« SuperRail – HTS Installation am Gare Montparnasse»

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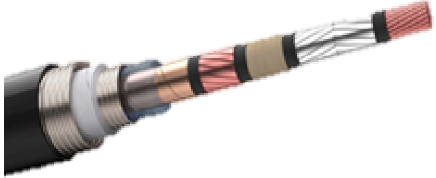

This project is supported by France 2030.

RATIONALS

Need to increase the traffic on the railway network in densely populated areas with high constraint to comply with 2030 carbon reduction objectives

The solutions should be in line the strategy of SNCF :

- To reduce the losses
- To participate to the low carbon national strategy
- To optimize capital and operational expenditure to answer the needs

➡ Practical case = the supply of power from Vouillé substation to Montparnasse station tracks

This project is supported by France 2030.

CONTEXT

High constraints on the Montparnasse-Vouillé Site

In 2023 SNCF should deliver an electrical installation able to transmit more energy to the tracks in order to improve the robustness of the electricity supply of Montparnasse station (50 Millions of passengers in 2020, 90 Millions in 2030).

- **Conventional solution :** to reinforce wi**th copper cables**

  => not possible here due to limitations of the rights of ways

- **Innovating solution : Superconducting cable system**

Roadmap in progress to establish a strategy from 2025-2035 to reinforce the railway network on the left river side of Paris. This roadmap will identify other sites where superconducting technologies can be of interest.

This project is supported by France 2030.

PROJECT OBJECTIVES

SUPERRAIL

To increase the energy density in a highly constraint area **where conventional technologies,** based on reinforcement by resistive cables**, are not applicable.**

To increase **the commercial offer** by increasing the **public transport capacity and reliability**.

To develop industry and education related to the superconducting technologies (R&D, design, production, installation and test labs), particularly in France.

To deploy the world 1st demonstrator of superconducting cable permanently in exploitation in a railway network.

To validate the superconducting technology on Montparnasse-Vouillé site.
To qualify this technology for future projects to reinforce and secure the national railway network.

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CONSORTIUM

NETWORK OPERATOR

SNCF RÉSEAU

INDUSTRY

Nexans

ABSOLUT SYSTEM
INNOVATIVE CRYOGENIC SOLUTIONS

SuperRail
Superconductivity for Railway

RESEARCH LABS

CentraleSupélec

UNIVERSITÉ DE LORRAINE

FRANCE 2030

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LOCALIZATION

Railways tracks

”Ouest Ceinture” substation

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RATIONALS

Existing Rights of way saturated with only 4 pipes left (100 mm in diameter) to transport 2 x 3500 A @1500 V DC

Very risky to build new rights of way with one century old constructions and presence of a lot of other networks (water, gas, telecom)

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CHALLENGING SPECIFICATIONS

- 2 electrically independent cables system to supply each :
  - 1700 A @ 1500 VDC in rated conditions (max 3% of harmonics below 5 kHz)
  - 3500 A @ 1500 VDC current inrush (trains acceleration to reach traffic speed)
- Return currents through the rails (connected to the negative (0) pole of the DC supplies)
- Substation directly connected to the transmission network at 63 kV
  - Fault power of 1000 MVA
  - Fault current of 67 kA during 200 ms
- Cooling system
  - Power of 1,2 kW@67K for the cable system

