

Ultra Fog on the Orient Express

Fire protection engineering for a heritage railway vehicle

Massimo Farnesi – UltraFog S.p.A. | IWMC, Prague 2026



A Train That Became a Legend



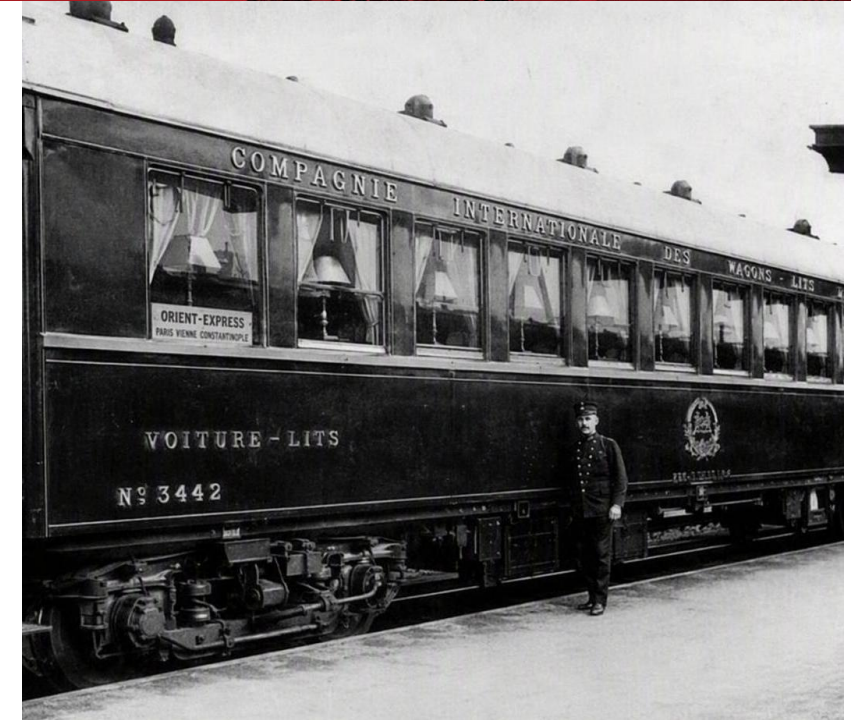
The story of the Orient Express began on **4 October 1883**, when the Compagnie Internationale des Wagons-Lits inaugurated its first service.

More than a rail service, the Orient Express became a symbol of European travel, luxury and technological progress.

Today, the **Venice Simplon-Orient-Express**, operated by Belmond, keeps that heritage alive through a fleet of historically significant carriages restored for modern luxury travel.

The challenge addressed in this project was simple to state:

How do you bring modern railway fire safety into a train designed almost one hundred years ago?



Rolling Stock



Marine

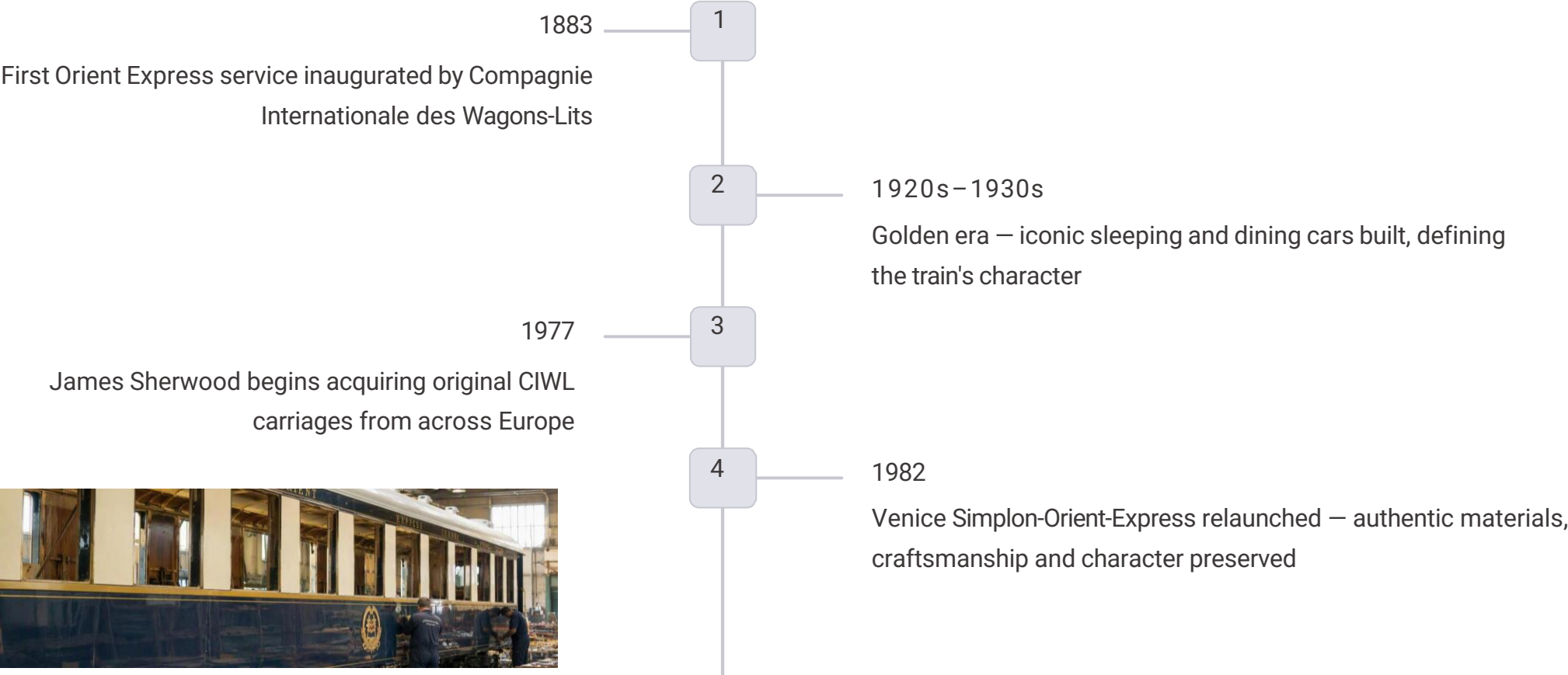


Land



Offshore

From Original Carriages to a Modern Luxury Train



The restoration philosophy was not to reproduce an old train. It was to **preserve the authentic materials, craftsmanship and character of the original vehicles**, while returning them to operational service. This philosophy became one of the fundamental constraints of the fire protection project.

