

Innovation the key to transformation and adaptation

2026 Innovation Report
of SNCF Group



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Innovation is shaping the mobility of tomorrow



Jean Castex
Chairman and CEO, SNCF Group

Research and innovation in the SNCF Group are preparing the mobility of tomorrow – low-carbon and high-performance mobility serving all passengers regardless of their situation. While rail is indisputably the most ecological mode of transport, we must continue to make it more attractive, more accessible, and more competitive in all regions. That is why SNCF Group invests an average of €100 million per year in its innovation policy, which was embodied in about 150 projects in 2025.

The challenge: to transform to serve better

In a world where technological revolutions in artificial intelligence, robotics, automation, and telecommunications are accelerating, SNCF Group is accelerating its ongoing transformation. Our goal? To offer passengers and freight customers reliable, high-performance rail solutions each day – solutions that are more affordable and more resilient to challenges such as adaptation to climate change and cybersecurity.

To achieve this ambition, SNCF has established some ten academic partnerships and is contributing to about twenty research chairs alongside other industrial partners. This ambition is also reflected in the commitment of SNCF and its partners to the State-sponsored France 2030 plan. Projects for innovation in the rail

sector conducted through CORIFER receive more than €245 million in funding, including €45 million for SNCF, as part of the 2021 and 2023 calls for expressions of interest (CEI) for projects lasting up to five years. This support may increase with a future CORIFER CEI, whose publication is eagerly awaited.

Innovation, a collective strength

The opening of the market to competition makes the pioneering role played by SNCF Group even more crucial to maintaining the sector's competitive edge. With more than 1,000 active patents and 38 new filings in 2025, SNCF Group ranks 41st among French companies in the number of patents filed last year.

Underlying every innovation presented in this report is the desire to concretely improve everyday life – the lives of our customers, our employees, and the regions we serve. By starting from real needs, we make – and will continue to make – the right choices.

I am counting on all the employees of SNCF Group to contribute with their talents and skills to the preparation of tomorrow's rail system. They are guided in this mission by some 600 scientific and technical experts working in our companies and subsidiaries, with support from the 60 doctoral students with CIFRE agreements hosted in 2025.

A critical European dimension

Many key challenges for the future of rail and the SNCF Group are being addressed at the European level, and we must maintain and strengthen our ties with the European ecosystem. As a major player in Europe's Rail, a partnership with 360 participants from 27 countries, SNCF Group is leading the largest project underway in this program. It is serving as the coordinator of the 28 partners in the R2DATO project, which is focused on the digitalization and automation of rail operations. By working with our partners, we will collectively strengthen our competitiveness and industrial sovereignty.



Carole Desnost
Vice President, Technologies,
Innovation and Group Projects

In an increasingly competitive environment, innovation has never been more important to the Group to meet the challenges of competitiveness, sovereignty, and resilience. The research and innovation efforts undertaken in recent years with strong support from academic and industrial partners are now bearing fruit with very concrete results.

Working with manufacturers, we have demonstrated the feasibility of the low-carbon trains we have envisioned. The hybrid regional train (TER) has already traveled tens of thousands of kilometers, achieving highly satisfactory levels of performance and energy efficiency, and battery-powered trains will soon enter service. To improve mobility in the regions of France, we are delivering true technological breakthroughs with light transport train projects such as TELLi and DRAISY, which offer efficient models of rail transport with optimized costs.

As for open-access services, we will soon see implementation of innovations developed in the next-generation TGV project in areas such as signaling and control systems, energy storage, aerodynamics, and modular interior design.

As technological cycles accelerate, it is essential to anticipate and serve both as a guide to long-term development in our technological environment and as an integrator in dealing with major cross-cutting issues such as energy, climate resilience, and cybersecurity.

Innovations developed in close cooperation with the Group's companies are aimed at strengthening our positions and developing new mobility solutions and services in conjunction with the ambitions set forth by CORIFER at the national level. Last, steady progress is being made in creating a single, interoperable railway space in Europe for both freight and passenger transport, based on sovereign technologies.