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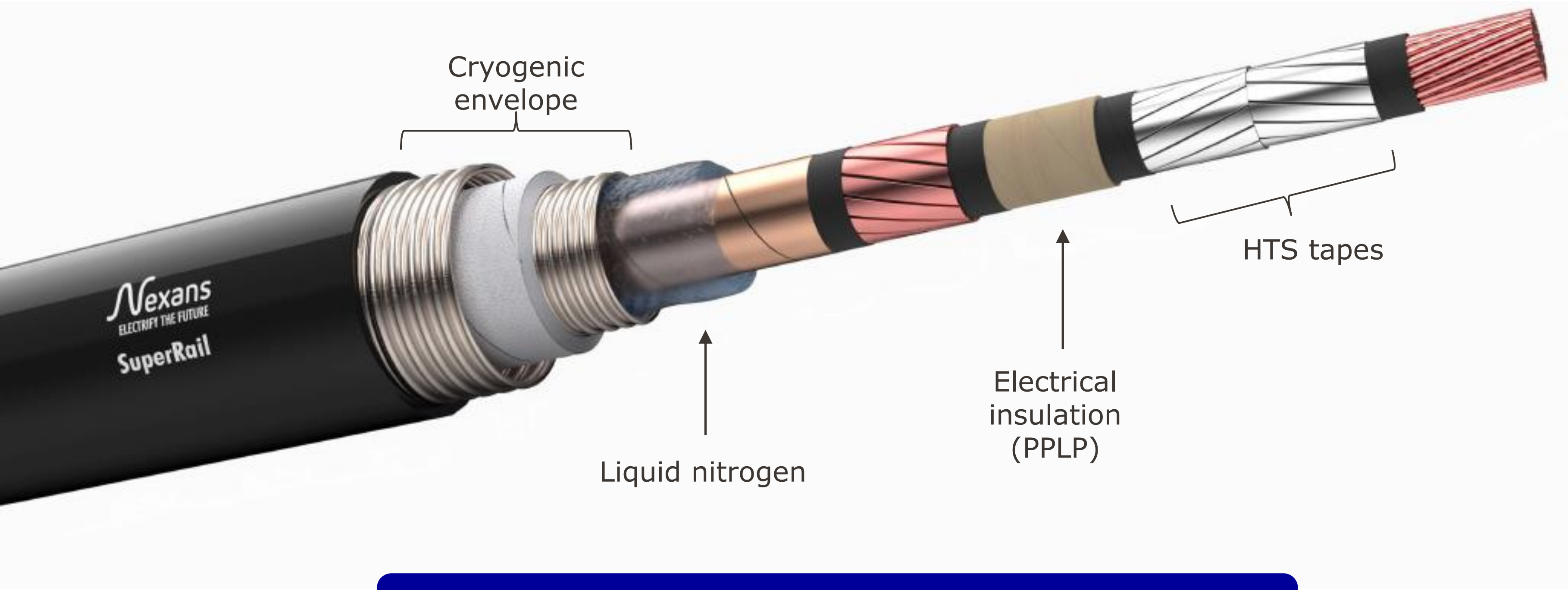
CABLE DESIGN



63 mm cable to be pulled in 100 mm pipes

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SUPERCONDUCTING CABLE TERMINATION

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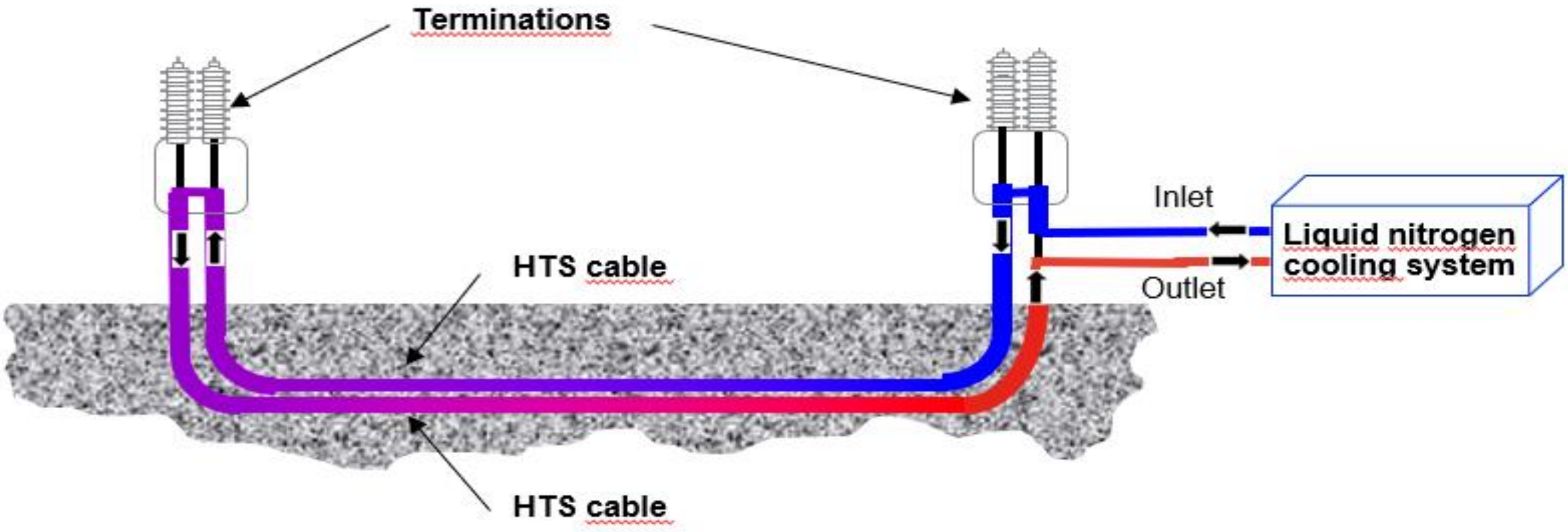
COOLING SYSTEM AND MONITORING



