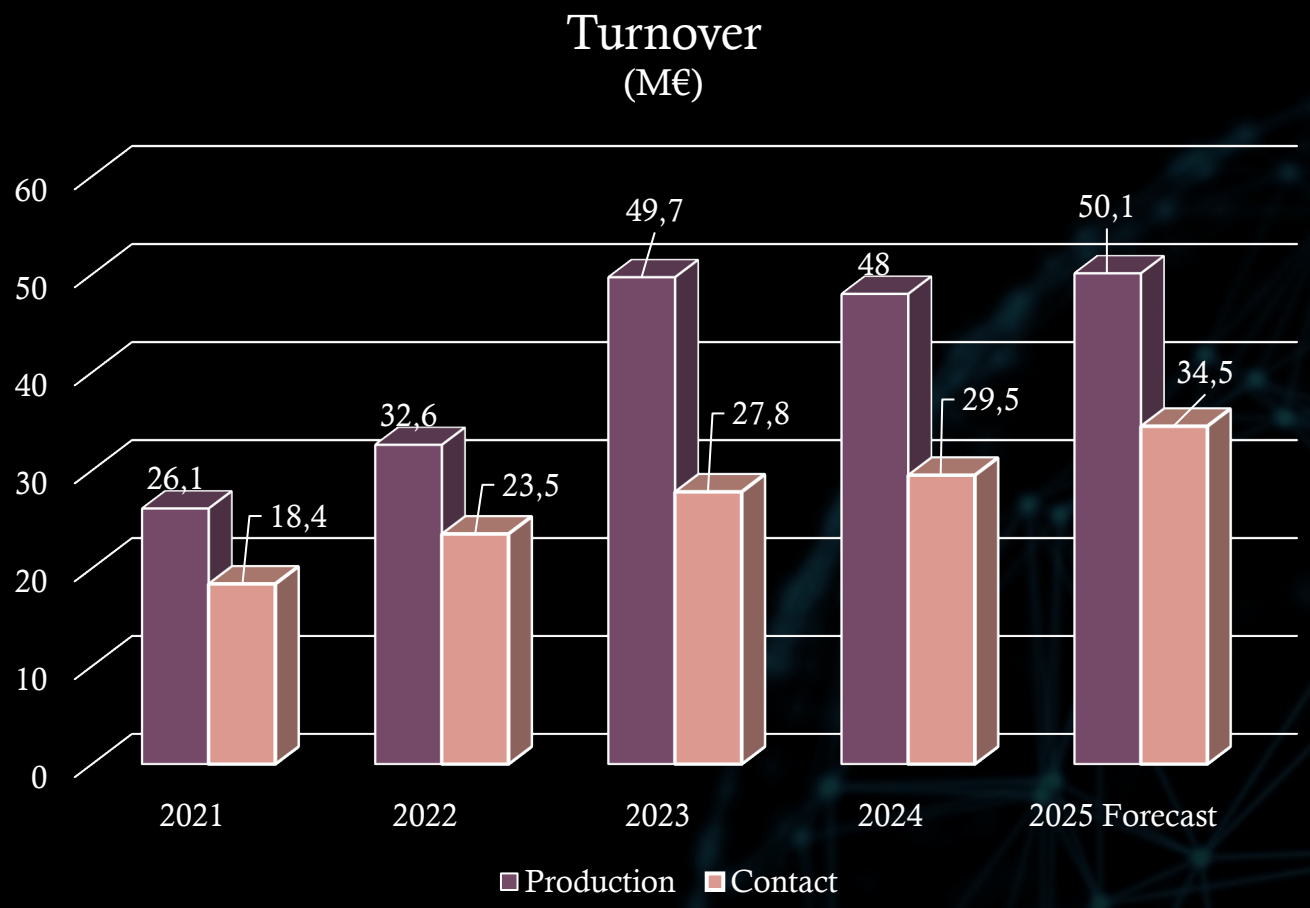
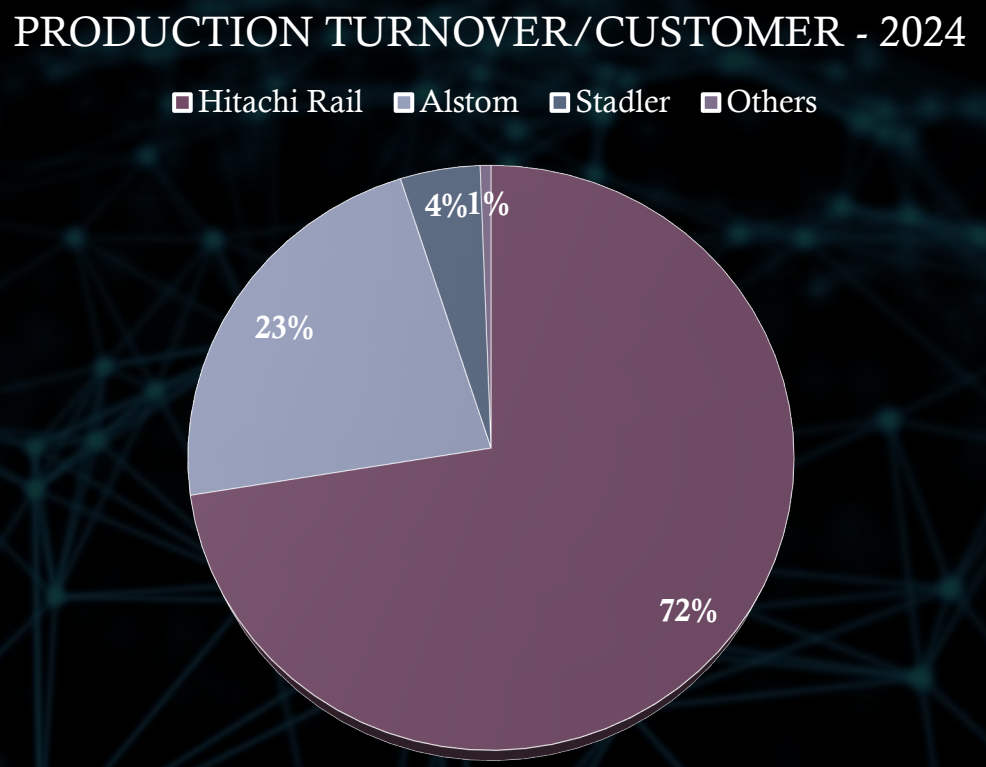
Introducing Production Group: Turnover and Main Customers





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Introducing Production Group: Product Range and Process Capability

Product Range

Design, development, testing, manufacturing, installation and maintenance of the following train sub-systems:

- Front Ends (Fully Equipped, Plug in)
- External Parts (Roof Cover, End Walls, Bogie Skirt)
- Toilets
- Interior Lining
- Driver Desk