The Train Is the Heritage



The Venice Simplon-Orient-Express is not a modern train made to look historic. Its identity comes from the original rolling stock.

The fleet includes authentic sleeping and dining cars built mainly during the 1920s and 1930s, each with its own history. The interiors contain:

- Historic wood panelling and marquetry Art Deco decorative elements
 - Fine fabrics and upholstery
 - Historic glass and decorative components
 - Bespoke furniture and fittings Original architectural details
- Every intervention therefore has two objectives:

- Preserve the heritage.
- Improve the safety.

When Heritage Meets Modern Safety



A modern railway vehicle is designed around safety requirements from the beginning. A heritage vehicle is different.

In the Orient Express, every element already existed:

- The geometry already existed
- The materials already existed
- The interior already existed
- The structural interfaces already existed
- The equipment spaces were already occupied
- Access for installation was extremely limited
- And the historic materials could not simply be replaced or extensively modified to achieve a modern fire performance.

The Fundamental Constraint

The fire protection system had to adapt to the train.

Not the train to the fire protection system.

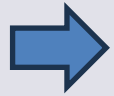
This single principle shaped every engineering decision that followed — from nozzle placement to pipework routing to system architecture.



The Regulatory Framework

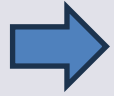


The project was developed within a railway safety and certification framework including, as applicable:



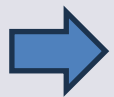
UNI 11565:2021

Design, installation, validation and maintenance of fire detection and extinguishing systems for railway vehicles



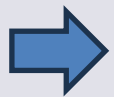
EN 45545 Series

Fire protection and fire behaviour requirements for materials on railway vehicles