- The alarm levels, for temperatures and pressures, and algorithms are defined with SNCF in charge of the control cabinet to communicate with exploitation & protection systems

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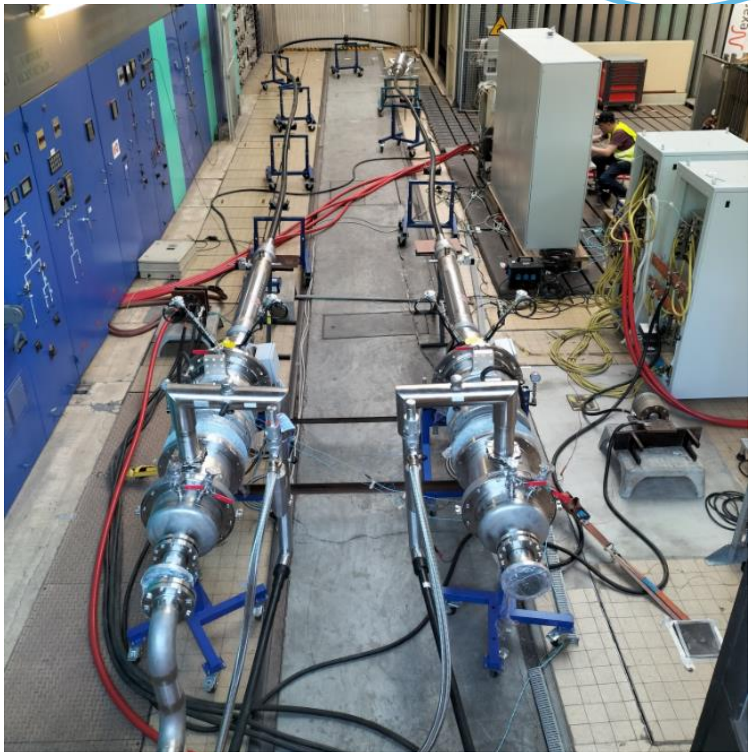
SUPERRAIL

TYPE TEST IN SNCF LABORATORY

Pre-Test	Applicable standard	Description
Bending Test	IEC 63075*	3 bends of 180° repeated in both direction + Visual inspection
Critical current	IEC 63075*	Check if any Ic degradation on tapes after bending
Pressure test	IEC 63075	1,1 x max operating pressure After installation, prior to cool down without the safety devices
Thermal test	IEC 63075	5 Cycles of cooling down and warming up



* IEC 63075:2019 specifies test methods and requirements for high temperature superconducting (HTS) AC power cable systems, cables and their accessories, for fixed installations, for rated voltages from 6 kV (U_m = 7,2 kV) up to and including 500 kV (U_m = 550 kV)