Process Capability

- Composite Lamination (HLU, VIP, LRTM, RTM)
- Bonding (EN 17460)
- Painting
- Thermoforming
- Laser Cutting
- Metal Sheet Bending
- Machining (5-Axis)
- Welding and FPI/Visual Inspection (EN 15085)
- Tapping Test
- 3D Dimensional Inspection Laser Scanning

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Introducing Production Group: Product Range

Toilet - ETR 1000 Executive

TGV 2020 – Stair Lining

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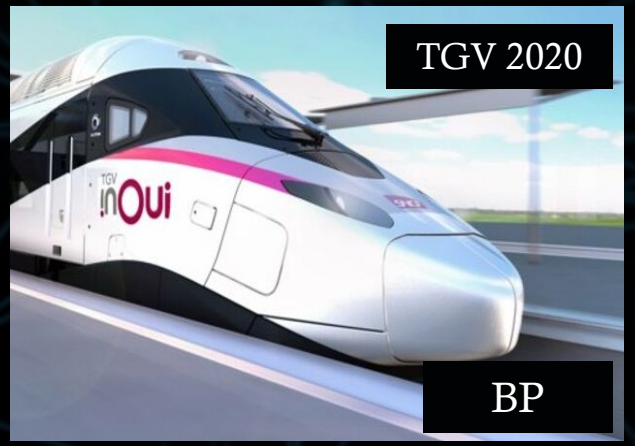
Introducing Production Group: Front End



Legend – BS: Build to Spec; EQ: Equipped; BP: Build to Print

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Introducing Production Group: Front End

Validation Test: Shock and Vibration test (EN 61373) on VHST Bogie Skirt, Half Skirt and Spoiler.

Non destructive test: Tapping test with Electronic Digital Tap Hammer for voids , degradation and delamination in composite structures

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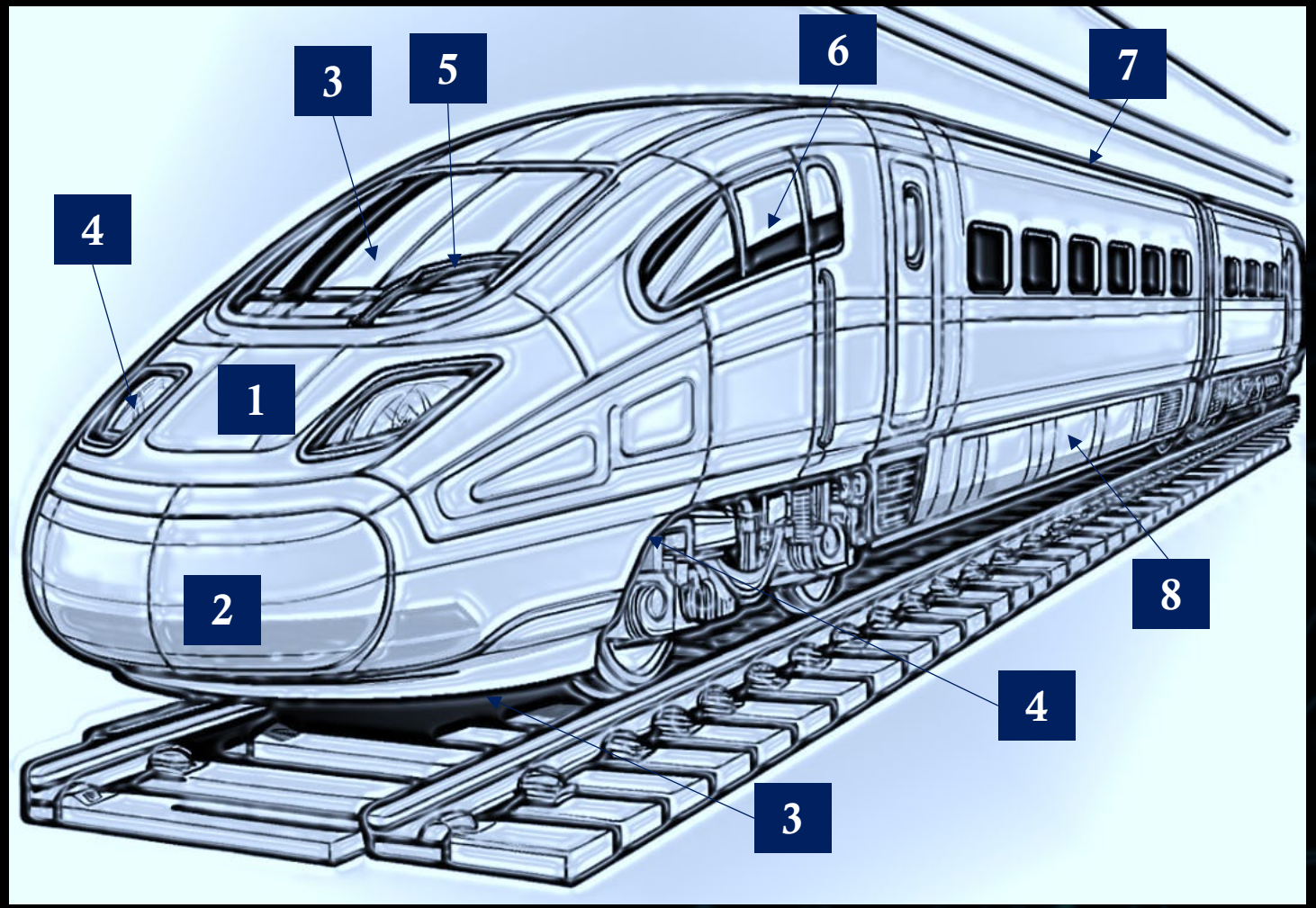

Equipped Front End

Front End

External Parts

1) Front Ring (*)
2) Coupler Front Hatches (*)
3) Lower Fairing (*)
4) Bogie Skirts (*)
5) Windscreen
6) External Lights
7) Wiper
8) Side Windows
9) Roof Cover (*)
10) Side Skirts

(*) – Parts built in composite

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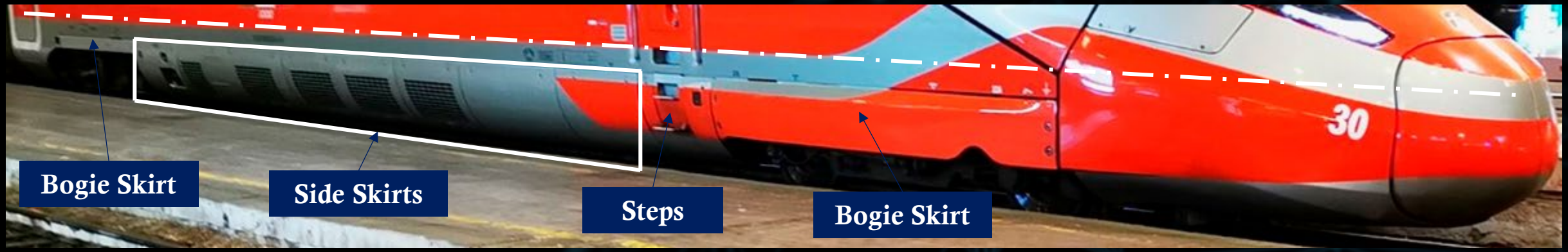
External Parts: Side Skirts

The Side Skirts close the visible open areas of the underfloor of the coach, optimizing the aerodynamic flow, reducing noise, and providing the underfloor equipment protection against impact (ballast) and dirt.