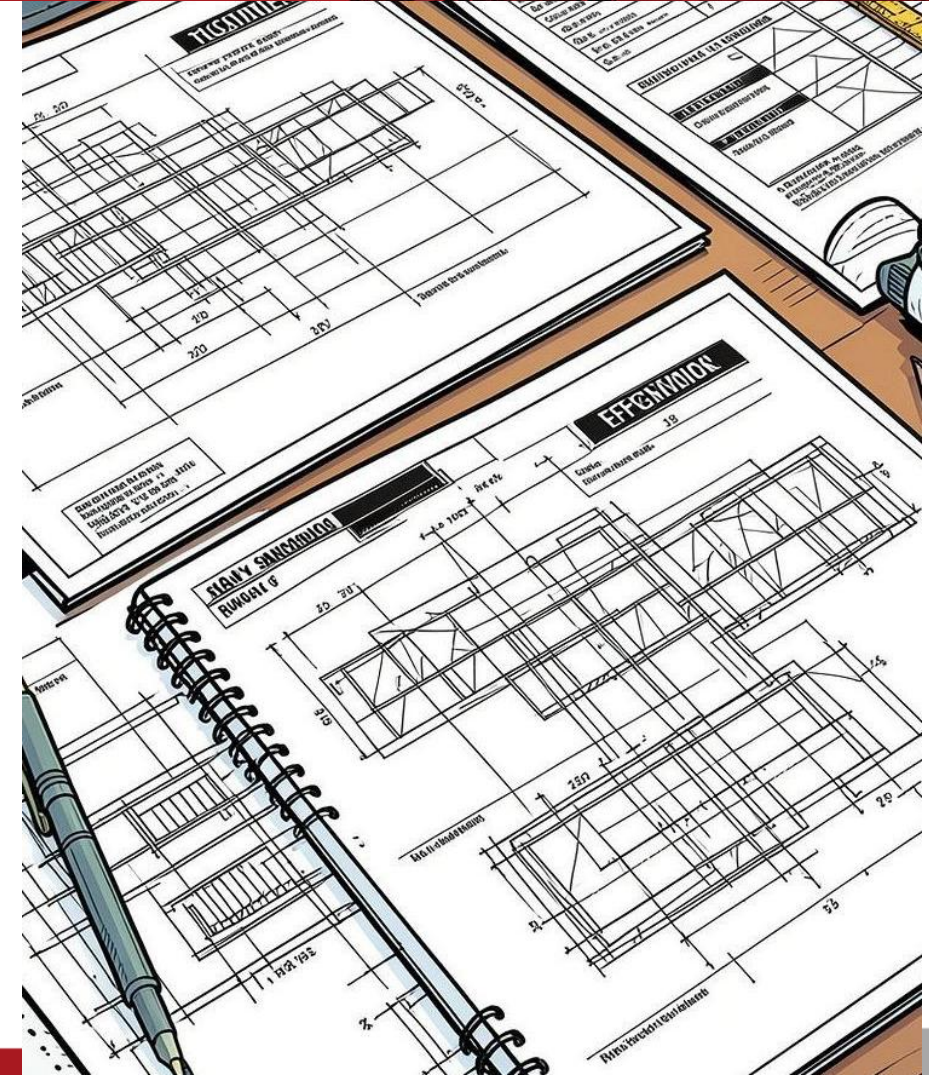
EN 61373

Shock and vibration requirements for railway rolling-stock equipment



EN 15085

Welding requirements for railway vehicles and components



Rolling Stock

Marine

Land

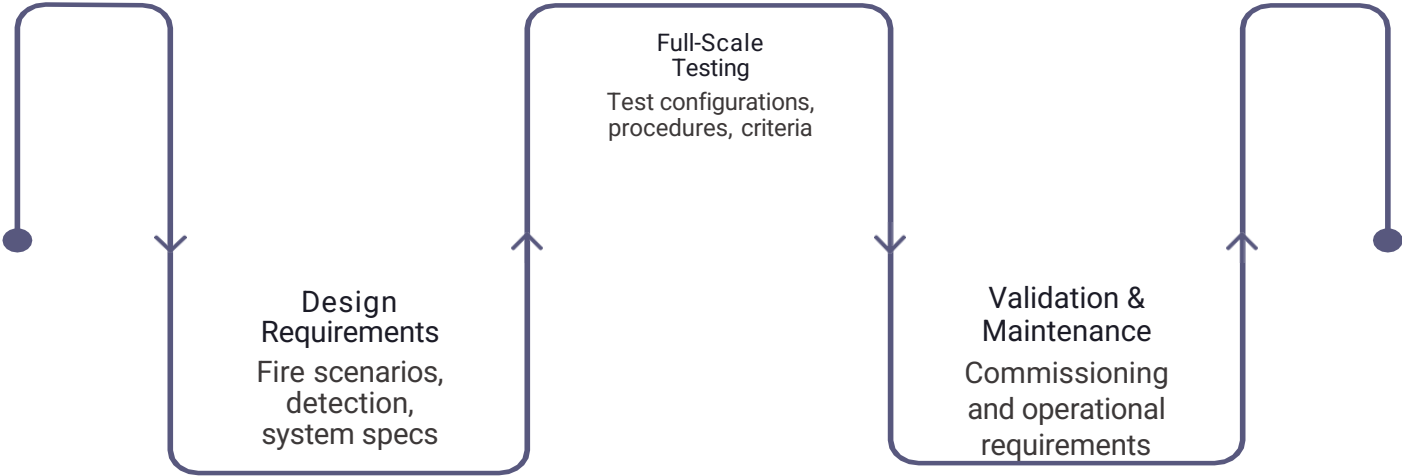
Offshore

UNI 11565:2021 From Prescriptive Design to Performance



ULTRAFOG SRL
UNISTore - 2022 - 2022/322608

NORMA ITALIANA	Veicoli ferroviari - Progettazione, installazione, validazione e manutenzione di sistemi di rilevazione ed estinzioni incendi destinati ai veicoli ferroviari - Principi generali	UNI 11565
		LUGLIO 2021



The key concept is **performance**. UNI 11565:2021 defines a complete framework covering design requirements, detection requirements, fire scenarios, full-scale test configurations, test procedures, performance criteria, validation requirements and maintenance requirements.

The objective is to demonstrate that, during the defined fire scenario, the system **maintains the required safety conditions**.

Safety conditions are defined by the tenability parameters set out in UNI 11565:2021.



The Performance Target



For passenger-area fire scenarios, the philosophy behind UNI 11565 is fire control and containment. The objective is not necessarily immediate extinguishment of every possible fire, but the water-mist system must keep tenability parameters within the prescribed limits.

65 °C

Maximum temperature – 1.5 metres from the fire
Upper limit maintained throughout the observation period

15%

Min Oxygen
Minimum O_2 concentration allowed

CO / CO₂ /..

Toxic Gas Limits
Prescribed concentration limits for all principal toxic species

The objective is to **control the fire and maintain tenable conditions for passengers and crew**. The 2021 revision must be used for the final project-specific test definition and acceptance criteria.



But This Was Not a Standard Coach



The standard provides a framework. The Orient Express presented a completely different reality.

Physical Constraints

- Highly combustible historic and decorative materials
- Complex and irregular geometries
- Furniture and fittings occupying the available volume
- Very limited free space above the ceiling
- Restricted locations for pipework
- Restricted locations for nozzles
- Areas where conventional installation methods were simply impossible

The Critical Constraint:

- Most importantly: **the visual appearance of the historic interior could not be compromised.**
- This transformed a standard railway fire protection project into a **custom engineering project.**
- Every nozzle position, every pipe run, every bracket and every penetration had to be resolved individually — balancing fire performance against heritage preservation.

The Design Philosophy



The design process started from four simultaneous requirements — each non-negotiable, each shaping the final solution.



1. Fire Performance

Meet the performance required by the applicable fire-test and certification framework to obtain ANSFISA authorisation to operate on the Italian rail network.



2. Heritage Preservation

Avoid unnecessary modifications to historic interiors and materials and integrate safety equipment seamlessly into the historic interior.



3. Railway Robustness

All equipment and supports must withstand the mechanical environment of a railway vehicle



4. Maintainability

The system must remain testable, serviceable and refillable throughout the operational life of the train.

The result was not simply a water mist system installed on a train. It was a **water mist system engineered around a historic train.**