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TYPE TEST IN SNCF LABORATORY

Electrical Test	Applicable standard	Description
Lightning impulse	EN 50124-1** Table A2 EN 60664-1** (only for 1,5 kVDC)	Un= 1,5 kV ➔ U_{Nm} =1,8 kV ➔ U_{Ni} = 15 kV (OV4) Un= 3 kV ➔ U_{Nm} = 3,6 kV ➔ U_{Ni} = 30 kV (OV4) Page 18 : 3 x 1,2 µs/ 50 µs each polarity
Dielectric test	EN 50124-1** Table B1	U_{Ni} = 15 kV ➔ Ua= 6,9 kVrms / 10 kVDC U_{Ni} = 30 kV ➔ Ua= 14 kVrms / 20 kVDC
Fault current	No specific standards	Energy equivalent to 67 kA – 100 ms fault with terminations temperatures monitoring until recovery

** electrical standards specific to railway network

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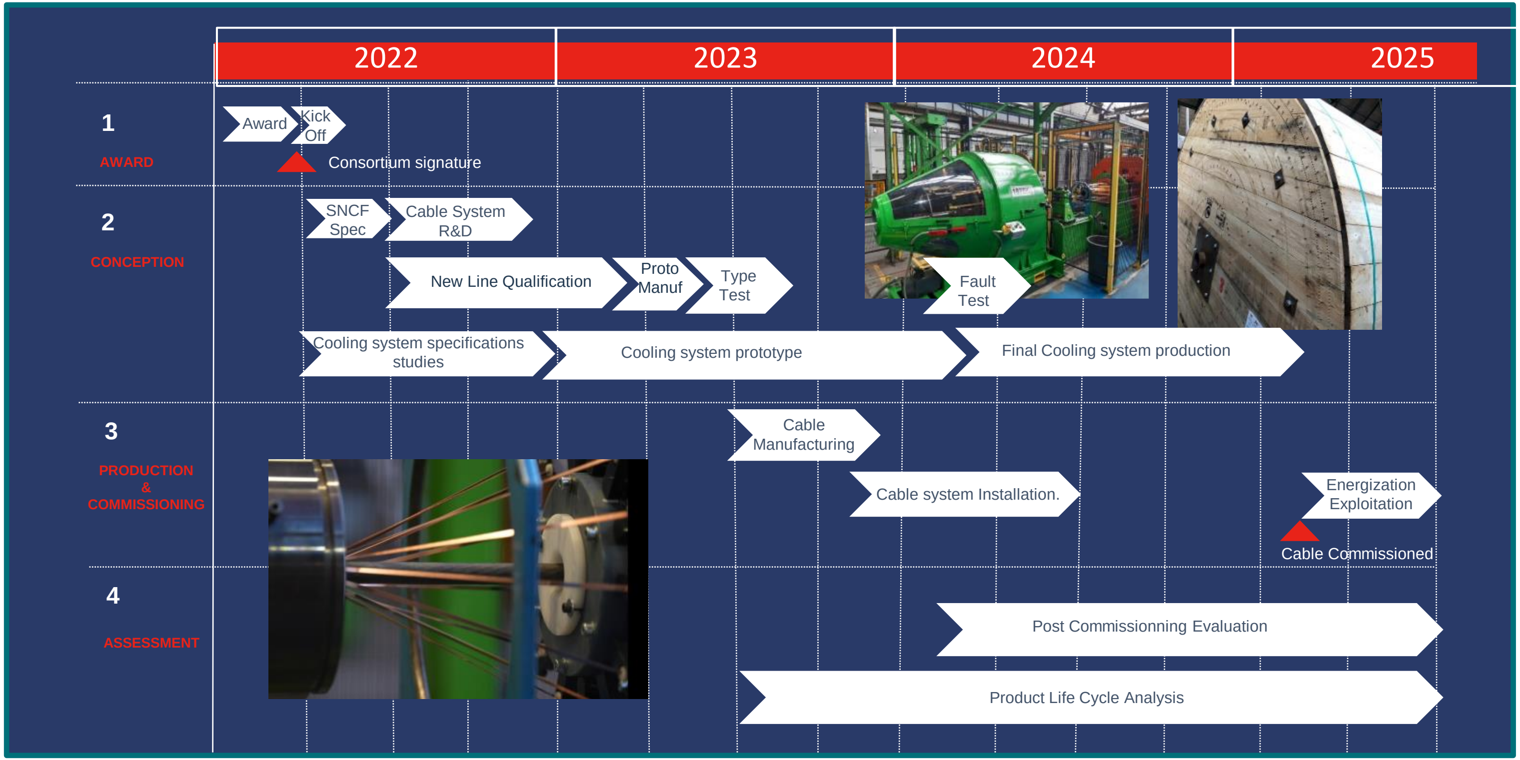
SCHEDULE