Whilst Bogie Skirts are usually built in composite material, as a natural extension of the Front End with 3D shapes that would require more expensive tooling if built in metal, the Side Skirts are generally built in metal. Especially for Very High-Speed Train (VHST), rarely do the designers choose to use composite materials. In the last decade, the Technical Specifications issued by train builders for said components convey the choice towards metals, such as aluminum alloy.

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External Parts: Side Skirts

Number 1 requirement in car builder technical specifications covering the design and construction of Side Skirts for VHST is the use of metal. Below two abstracts of specifications for Side Skirts of a VHST, general requirements and concept:

General requirements

The skirt assembly shall fulfill the following criteria:

- *The skirts shall be designed as a sheet metal construction.*
- *[…]*

Lateral Skirt Concept

The preliminary concept consists of a skin in painted aluminum made of shaped sheets and extruded profiles.

[…]

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The Project: Where Anything Started

Production is performing the maintenance of the Side Skirts of a fleet of VHST.

The activity includes the inspection of the conditions of paint finishing, presence of corrosion, conditions of equipments, etc.

Production has investigated into corrosion phenomena on Side Skirts evaluating them in accordance with ISO4628-3 (*Paints and varnishes — Evaluation of degradation of coatings […] - Assessment of degree of rusting*) and determining the Degree of Rusting (Ri). Observed Ri's ranged between R2 and R4, meaning a degradation between 0.5% and 8% of the component's surface.

In addition to that, a reduction of thickness in oxidized surfaces of 0.75 mm, that is, a relative reduction of the thickness of 50%, was obserbed.

Side Skirts close to Waste Water Tanks showed cases of a relative reduction of the thickness up to 100%.

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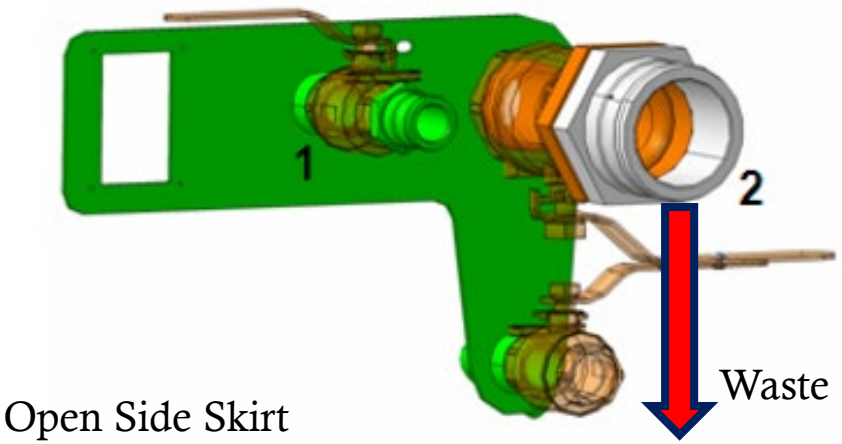
Side Skirts: Few Words About Trains' Servicing



Open Side Skirt

At the end of every mission, Waste Water Tanks are emptied. Suction pipe is connected to nozzle no. 2, in the picture on the left.

Once the Waste Water Tank is emptied and the pipe is removed, residual waste may fall on the open, almost horizontal Side Skirt, from the pipe.

In addition, the geometry of the Side Skirt promotes the accumulation of the waste, once the skirt is closed.

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Why aren't they built in composite materials?

«Why aren't they built in composite materials» was the questions at Production, during the analysis of the data collected from field.

Production decided to launch the Project: to re-engineer a Side Skirt, adjacent to the Waste Water Tanks, in composite materials, despite the «service proven» metal solution that (still) leads the market.

The objectives of the Project were the following:

a) To meet applicable requirements of the currently applied technical specification (except the ones specific to the material to be used).

b) The Side Skirt had to be completely interchangeable with an original built in aluminum currently used on rolling stock.

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Development Process

Phase 1

Analysis of Applicable Requirements

Emission of Technical Specifications

Preliminary Design

Phase 2

Testing & Validation (including Mechanical Characterization of Composite Materials and Ballast Projection Impact)

Detailed Design

Phase 3

Prototype Construction

End of Life and Recyclability

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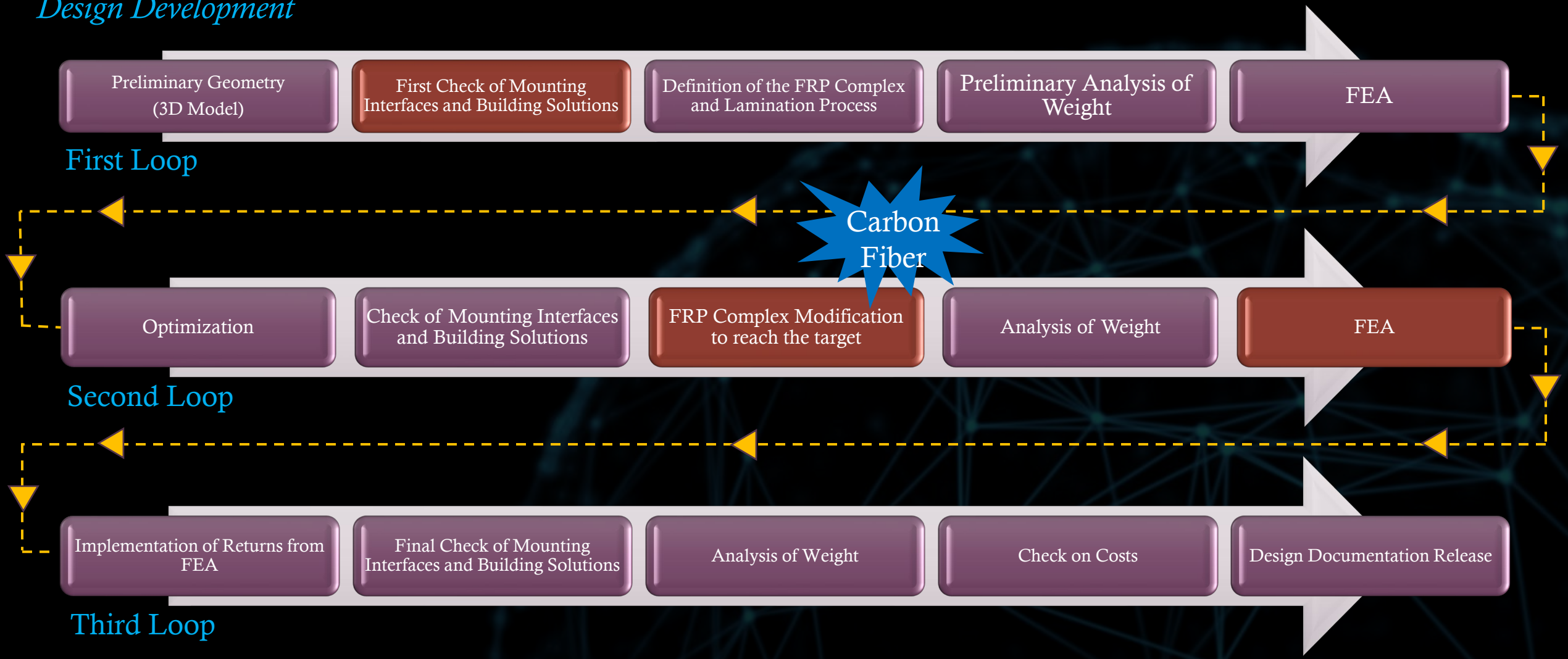
Design Development