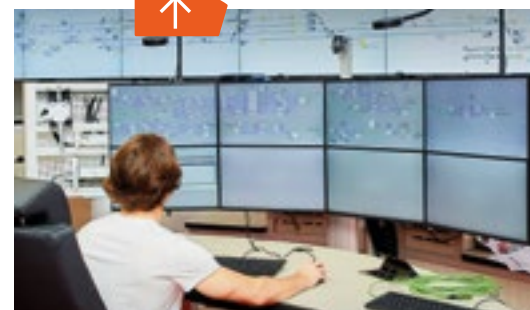
To illustrate these points, the following pages present several prime examples of the rich diversity of research and innovation in the SNCF Group.



10 emblematic projects

Next-generation signaling with ARGOS

This technological breakthrough is fundamental to SNCF Réseau's digital modernization. Co-designed with Hitachi Rail, Alstom, and Compagnie des Signaux, ARGOS replaces mechanical technologies with innovative software solutions. These ensure real-time, ultra-reliable communication between trackside signaling installations and the network's centralized control centers. The ARGOS technology is a key development in ERTMS Level 2 (see p. 23), the future European standard for rail signaling. **Deployed first in the Grand Est region in November 2025.**



Next-generation TGV

With its rollout scheduled for 2026, the 5th-generation TGV is modular, 97% recyclable, and, thanks to a redesigned and more aerodynamic composite nose, 20% more energy-efficient. The new TGV is packed with technologies, including more than 400 innovations such as the "greffon," a revolutionary backup battery system that enables the train to continue running in the event of a main power supply failure until it reaches the nearest station.

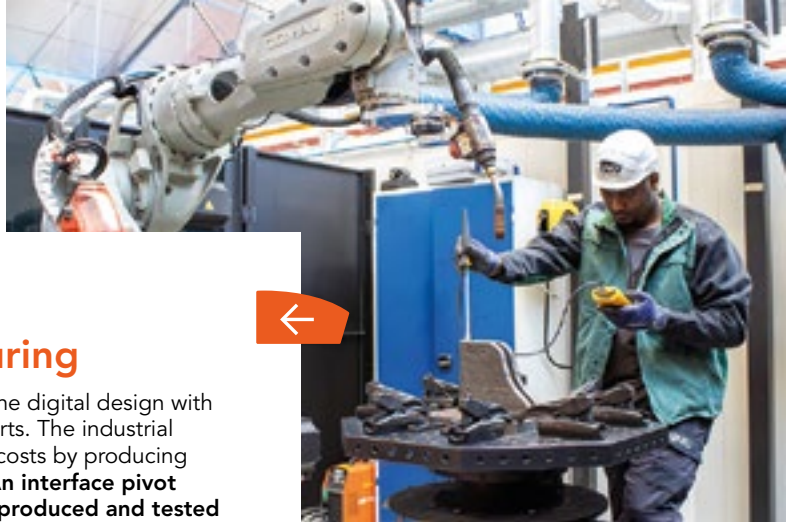


NExTEO, the future of operations in the Paris region

This next-generation signaling and train control system for mass transit is designed to significantly and safely increase frequency and punctuality. Trains are spaced using virtual moving blocks that adjust and maximize capacity in real time. **Currently undergoing tests on Line E, NExTEO represents a major step toward the automation of public transport in the Paris region.**

On-demand production with additive manufacturing

Additive manufacturing technologies combine digital design with the rapid production of metal or polymer parts. The industrial equivalent of 3D printing, they help reduce costs by producing components individually or in small series. **An interface pivot between the bogie and the car body was produced and tested in 2025 by ADDITIVE4RAIL** (see p. 24), a new alliance between SNCF, Centrale Nantes, and VLM Robotics that receives government support. This confirms the maturity of the technology and its potential.



Robotics: the first network maintenance robots

SNCF Group is beginning to investigate the potential of robotics on the rail network with PRIME. Equipped with laser sensors, this multifunction inspection robot measures track profiles and catenary wear. Thanks to its batteries, LiDAR, and GNSS, it can move autonomously over 12 km to perform pre-programmed tasks. Developed in the European IAM4RAIL project (see p. 24), it signals the arrival of modular, smart network maintenance. **By the end of 2025, PRIME had reached a level of maturity that will allow exploration of new maintenance functions from 2026 onward, with large-scale deployment targeted by 2030.**