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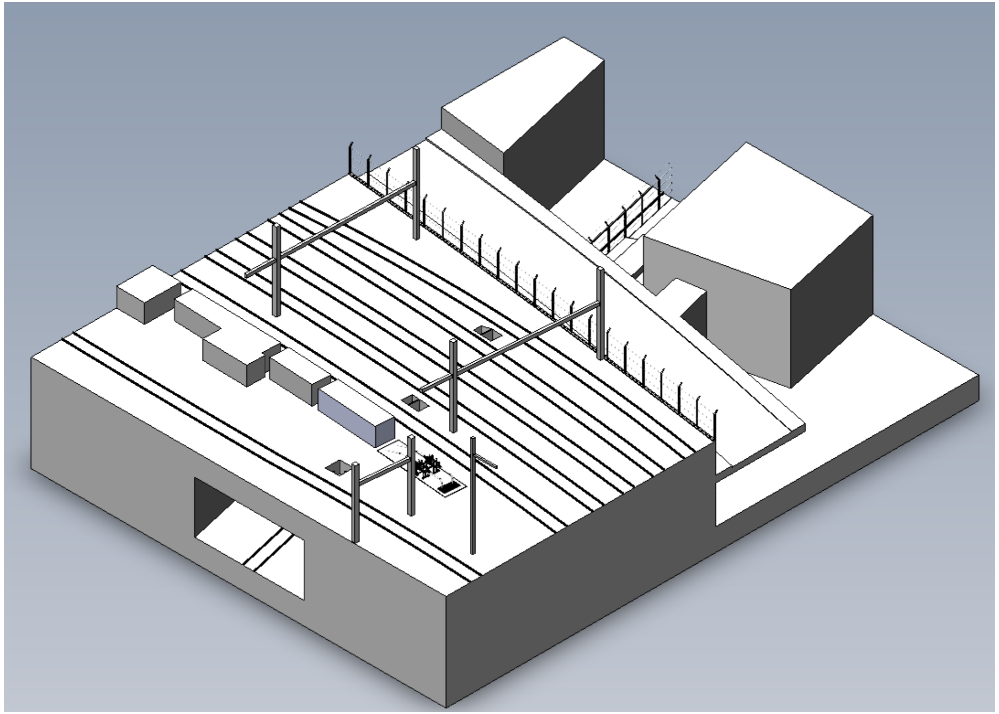
3D SITE MAP



- LIDAR scan of the area
- Construction of a 3D drawings for the virtual integration of equipement to anticipate issues and confirm designs of different components