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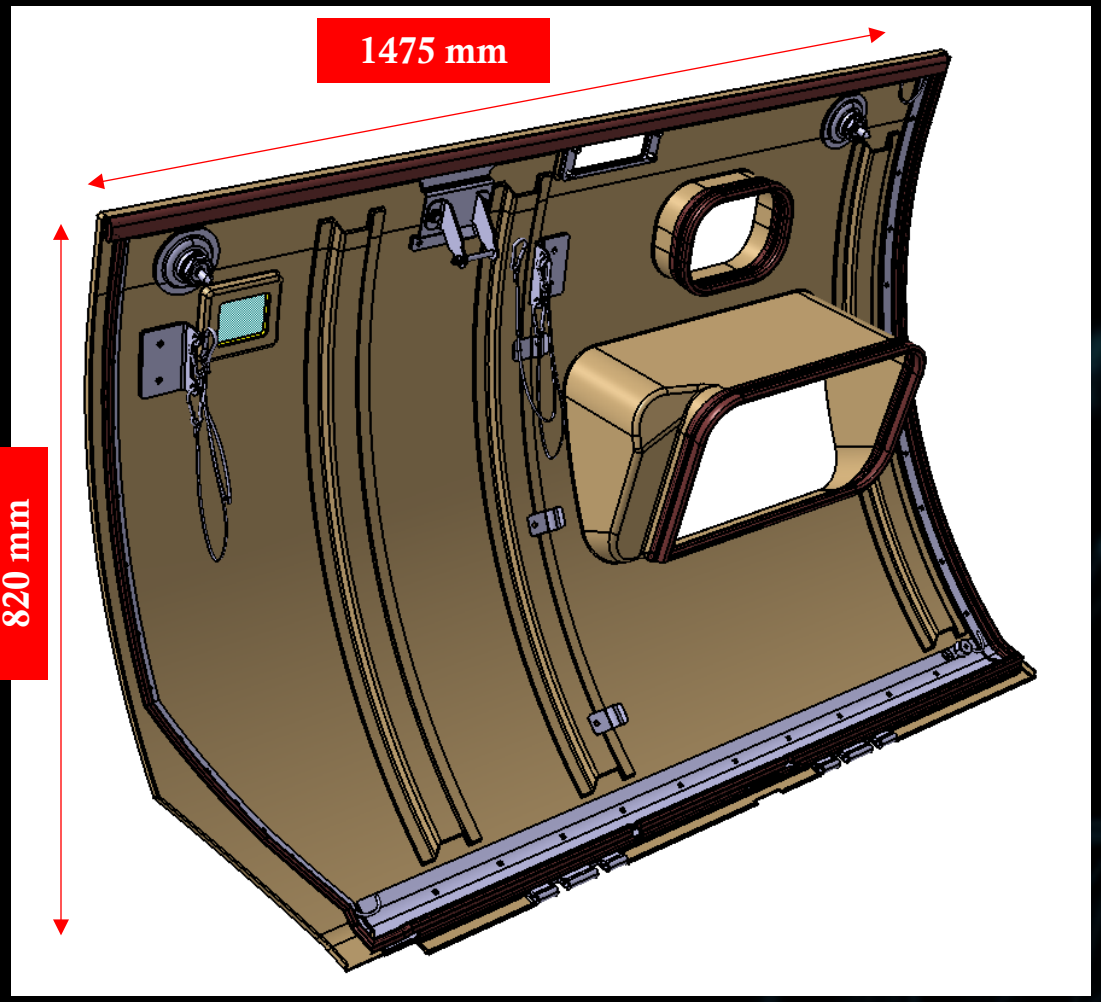
First Check of Mounting Interfaces and Building Solutions



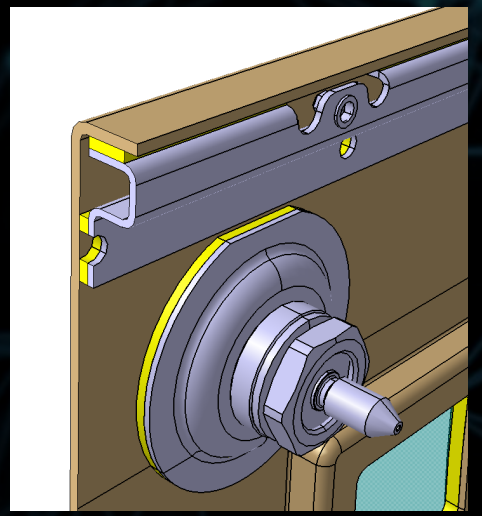
Main Concepts

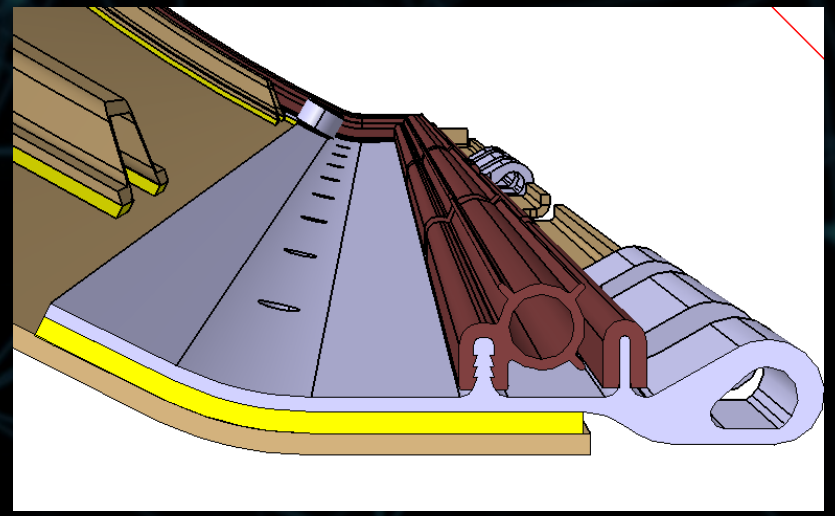
A. All articulation parts should maintain the same axis of rotation (taking into account the difference of thickness of the skirt).