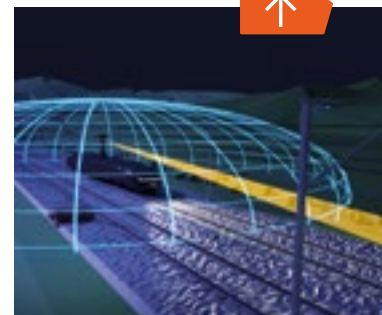
Battery trains

Battery-powered trains are emerging as one of the solutions for decarbonizing rail on non-electrified lines by replacing diesel with lithium-ion batteries. This innovation transforms existing systems into cleaner and more cost-efficient rail transport. **Three trainsets with a range of 80 km will be delivered in 2026.**



High-speed inspection with Mars LGV

The daily inspection of high-speed lines that is essential for safe train operations is entering a new era. These inspections, which were previously done by commercial trains, are performed more efficiently by the Mars LGV. The autonomous, battery-powered GoA4 unit travels at 230 km/h and inspects tracks using 360° sensors (LiDAR, radars) combined with AI analysis to detect anomalies in real time. **Large-scale deployment is expected by 2030.**



TELLi and DRAISY light train solutions

TELLi, with capacity for 150 passengers and a range of 200 km, is an innovative train meant to replace small diesel trains at their end-of-life. The more compact DRAISY, with space for 80 passengers and a range of 100 km, is designed to reopen small rural lines. Equipped with batteries and modular features (bicycles, micro-freight), both trains reduce infrastructure and operating costs, thus permitting denser regional coverage. **Regional authorities are expected to begin placing orders in 2028.**



Energy storage with Raccor-D

As France's largest industrial consumer of electricity, SNCF Group has carried out numerous innovation projects to bolster its energy resilience in terms of availability and costs. With Raccor-D, it is now possible to recover and store the 5% of braking energy previously lost on the 1500V network. Another benefit is that it allows energy from solar farms to be fed into the direct current network. **Trials to validate the technologies will be conducted at a test site being set up now in the Aude region.**