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Land



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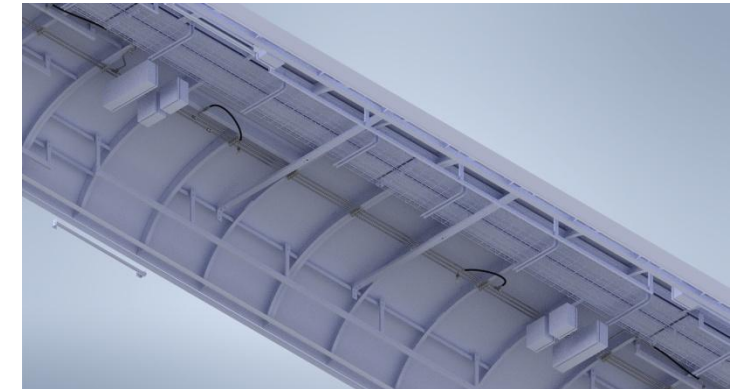
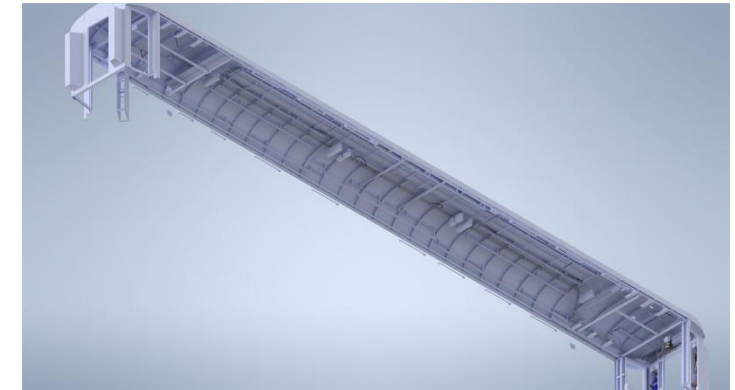
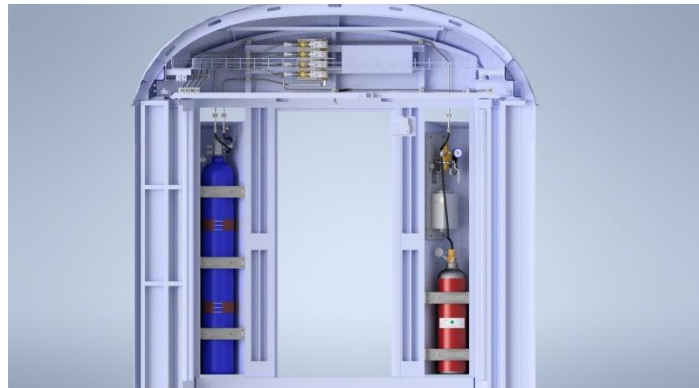
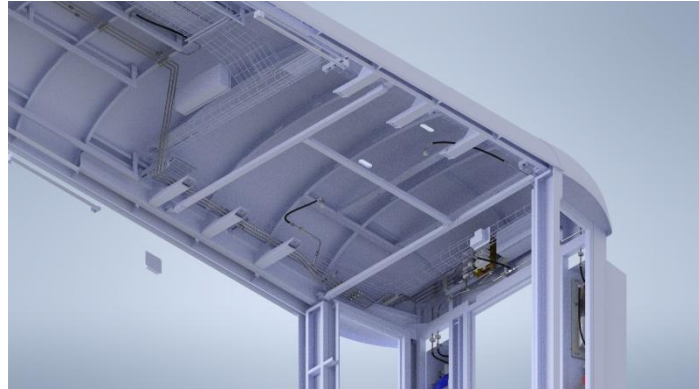
Engineering Started in 3D

For this project, 3D modelling became more than a design tool.

It became the common engineering environment.

The digital model included:

- Carriage geometry
- Historic architectural elements
- Equipment locations
- Pipe routes
- Nozzle positions
- Brackets and supports
- Interfaces with existing systems
- Water package
- Maintenance and access areas



Every component had to fit into the real geometry.

If it did not fit in the model, it would not fit on board the train.



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From 3D Model to Real Installation

One of the most important innovations was the use of the 3D model to control the entire installation sequence.

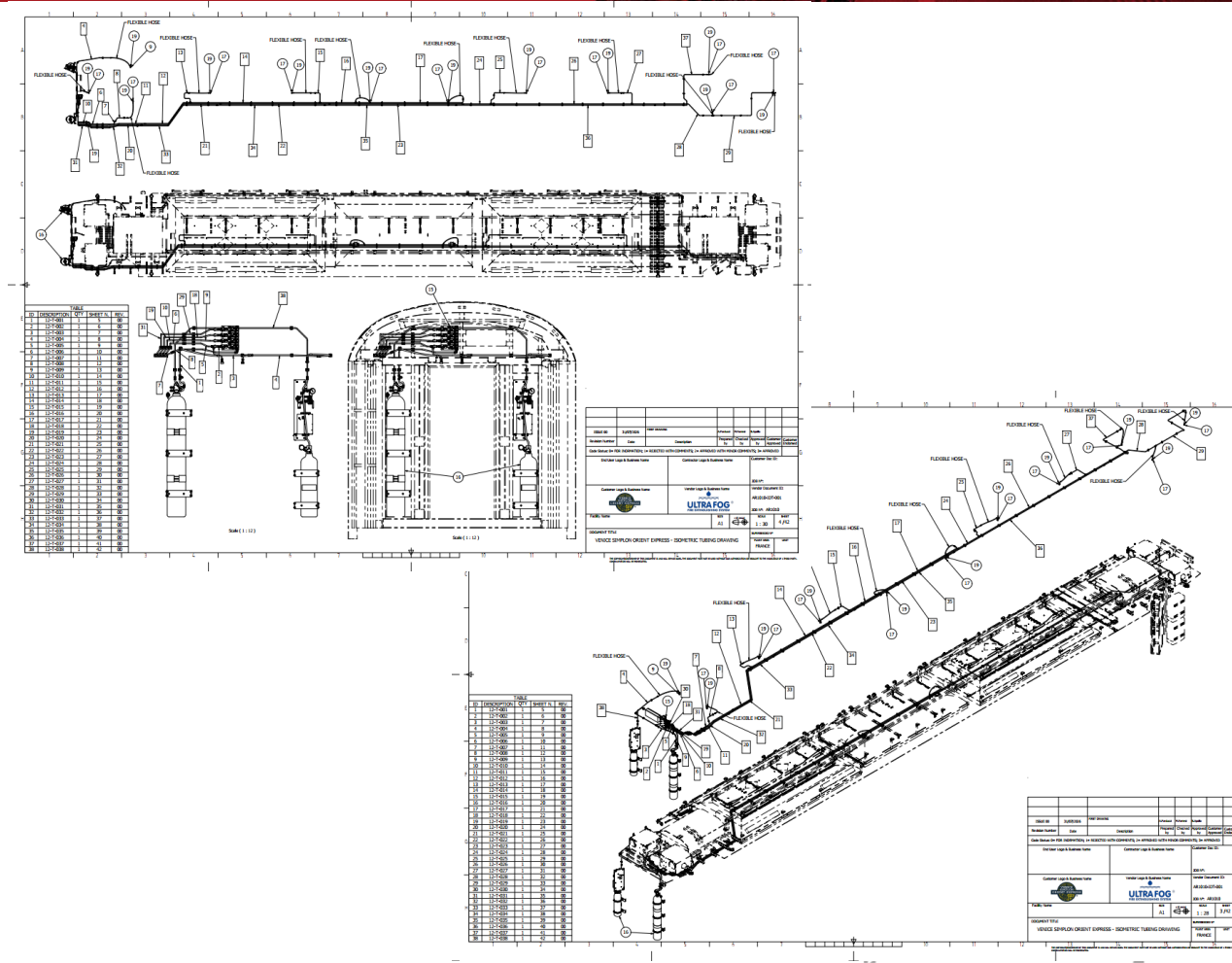
- The position of every pipe support and mounting plate was defined digitally.
- The support plates were installed and welded to the carriage structure before the subsequent surface preparation and finishing processes.