B. All fixations should be the same.

C. Equipment and accessories have to be the same

D. Every geometry of the composite skirt had to be contained within the envelope of the original skirt.





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Side Skirts: Applicable Requirements

Requirements	Reference	Aluminum	Composite	Checked and Confirmed
Mechanical Interfaces	Technical specification, drawings	Yes	Yes	☺
Weight	Technical specification, drawings	Yes	Yes	☺
Structural Strength and Fatigue (Calculation)	Technical specification EN 12663-1	Yes	Yes	☺
Material characterization	Aluminum: in accordance with standards Composite: NF F 01-281	No	Yes	☺
Crashworthiness	Technical specification (calculation only)	Yes	Yes	☺
Bonding	Technical specification DIN 6701	Yes	Yes	☺
Fire & Smoke	EN 45545-02	Yes	Yes	☺

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Side Skirts: Applicable Requirements

Requirements	Reference	Aluminum	Composite	Notes
Protection from corrosion	Technical Specification Salt Spray ISO 9227	Yes	Yes	☺
Painting	Technical Specification	Yes	Yes	☺

In addition to the tests required by applicable technical specification, Production has carried out a Flying Ballast Impact Simulation in accordance with the principles of French standard *NF F 07-101: 2002 – Essai de choc par simulation de projection de ballast.*

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Mechanical Characterization of the Composite Materials

Requirements	Reference	Notes
Tensile Test: test carried out on each type of supports in all directions.	ISO 527-4	Input data for FEA
Compressive Test: test carried out on each type of supports in all directions.	ISO 14126	Input data for FEA
Shear Test: test carried out on each type of supports in all directions.	ISO 14129	Input data for FEA
ILSS Test: test carried out on each type of supports in all directions.	ISO 14130	Input data for FEA
Flexural properties	ISO 14125	☺ - Compliant to NF 01-281 (External Parts)
Determination of Void Content	NF F 01-281 ISO 7822	☺ - Compliant to NF 01-281 (External Parts)

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The Project: FRP Complex Modification to reach the target

Skirt (Vacuum Infusion Process)

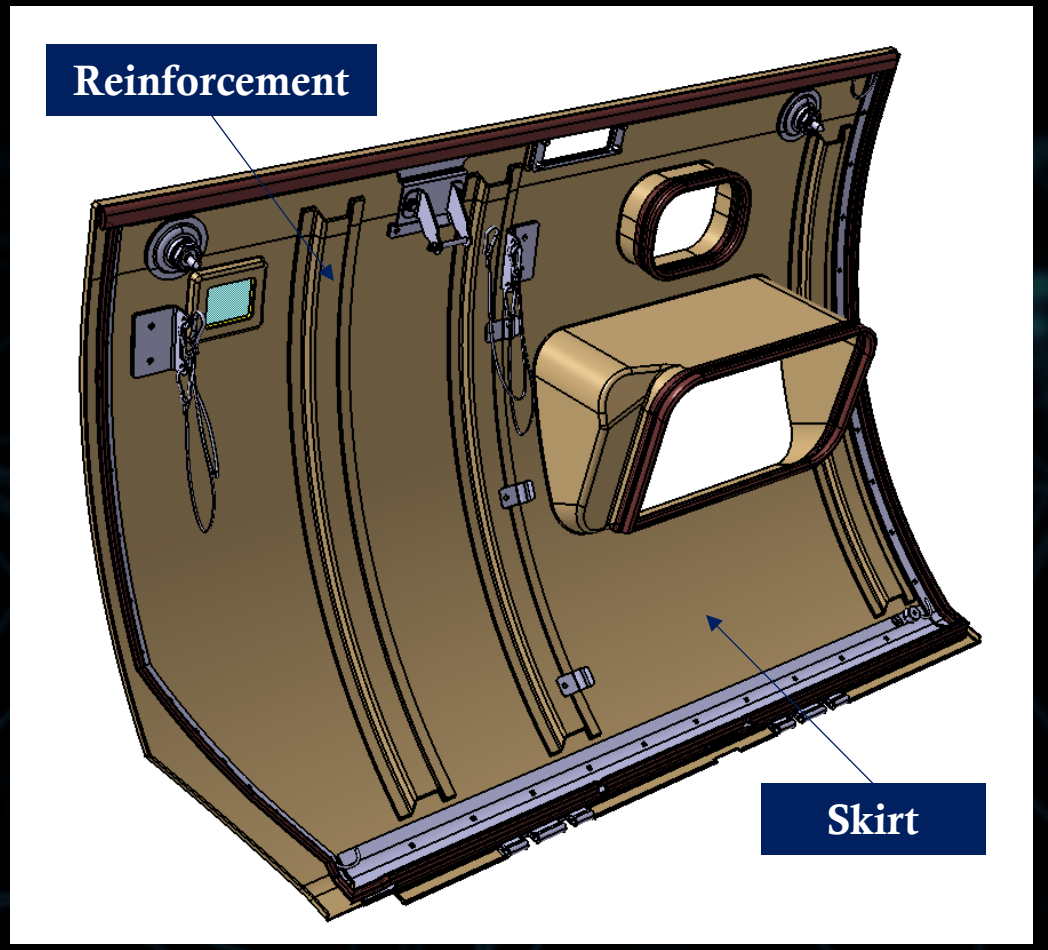
- Intumescent polyester gelcoat
- Biaxial e-glass reinforcement
- Biaxial carbon fiber reinforcement — **2nd loop**
- Biaxial e-glass reinforcement
- Fire retardant vinyl ester resin

3 mm

Reinforcement (Vacuum Infusion Process)

- Intumescent polyester gelcoat
- Biaxial e-glass reinforcement
- Continuous Filament Mat
- Biaxial e-glass reinforcement
- Fire retardant vinyl ester resin

2,3 mm



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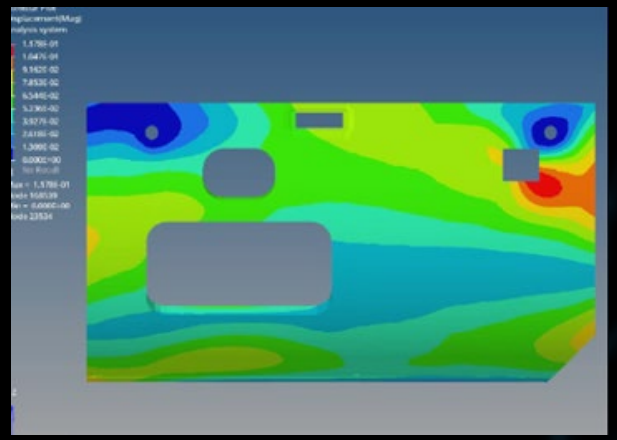
The Project: Manufacturing Sequence