3D Factory and predictive network maintenance

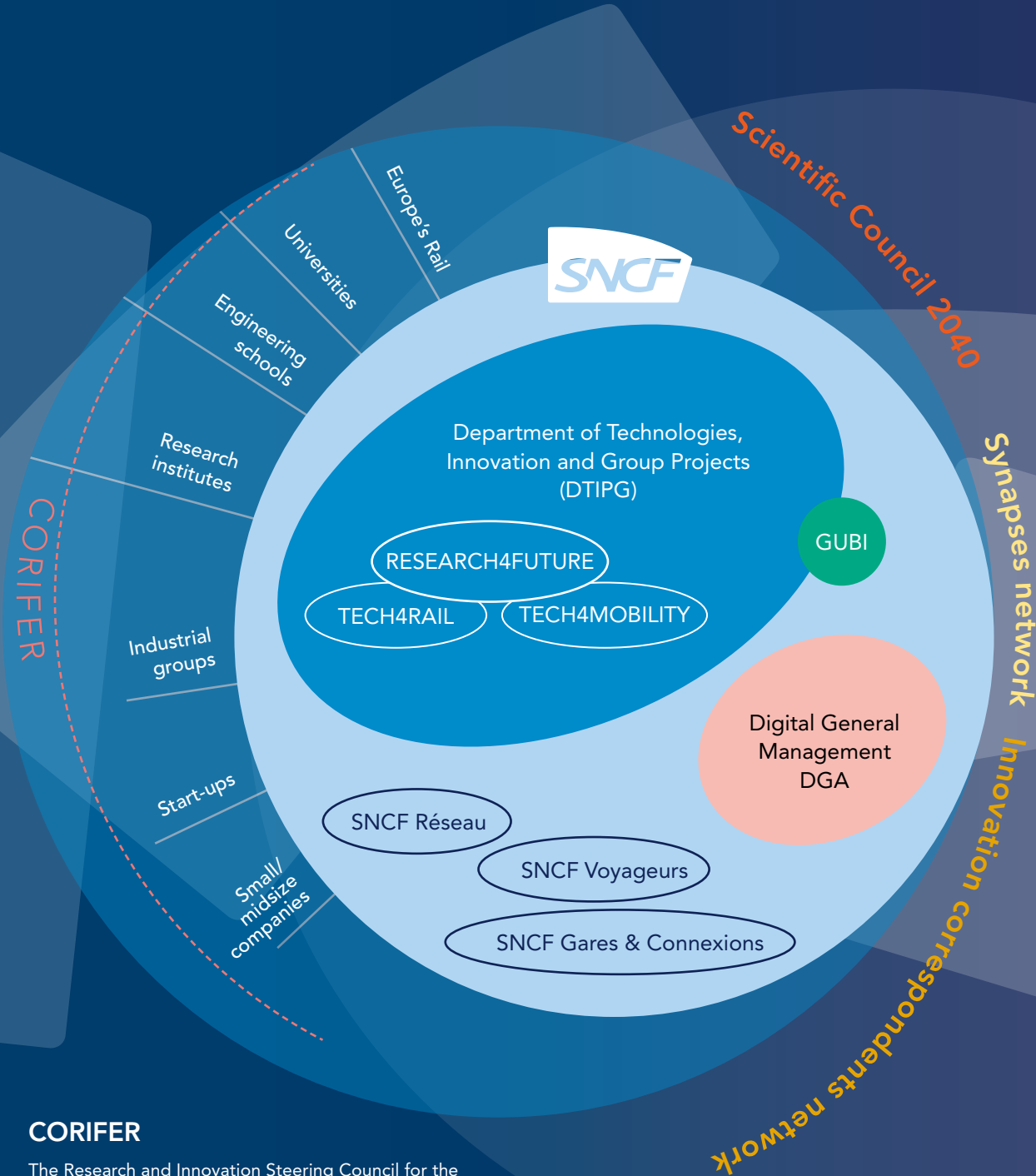
In this project, 3D LiDAR data collected by monitoring and measurement equipment is used to optimize network maintenance. The system covers the entire value chain, from data acquisition via drones or trains to point-cloud analysis using AI algorithms. It is a strategic tool for efficient predictive maintenance and enhanced safety. The 3D Factory is intended to make SNCF Group a global leader in LiDAR data processing in rail transport. The system enables large-scale clearance checks, catenary inspection, and ballast analysis. **Automated detection of fences, retaining walls, and vegetation is currently being developed to provide even better knowledge of infrastructure.**

automation

safety

predictive maintenance

The research and innovation ecosystem serving the growth of rail transport



CORIFER

The Research and Innovation Steering Council for the rail sector (CORIFER) serves as a forum for dialogue between government and the rail industry, guiding and optimizing support for innovation and directing industry projects toward public funding mechanisms, particularly those in the France 2030 plan.

The companies in SNCF Group and their subsidiaries carry out research and innovation projects in wide-ranging fields such as digitalization, decarbonization, energy efficiency, and improvement of mobility in the regions. These projects are also enriched by expertise coming from internal networks as well as from partnerships with the academic and industrial worlds.



- General Management Engineering, Asset Management and Maintenance
- General Management Customers and Operations
- Rail Open Lab
- Altametriz
- Sferis



- Strategy and Development Department with the entities of Rail Logistics Europe



- Strategy, Innovation & Operational Excellence Department
- Customers and Digital Department
- AREP



- Rolling Stock Engineering
- Traction Department
- Mass Transit Academy
- TER Innovation Department
- SNCF Connect & Tech

Synapses Network

Led by the Technologies, Innovation and Group Projects Department (DTIPG), this network is made up of 604 scientific and technical experts from all SNCF Group entities. Selected for renewable three-year terms, they provide vital support to research and innovation in six clusters: Energy, Sustainable Development, System Safety, Maintenance, Resource Optimization and Operations, and Mobility Services & Experience. Regardless of their organizational affiliation, they collaborate within each cluster to ensure a systems-based approach. The Synapses Network facilitates knowledge-sharing and develops expertise in key fields (artificial intelligence, cybersecurity, civil engineering, complex systems, and acoustics, among others) that are critical to the Group's future. Synapses experts are involved in many of the projects presented in this report.

Scientific Council 2040

This body brings together strategic and technical leaders from SNCF Group companies and subsidiaries to inform SNCF's governance on future challenges and technologies, guide the innovation and research strategy, and identify opportunities for differentiation and diversification in a competitive environment.