This approach created a controlled installation interface.

Later, the pipework could be manufactured as pre-formed spools, based directly on the 3D geometry.

The objective was simple:

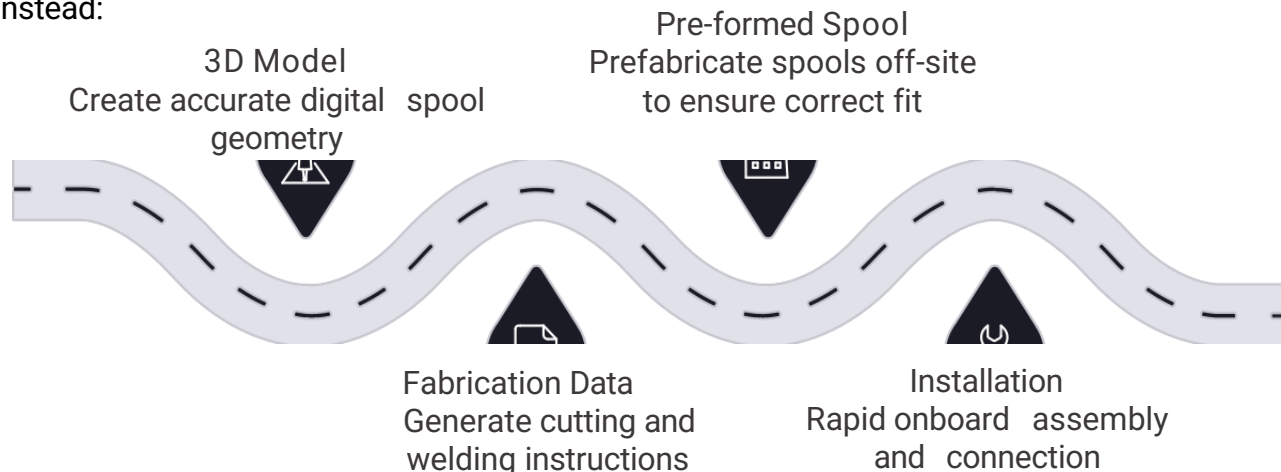
Move complexity from the carriage to the engineering office and the workshop.



Prefabricated Pipe Spools

The pipework was not designed as a collection of individual pieces to be measured and adapted on the train.

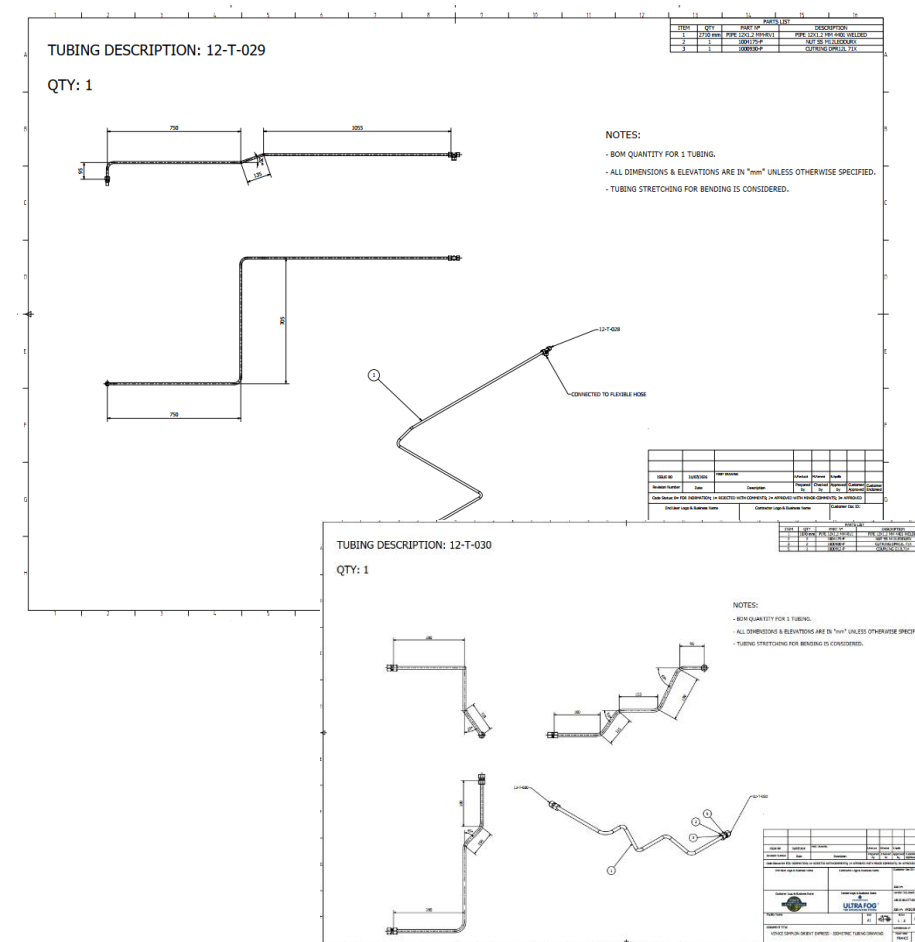
Instead:



This provided:

- Repeatable geometry
- Reduced onboard installation time
- All onboard hot work was completed in a single phase before sandblasting.
- Reduced risk of damaging historic interiors
- Better dimensional control

The railway vehicle became the final assembly environment rather than the manufacturing environment.