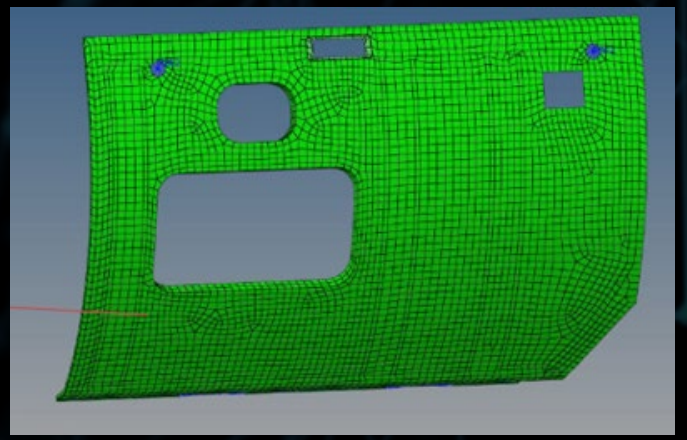
Finite Element Analysys (FEA)

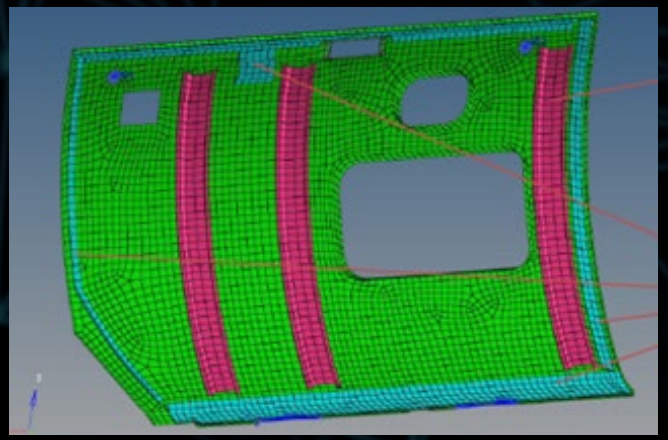
The FRP complex (resin and reinforcements) has defined and confirmed after a series of preliminary FEA checks carried out on the re-engineered composite Side Skirts.

Checks have been carried out in terms of:

- Structural resistance to static loads of components and their fixations;
- Structural resistance to aerodynamic loads;
- Structural resistance of components and their fixation to fatigue loads;
- The verification of eigenfrequencies in the frequency range (0 – 40) Hz.







Very High-Speed Trains Side Skirts - **Composite Build**

The Project: Manufacturing Sequence

- Lamination of Skirt (VIP)
- Post cure

- Lamination of Reinforcements
- Post cure
- Trimming

- Pre-Assembly (bonding and over lamination of reinforcements and metal inserts (in the mold)
- Demolding
- Trimming
- Preparation for painting
- Painting
- Final Assembly and Inspection

Very High-Speed Trains Side Skirts - **Composite Build**

The Prototype

Very High-Speed Trains Side Skirts - **Composite Build**

Flying Ballast Impact Simulation Test

Flying Ballast Impact Simulation: Degree of Protection

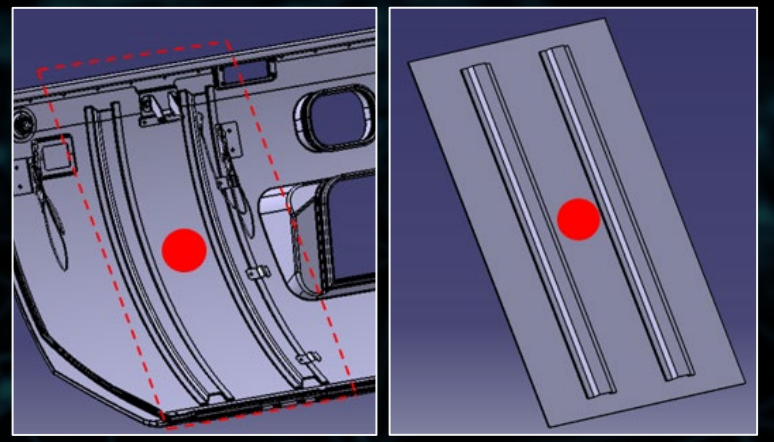
The purpose of the test is to verify that the degree of protection against ballast projections on Side Skirts made in composite is equal (or higher) to that guaranteed by Side Skirts made of aluminum.

The test, carried out in accordance with the principles of standard NF F 07-101: 2002 – *Essai de choc par simulation de projection de ballast*, is comparative and it is finalized to evaluate the effect of impacts from projectiles on specimens (dimensions: 1000 x 700 mm) made of:

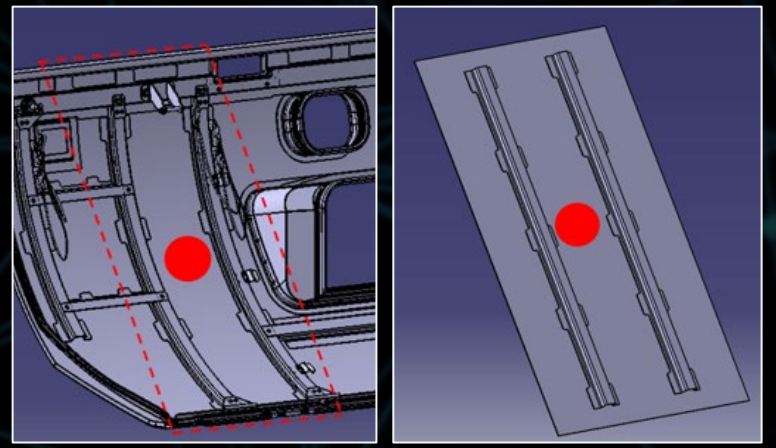
- Aluminum alloy AW5754 H111, representative of the solution currently in use on rolling stock.
- Composite, representative of the "composite build" solution.

The test is performed with the pneumatic launcher, available in Production.