Single Patent & Innovation platform (GUBI)

GUBI's mission is to protect SNCF employees' inventions through involvement in the various stages of patent filing. It manages the entire SNCF patent portfolio, analyzes engineers' inventions, and assesses patent filing opportunities with business units. With 38 filings for the year, SNCF Group ranked 41st among French companies in the number of patents filed in 2025.

Innovation Correspondents Network

Bringing together representatives from SNCF Group companies and subsidiaries, this network steers innovation efforts, relying on two new groups created in 2024 within the DTIPG:

- Innovation Business Partners, who help translate business needs into projects and oversee their development
- Innovation Technology Leaders, who provide expertise in emerging technologies (AI, robotics, etc.) to guide research projects



Meet the people who drive research and innovation in SNCF Group companies



Innovation, a vital force for major transformations

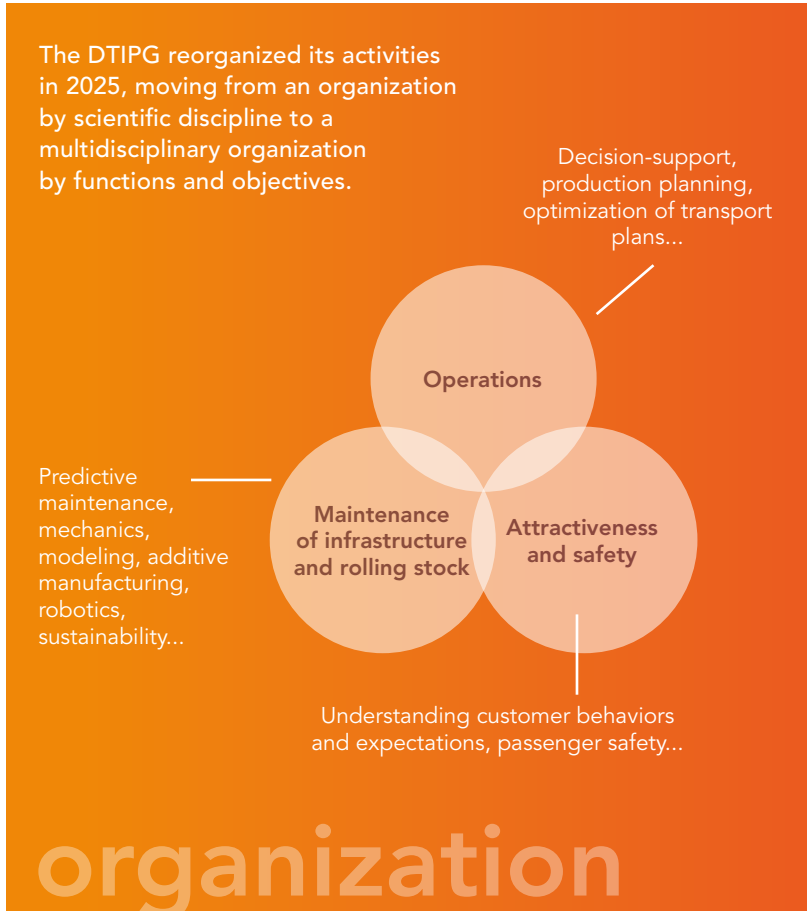
At a time when mobility is being reinvented in the 21st century due to environmental, digital, and societal transitions, innovation plays a key role in meeting new expectations of passengers and regions. In this context of transformation and market liberalization, the General Secretary's office, which I head, ensures the coherence of innovation policy in line with other strategic priorities and in particular CSR and safety. Innovation has always been in SNCF Group's DNA. The innovation projects we pursue with industrial, academic, and research institute partners must anticipate major challenges in rail transport related to mobility, ecological transition, industrial performance, and customer experience. This ambition reflects the company's determination to place innovation at the core of its strategy to sustainably support its transformations and address the challenges of the future.

Emmanuelle Cortot-Boucher,
Secretary General, SNCF Group



Innovation serving the activities of SNCF Group

Market liberalization and the development of a truly single, interoperable European rail space are prompting SNCF to rethink and adapt its research and innovation activities to new challenges. These developments are occurring at a time of instability that is bringing new risks, even as innovation cycles accelerate, driven by unprecedented technological revolutions.