Installation of Pipe Spools



All prefabricated spools were installed in the designated position.

All bracket mounting plates had already been welded in accordance with EN 15085, then sandblasted and painted.

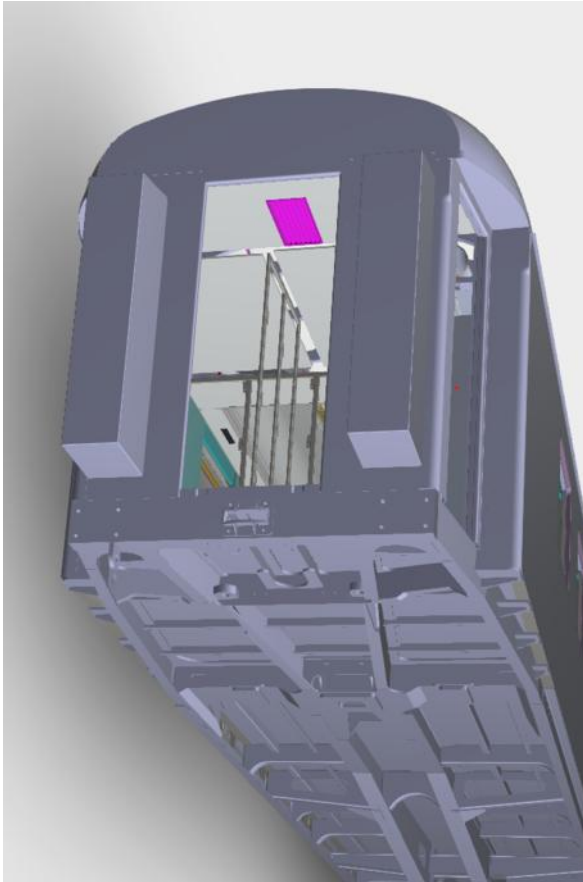
All lines were colour-coded so that they could be identified after the ceiling was installed, when tracing each line from the valve to the nozzles would no longer be possible.

All lines were finally pressure-tested at 1.5 times the working pressure before ceiling installation began.

Any leaks or required repairs could be addressed easily at that stage because all the pipework was still exposed and no valuable ceiling panels or furniture had yet been installed.



The Water Package



The water package is the “core” of the system and it had to satisfy requirements that go far beyond just storing water and nitrogen.

The central unit had to perform several functions, but first we needed to find space on board.

→ **The former coal-storage boxes were selected to house the water-package system.**

This choice introduced some more factors to be included in the design:

- Thermal exposure (boxes are not insulated)
- Structural verification according to EN61373 (wall thickness of the coal box was not designed for it)
- The unit had to be divided between two separate locations.



Freeze Protection and Water Management

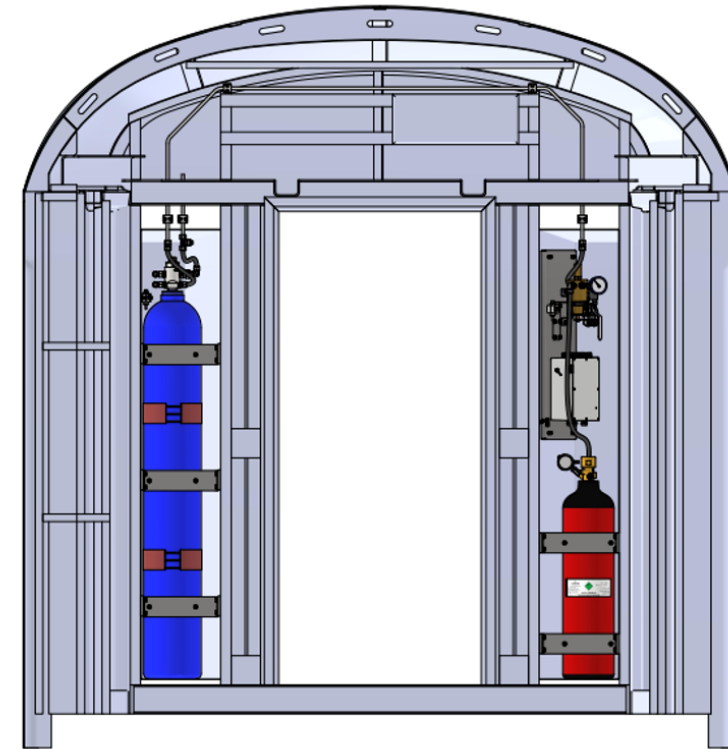


The design incorporated several features:

- Water storage with internal lining to avoid water contamination
- Pressurisation system comprising a nitrogen cylinder and a fixed pressure regulator.
- Distribution lines using motorized valves to discharge water only in the area affected by the fire.
- Temperature monitoring in both coal boxes
- Freeze protection using heating elements
- Pressure monitoring with an alarm triggered below the threshold value.
- System status monitoring (valve position monitoring, line monitoring etc)
- Test and maintenance functions (nitrogen discharge test, line blowing connection etc)
- Dedicated filling and draining connections to refill or replace water inside the bottle

The philosophy was:

The system must remain ready to operate under all operating conditions, including when out of service and parked in cold areas, while minimising maintenance activities that require access to the coal boxes.