Composite Specimen



Aluminum Specimen



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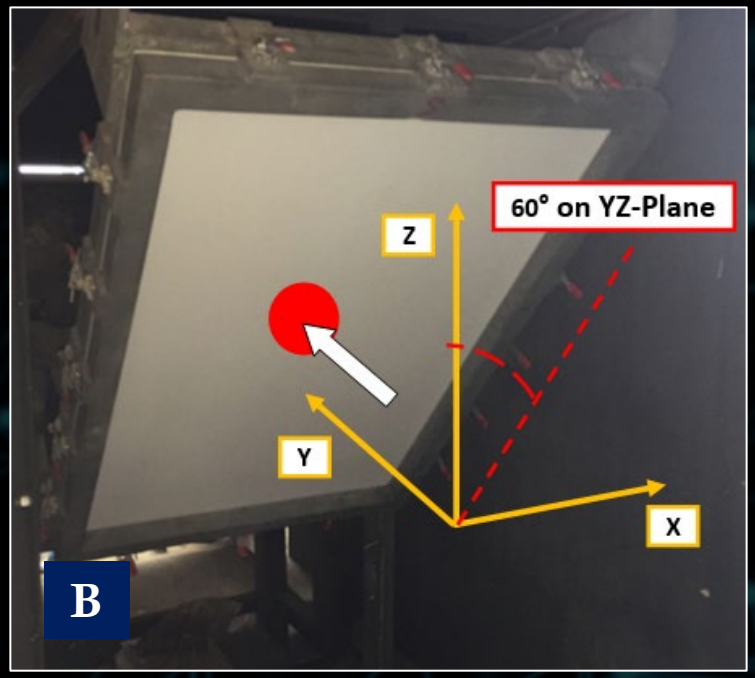
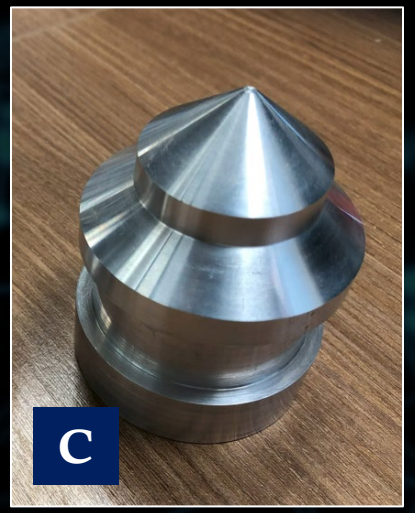
Flying Ballast Impact Simulation Test





A – Pneumatic Launcher in Production
B – Composite Specimen mounted in the impact chamber
C – Aluminum Projectile

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Flying Ballast Impact Simulation Test

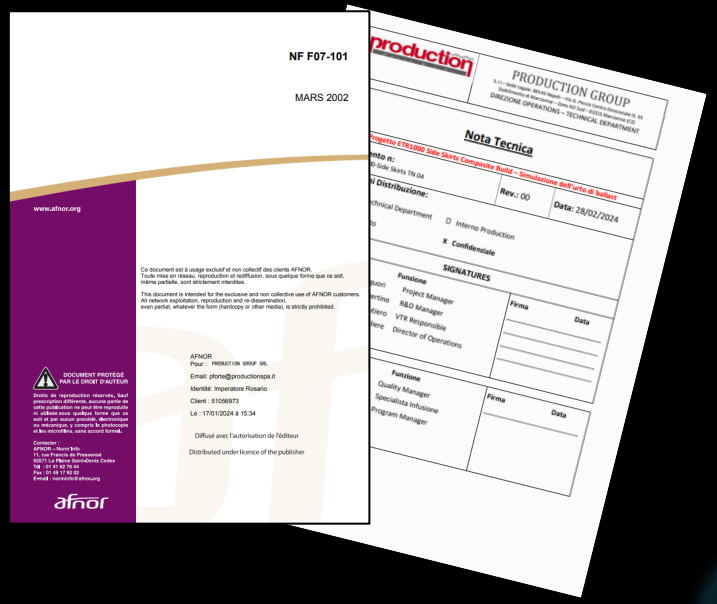
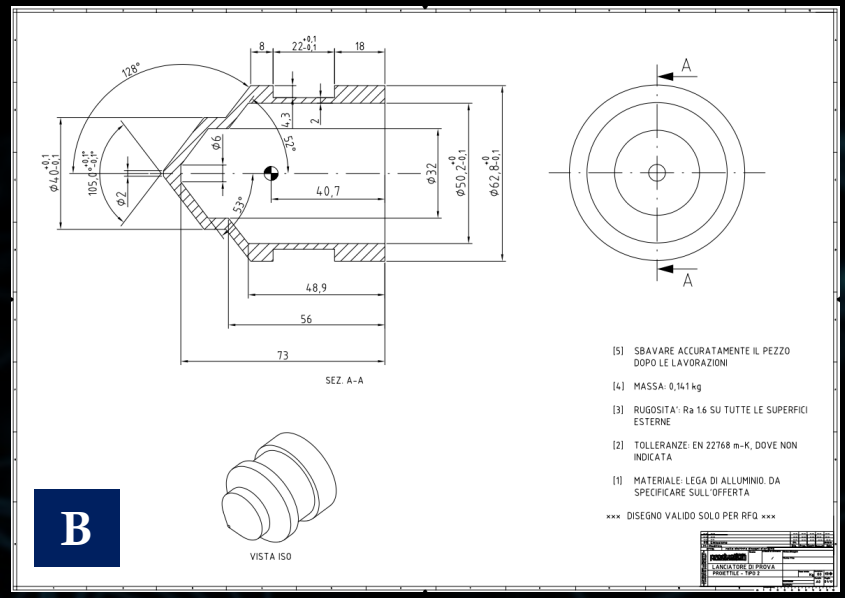


Tableau A.1

Classe	Niveau d'énergie (J)
K1	12
K2	15
K3	25
K4	35
K5	60
K6	95
K7	115
K8	170
K9	210
K10	240
K11	285

A



B

- NF F 07-101:2002 identifies 11 levels of energy, from K1 (12J) through K11 (285J) – Figure A.
- First launches made with prescribed projectiles (Ø 32 mm), with a Sabot to adapt it to the barrel diameter (Ø 68 mm).
- Due to the behavior of the Sabot, it was not possible to command the wanted speed. The projectile has been adapted to the diameter of the barrel of the Launcher (68 mm) – Figure B.
- Established Acceptance Criteria: Lack of penetration and reparaibility of the impact consequences.