Doing even more for Group companies

Each company has a dedicated Innovation Business Partner within the DTIPG whose role is to help identify its needs and, in collaboration with experts and project managers, propose new, innovative technological solutions. At the same time, Innovation Technology Leaders – high-level experts in fields such as robotics, artificial intelligence, telecommunications, systems engineering, and automation – possess key competencies for the exploration or incubation of subjects such as robotics for passenger services or trusted AI. Their work is shared with companies and the Scientific Council 2040. Created in 2022, the Scientific Council 2040 provides the Group's executives with

a forward-looking view of trends over the next 15 years. Its objective is to guide innovation strategy and research programs and identify means of differentiation for activities in competitive markets. The Scientific Council 2040 brings together experts to address major issues such as affordable rail, which was its focus in 2025.

Accelerating the transition from innovation to large-scale implementation

To give innovation greater impact, a "scale up" team has been created to prevent projects from falling into what is commonly called the "innovation valley of death" typically encountered during prototype development.

Regardless of the maturity level, and potentially even at an early stage of development, the goal is to support the transition from project to large-scale implementation. Depending on needs, the scale-up team proposes project management methods based on best practices, connects project leaders with all stakeholders (Innovation Business Partners, legal experts, GUBI, etc.) needed to ensure success, and helps identify and analyze risks while designing contingency plans. It also evaluates project phases to highlight potential financial benefits. The aim is to provide business units as early as possible with tangible elements to decide whether to adapt, pause, or stop a project, while ensuring decision traceability.



Strengthening the resilience and sovereignty of French and European railway systems is more crucial than ever.

Vincent Delcourt,
Director of Strategy and Technological Performance, DTIPG



Resilience and sovereignty: tackling the Group's challenges

SNCF Group, on behalf of all its companies, is focusing its efforts on the resilience and sovereignty of the rail system. This strategy contributes to the development of services for passengers and freight customers alike.

Resilience to natural disasters, resilience to cyberattacks, and economic resilience to rising costs (raw materials, energy, etc.) have become essential areas of research and innovation. They are crucial to the Group's ability to ensure service continuity and robust rail operations, regardless of external disruptions. It is also a matter of maintaining funding levels, which are essential to support network renewal and the

competitiveness of activities in an increasingly competitive environment. The growing prevalence of certain key technologies (telecommunications, energy, AI, robotics) raises questions about the Group's ability to integrate these innovations while preserving national sovereignty. These challenges also highlight the need to develop new capabilities so that the rail sector can meet its economic, environmental, and service commitments.

A systems approach

DTIPG adopts a systems perspective in coordinating the technological response to these new risks, with that response determined by the needs of each company in the Group. By taking into account interdependencies between subsystems (rolling stock, infrastructure, operations), DTIPG manages interfaces between the

Group's entities to achieve an optimal response. It can also form academic and industrial partnerships to consider joint investments to address these challenges.

European Directive 2022/2557 (Critical Entities Resilience) requires operators in the transport, energy, and digital sectors to **"strengthen the capacity of essential infrastructures to withstand and recover from physical and cyber incidents."**

Adapting to climate change

Adapting requires anticipating and managing the physical and operational risks (service quality) that the system will face in the coming years and decades. Based on a climate risk prediction tool developed in the **MINERVE** project in 2023, a decision-support model was created to provide a system-wide vision of these risks and to estimate the cost of inaction. This model was developed in collaboration with the Group's CSR department, SNCF Voyageurs, SNCF Réseau, SNCF Gares & Connexions, and Rail Logistics Europe. The methodology was tested in a Proof of Concept in the Rhône-Alpes region in 2025.

Energy

SNCF Group is the largest industrial consumer of electricity in France. Its energy bill surged during the 2022 energy crisis. Reducing consumption and integrating renewable energies thus became strategic priorities in addition to decarbonization, which had dominated its research and innovation efforts in recent years.

Economic performance and resilience are now the driving forces behind innovation projects, which are focused in several areas: energy efficiency, optimization of electrical installations and energy management systems through digitalization and AI, solar energy production and self-consumption, and the development of storage capacities.