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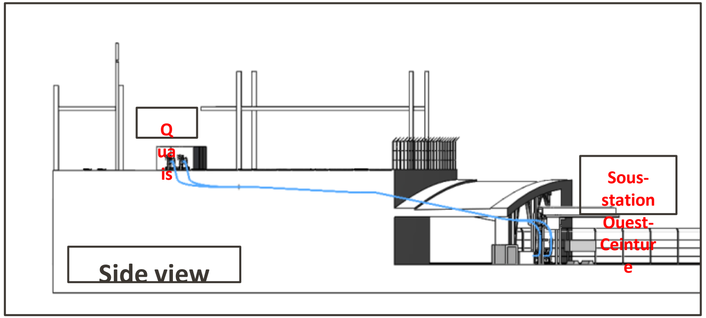
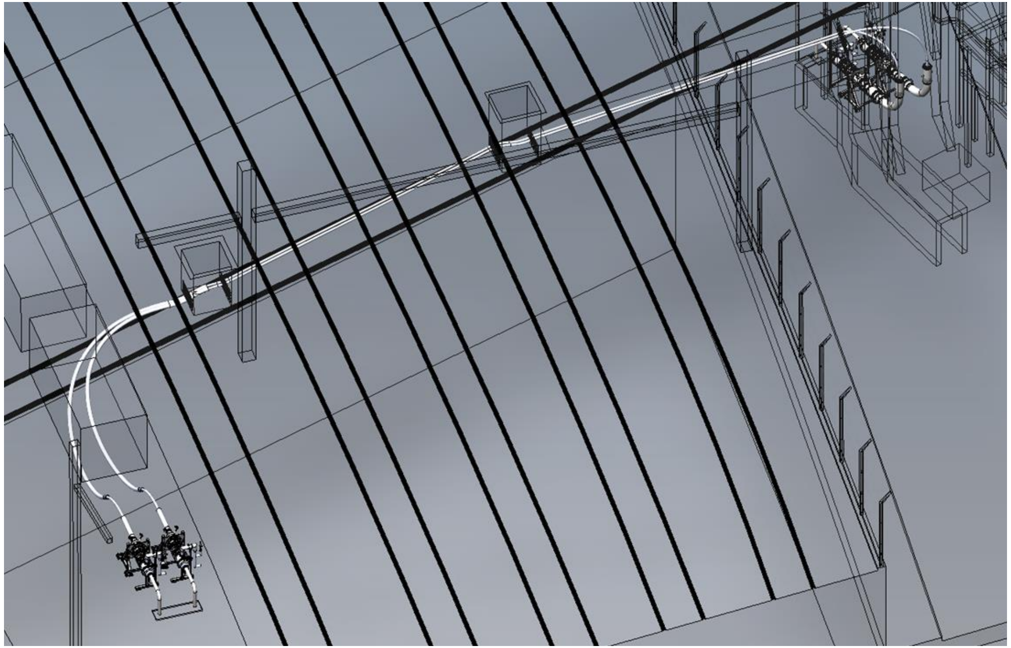
SUPERCONDUCTING CABLE ROUTE