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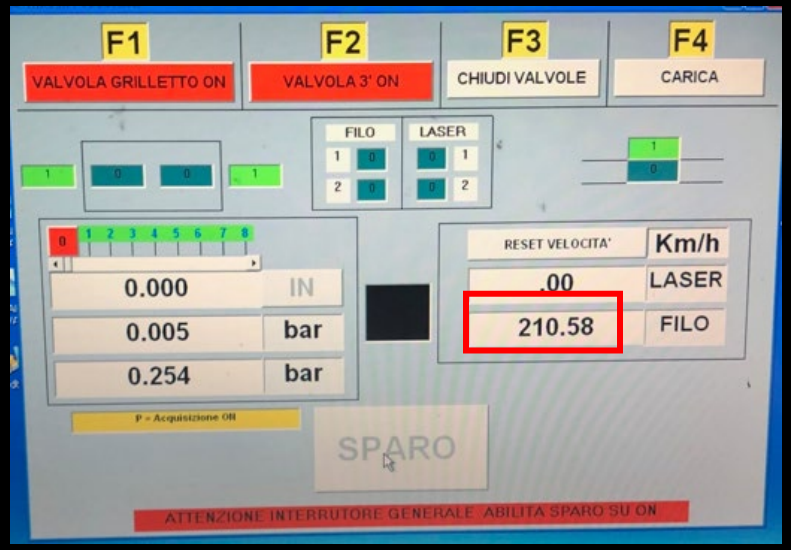
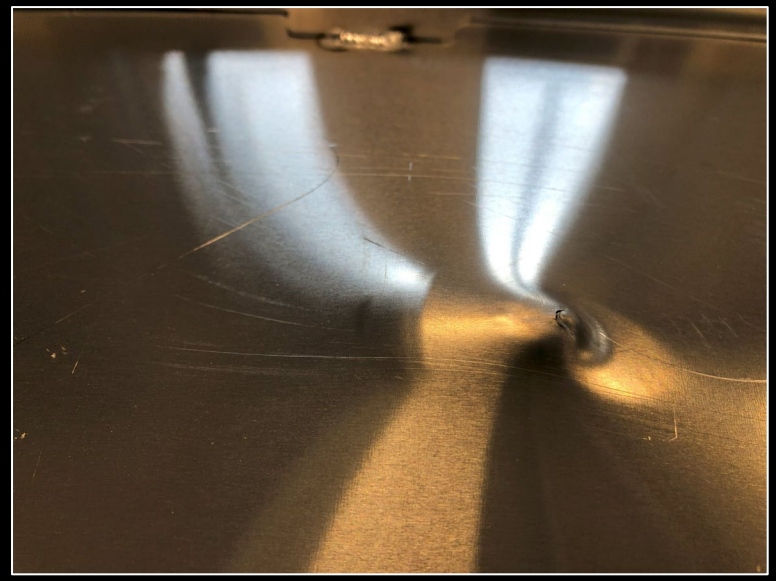
Flying Ballast Impact Simulation Test

Test results (Final Launch)

- Tested Specimen: Aluminum (AW5754 H111)
- Pressure: 0,254 bar
- Projectile Speed: 58,49 m/s (210,58 km/h)
- Kinetic Energy: 240 J
- Launch NF F 07-101:2002 Classification: K10





Observations - The projectile has not penetrated the specimen. It has caused an extensive deformation in the impact area and partial rupture of the sheet. The damage cannot be repaired.

The K10 class of the aluminum specimen represents the target class for the composite specimen.

Very High-Speed Trains Side Skirts - **Composite Build**

Flying Ballast Impact Simulation Test

Test results (Final Launch)

- Tested Specimen: Composite
- Pressure: 0,273 bar
- Projectile Speed: 59.39 m/s (213,80 km/h)
- Kinetic Energy: 247 J
- Launch NF F 07-101:2002 Classification: K10

Observations – The projectile has not penetrated the specimen. Widespread gelcoat cracking and extensive delaminations on the backside have been observed. Damage has been deemed repairable.

Very High-Speed Trains Side Skirts - **Composite Build**

End of Life

Production has investigated into solutions that could allow to recover value at the end of life (or scrap) of components, in case of supply of composite side skirts.

With the help of a competent and expert partner in this sector, Cobat Compositi, Production has verified the possibility to recover the materials to produce CSS-C (Secondary Solid Fuel), in compliance with Italian D.M. 22/2013 (Ministerial Decree), which establishes the End Of Waste criteria for CSS.

The CSS-C can be delivered to cement factories and/or thermoelectric plants that use it as fuel.

Production has launched a program of activities finalized to this.

Representative Specimen for the analysis of characterization of the waste

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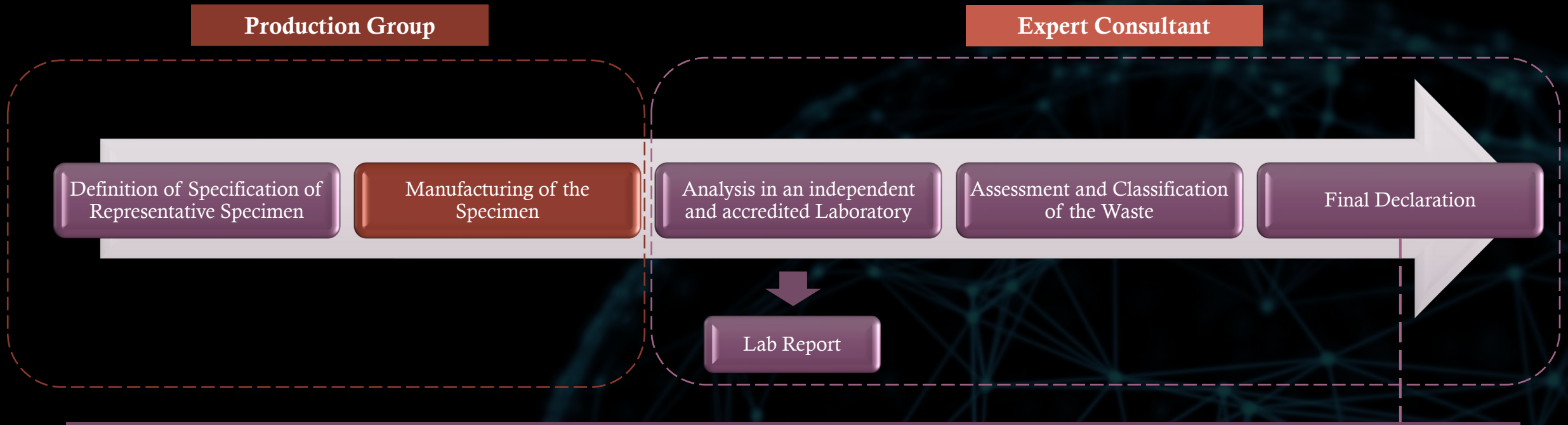
End of Life



Further to waste characterization analyses EER 070213, an Italian Operator specialized in energy recovery at authorized cement plants has confirmed the possibility to produce Secondary Solid Fuel from the treatment of the waste in question, even in End of Waste mode, provided that the chemical - physical characteristics of the materials remain unchanged .

Very High-Speed Trains Side Skirts - **Composite Build**

Conclusions

The Side Skirt manufactured in composite was:

- Able to withstand the static, fatigue and aerodynamic loads prescribed by applicable technical specification and standards.
- Lighter than the original design.
- More suitable to deployment in highly corrosive environment.
- Resistant to ballast impact as aluminum, but repairable after impact (for launch up to K10 class, observed).
- In line with the budget.

In addition, material has been proven able to recover value with the production of Secondary Solid Fuel from the treatment of the waste.

In conclusion, the outcome of the Project has demonstrated that the application of composite materials for the construction of VHST Side Skirts represents is a viable solution.

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