The success of these projects will be crucial to protecting the Group from large market fluctuations, strengthening the reliability of energy infrastructures, and supporting future electricity needs linked to the increase in both high-speed traffic and Regional Metropolitan Express Services (SERM).

The creation of **SNCF RENOUEVABLES** in 2023 to exploit the solar potential of SNCF land assets to contribute to the growth of renewables in the Group's energy mix is another initiative in this area, and it will also call for further work on storage solutions.

Digitalization, AI, drivers of transformation

Digital technology is now found everywhere in rail operations, customer relations, and support functions. As advances in artificial intelligence lead to profound transformations, the resilience of information systems has become critical to ensuring the resilience of the rail system as a whole.

In June 2025, a strategic partnership was signed with Mistral AI. Its ambition is to go beyond the use of technological solutions and to engage in a truly transformative collaboration involving the entire Group. "Mistral AI's expertise will allow us to accelerate our transformation to achieve operational excellence and the highest level of service quality," says Julien Nicolas, SNCF Group Director of Digital and AI. Since 2024, SNCF Group and École Polytechnique, which are partners in the Artificial Intelligence and Optimization for Mobility Chair, have worked with Mistral AI on predicting train delays. AI also offers new possibilities in predictive

maintenance, passenger information optimization, transport planning, and other areas. The objective for 2026 is to bring teams on board to move beyond the experimentation phase. "Awareness is already growing thanks to SNCF GPT, which is now accessible to 100,000 employees through e.SNCF Solutions. Specific projects such as conversational agents for Security have already been carried out (see page 19)."

Reconciling digital technology and ecology

Digitalization and AI are playing increasingly larger roles in rail transport. Digital technology is not environmentally neutral, however,

and SNCF closely monitors its emissions. Generative AI in particular is resource-intensive, so the applications being developed use it only when necessary, while the Group's Digital and AI department prioritizes less energy-intensive models such as Small Language Models (SLMs). To raise employee awareness, an SNCF GPT calculator shows the CO₂ equivalent of each prompt generated.

Preventing cyberattacks

As the use of digital and AI applications expands, so does the risk of attacks. Cybersecurity is a top priority for SNCF Group. Investments remained substantial in 2025, both in technology and in human resources. The goal is to bring skills back in-house, recruit specialists, train IT teams, and continue raising employees' awareness of "cyber reflexes," which were defined before the Paris 2024 Olympics. A "red team" continuously tests the robustness of information systems to detect vulnerabilities and remedy them as quickly as possible.



The objective for 2026 is to bring teams on board to move beyond the experimentation phase.

Julien Nicolas,
directeur Numérique et IA du groupe SNCF

Sensors to detect cyberattacks

France's Military Programming Law 2019–2025 introduced a network monitoring mechanism to detect cyber threats via electronic communications operators. Extensive work is being done in conjunction with this mechanism to improve the reliability of cyberattack detection probes. The **RAISILIENCE** project, led by DTIPG and supported by France 2030, is being conducted with the Group's Digital and AI department, e.SNCF Solutions, and the probe designer Gatewatcher. Its objective is to create dynamic mapping of information systems, fed in real time by AI models, to precisely locate affected areas of the IS to enable faster, targeted responses.

Additional work is being done, first for SNCF Voyageurs, with a view to embedding detection probes on trains. Research into electromagnetic attack threats is also being conducted by Synapses Network experts. Given the complexity of these issues, SNCF Group participates in European projects alongside partners such as Alstom and Airbus Defence and Space.



Real-time analysis with the Sirius Next application

The growing use in all activities of IoT tools of the measurement-sensor type is being accompanied by the development of real-time analysis systems. These enable action to be taken regarding such things as emissions, the consumption of heating, electricity and fluids in buildings, and traction energy. For example, the Sirius Next application allows SNCF Voyageurs train drivers to reduce energy consumption by 3% to 5% by providing them with better knowledge of rolling stock, infrastructure, and route geography.

IA@Réseau

In 2024, SNCF Réseau launched the IA@Réseau initiative with the Group's Digital and AI department to structure AI deployment in the company. The AI Lab is central to this effort by acting as a catalyst. It uses a shared portfolio of use cases to focus efforts where AI will increase efficiency the most in SNCF Réseau's activities.