« Ouest-Ceinture » substation



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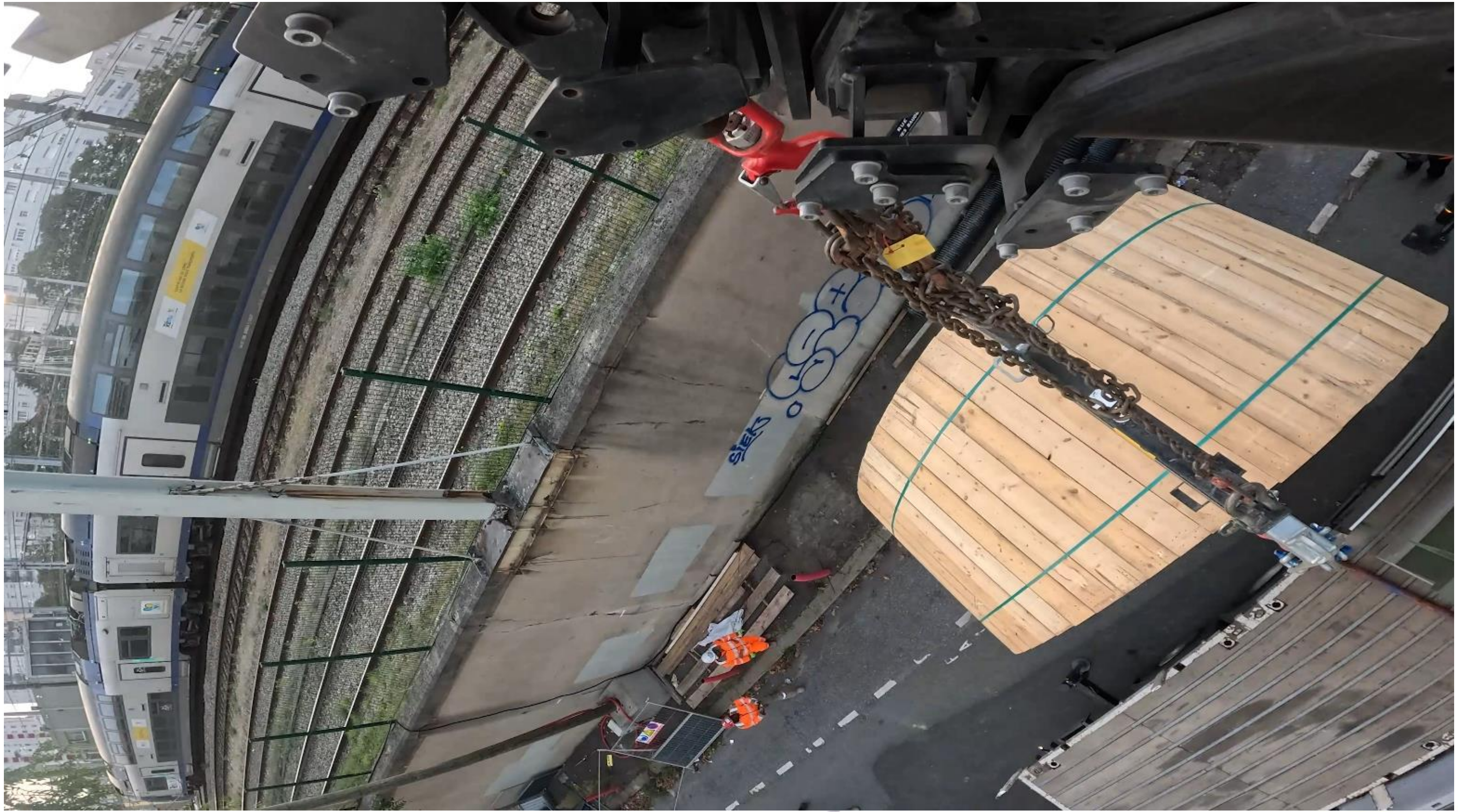
SUPERCONDUCTING CABLE INSTALLATION



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SUPERCONDUCTING CABLE INSTALLATION