FRONT VIEW
Scale (1:10)



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Railway Robustness: Shock and Vibration



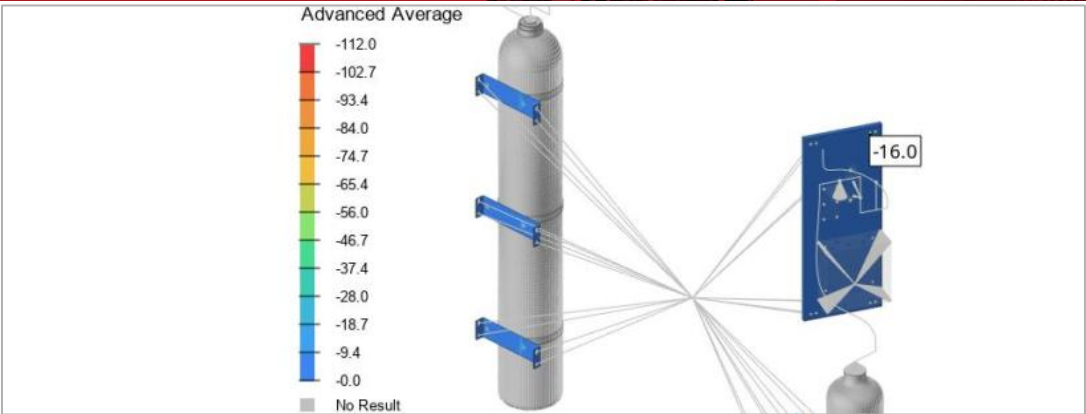
A fire-protection system installed in a building does not experience the same mechanical environment as equipment installed on a railway vehicle.
Every relevant assembly therefore had to be considered for:

- Shock
- Vibration
- Structural integrity
- Pipe/support interaction
- Equipment fixation
- Connections

Long-term mechanical reliability
The qualification programme was developed against the applicable railway shock and vibration requirements, applying the principles of EN 61373.

Finite-element analyses were performed on each component and each connection to the carriage structure to verify compliance with the EN 61373 railway shock and vibration requirements.

The objective was not simply:
"Does the system work?" It was:
"Does the system still work after the railway environment has acted on it?"



-1gY-1gZ	39.4 Mpa	355 Mpa	1.15	0.13
+1gZ	12.5 Mpa	355 Mpa	1.15	0.04
-3gZ	37.6 Mpa	355 Mpa	1.15	0.12
+5gX-1gZ	167.0 Mpa	510 Mpa	1.5	0.49
-5gX-1gZ	145.3 Mpa	510 Mpa	1.5	0.43
RISULTATI FATICA				
Caso di carico	P1 max	P3 min	σ_{adm} (@10 ⁷ cicli)	UF
0.3gX+0.3gY	16.5 Mpa	-16.0 Mpa	102.7 Mpa	0.16

RRA Y	53.7MPa	355 Mpa	1.15	0.92
RRA Z	25.9MPa	355 Mpa	1.15	2.97

Tabella 15 – Massimi UF valutati sulla struttura SKID bombole (EN 61373 – RRA)

RISULTATI BOLTS: M8								
Caso di carico	Crit. Bolt ID	Axial Force (3σ)	Shear Force (3σ)	Scorrimento	Trazione	Taglio	Rifollamento	Taglio + Trazione
RRA X	10	580.20N	436.47N	0.29	0.70	0.03	0.39	0.53



Rolling Stock



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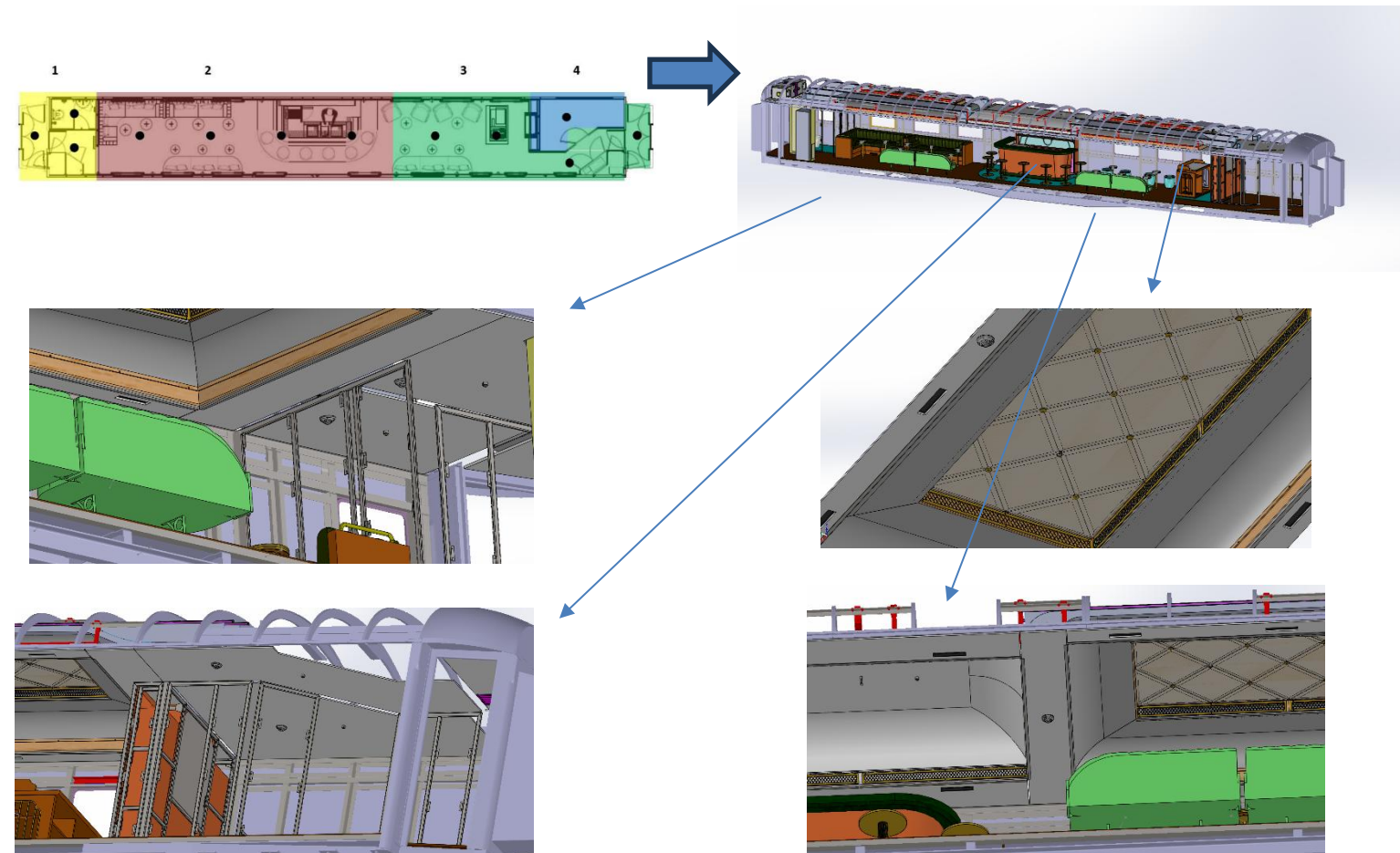


Land



Offshore

Nozzle distribution in the car



The nozzle positions were initially sketched according to certified spacing to determine the required quantity.

In a second stage, the position of each individual nozzle was fully engineered and integrated into the 3D model.

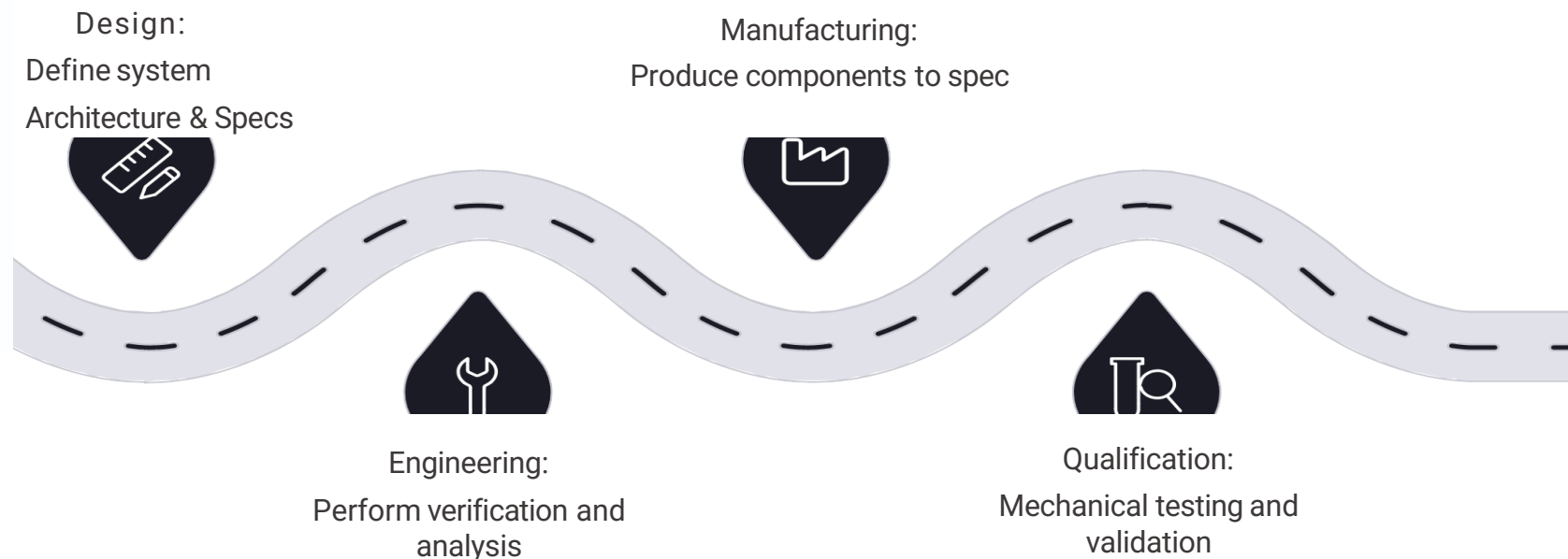
Each case was evaluated to minimise the impact of the installation on valuable historic items and to avoid areas where it was impossible to create an opening, such as mirrored surfaces or glass ceilings.

A dedicated team of interior architects worked alongside our engineers to determine the best integration for each nozzle.



Validation and Certification

The project followed a complete verification and validation chain:

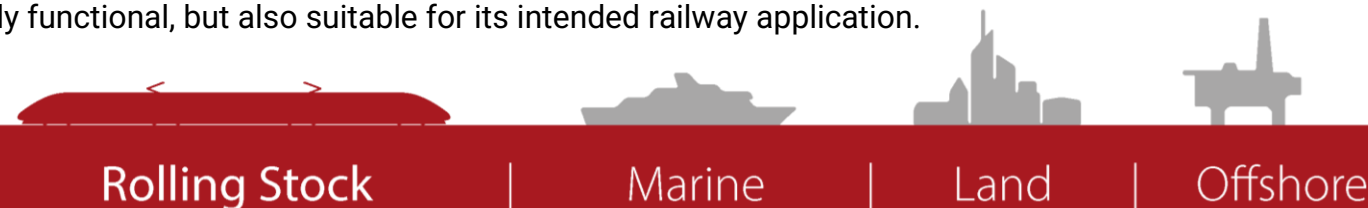


The complete system is currently being installed and will be tested and commissioned with the involvement of the relevant certification framework and **CERTIFER**.

All processes are carried out in accordance with IRIS Certification requirements (ISO 22163).

ISO 22163 (IRIS) is a global quality standard created by UNIFE (the Association of the European Rail Industry) to ensure the safety and reliability of components across the railway supply chain. It takes standard manufacturing rules (ISO 9001) and adds strict requirements for project management and long product lifespans required by major transit operators.

The final objective is to demonstrate that the system is not only technically functional, but also suitable for its intended railway application.



Classic Luxury. Modern Safety.



Almost one hundred years separate the design of the original carriage from today's fire protection technology.

But the engineering objective is the same:

Protect people. Protect the vehicle. Preserve the experience.
The Orient Express demonstrates that modern active fire protection can be integrated into a heritage railway environment without turning the heritage vehicle into a modern one.
The most important innovation is therefore not the water mist itself. It is the engineering approach that makes the water mist belong there.

UltraFog — Classic Luxury, Modern Safety.

Thank you.

Massimo Farnesi UltraFog S.p.A.