SUPERRAIL

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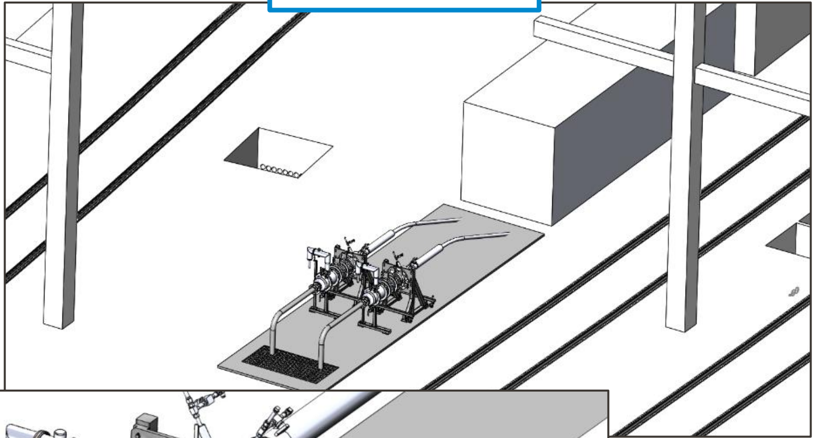
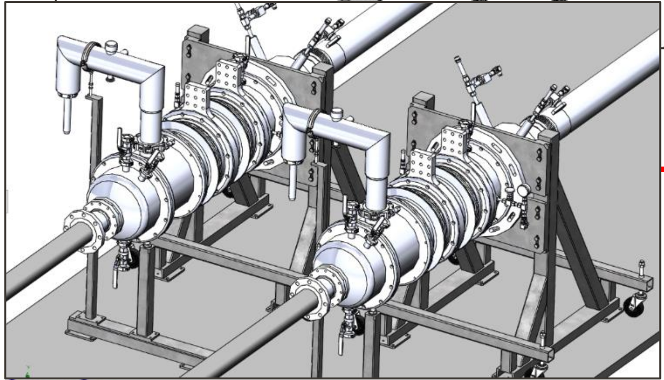
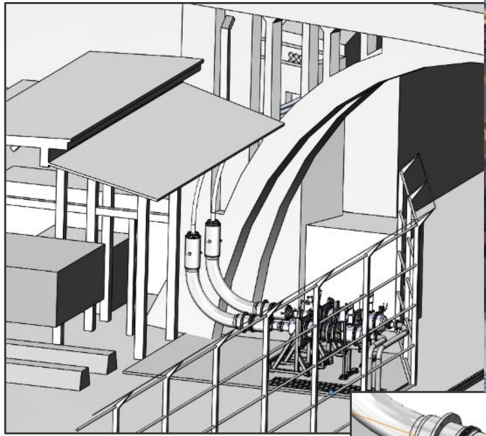
TERMINATIONS INTEGRATION

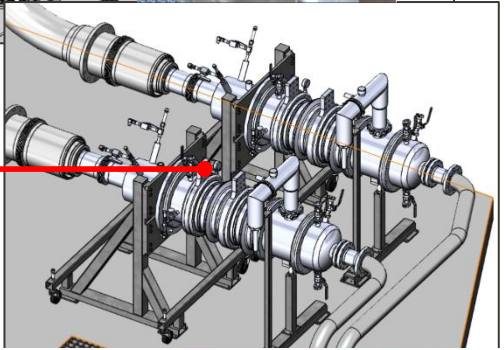
PLATEFORM SIDE

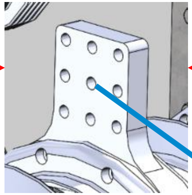




SUBSTATION SIDE







Copper plate to connect to conventionnal network

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CONCLUSION

- **SuperRail** constitutes an excellent example of **how a superconducting can unlock situations in power grids** where conventional technologies are not applicable.
- The superconductivity is **a way to increase the capacity of power supply to public transport** in dense areas, allowing **to meet national low carbon objectives.**
- The validation of **the superconducting technology** during SuperRail will qualify superconducting cable **for future projects to reinforce and secure the national railway grid.**
- SuperRail promotes **continuous improvement** of superconducting system through R&D approach **to reduce losses** and through **experiences in exploitation with SNCF teams** up to the end of the project and beyond

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SUPERCONDUCTIVITY TO PROMOTE LVDC AND MVDC IN ENERGY NETWORK

SUPERRAIL

SCARLET

Superconducting CAbles foR sustainabLe Energy Transition

SCARLET
Superconducting CAbles foR sustainabLe Energy Transition

European Project SCARLET (2022-2027)

- **Goal**: develop and industrially manufacture MVDC superconducting cable systems at the gigawatt level, bringing them to the last qualification step before commercialization
- Expertise from 15 industry and research organisations in the fields of material sciences, cryogenics, energy systems and electrical engineering

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ABSOLUT SYSTEM INNOVATIVE CRYOGENIC SOLUTIONS
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RSE Ricerca Sistema Energetico

Project structure

- 3 demonstration work packages
  - MVDC HTS superconducting cable systems
  - MVDC MgB_2 cables in liquid hydrogen
  - System protection
- 1 work package on architectures of offshore superconducting cable systems
- 1 work package for integration studies and economic evaluation
- lastly, work packages for communication and coordination