"Classic" AI is already widely used, particularly to predict disruptions on the 28,000-km network and to optimize maintenance and traffic management. Image and video analysis solutions improve safety and performance, for example, through the monitoring of infrastructure.

At the same time, the AI Lab is supporting the rapid growth of generative AI, which enriches technical documentation and speeds up analyses.

A private platform built around models such as OpenAI, Mistral, and Claude provides teams with safe access to these tools. Initial exploratory projects are focused on cross-functional efficiency, assisted writing, and engineering support.

The AI Lab also participates in an open innovation ecosystem with industrial partners and start-ups that focuses on AI applications for industry. Demonstrators developed with companies like Cleo, Kai, and Lunaar illustrate SNCF Réseau's ability to turn technology tracking into operational solutions.



Building trustworthy AI: a strategic challenge

The growth of AI in SNCF Group requires development of truly trustworthy AI, not only for reasons of cybersecurity, but also for effective use in critical systems. To achieve this, AI must be designed so that it is secure throughout its entire lifecycle as well as being robust, explicable, well-controlled in terms of training data, and compliant with both business and regulatory requirements. For example, work carried out in the Dependable and Explainable Learning (DEEL) research program, a Franco-Canadian initiative bringing together around fifty companies, or through partnerships with Numalis* shows that it is possible to develop AI systems capable of justifying their decisions and remaining reliable even in the event of disruptions or attempted attacks. "This approach is based on a systematic risk analysis for each use case (model, criticality, data, role in decision-making, software dependencies), along with close human oversight," explains Laurent Gardès, head of the AI platform at the DTIPG.

MONITOR and DAC: rail freight operations go digital

Rail Logistics Europe has partnered with the Marseille Metropolitan Transport Authority and the American rail equipment manufacturer Wabtec in the MONITOR project (Measuring Online Network Integrated Train Operations in Real-Time), which is funded by ADEME (France 2030) and the European Union (NextGenerationEU). One objective of MONITOR is to simplify time-consuming and physically demanding train preparation operations by automating brake testing. The project is also looking at the monitoring of train composition and integrity procedures and continuous tracking of wheels and axles to prevent incidents, thus enhancing operational safety.

The solution is based on autonomous electronic units communicating via LoRa (a low-speed, long-range radio technology), with data transmitted in real time to both the operator and the driver. The sensors developed

in the project are compatible with a wide range of wagon types.

After two years of development with support from the rolling stock engineering teams at SNCF Voyageurs, the system will be tested in 2026 on two routes, one in southern France and the other along the East-Southwest corridor.

MONITOR is in the same research field as the Digital Automatic Coupling (DAC) project, a major innovation initiative in Europe pursued as part of the Europe's Rail program, in which the European Commission is associated with numerous stakeholders in the rail sector (manufacturers, rail operators, and infrastructure managers, among others). Rail Logistics Europe is actively involved in this project, whose aim is to automate train coupling and uncoupling operations as well as to digitalize brake testing and train composition detection.



*The start-up Numalis develops ISO standards to facilitate the adoption of AI in industry. The ability to prove the reliability of artificial intelligence can help highly regulated industries such as transport overcome obstacles to certification and regulatory approval specific to these technologies.

Research and innovation for rail security

With the increase in drone flights over industrial sites and sensitive infrastructure, detection and identification of drones have become a key issue for the rail system. At the same time, advances in video processing and the emergence of multimodal AI models (text, image, sound, video) are prompting SNCF Group's Security department to adapt its methods and explore new solutions to protect assets and people.

Combating malicious drones

The Security department is studying the technological potential of drone detection and identification systems. The objective is to spot overflights early so as to describe and, if necessary, report activity of unauthorized remote pilots over SNCF premises. The most advanced solutions combine radio sensors, radar, optical and thermal cameras, and Wi-Fi network analyzers. These systems can detect drones with or without radio emissions, track their trajectories, and eliminate uncertainty. Since July 2025, the national Security command center has been processing alerts from these detection systems in real time. The Security department is cooperating with the French interior ministry, as the neutralization of drones remains the responsibility of law enforcement agencies. The next step is to identify and protect the most exposed sites in collaboration with entities in the Group.

Vision Language Models (VLM)

Generative AI for video surveillance

Several experiments with enhanced video were conducted during the Paris 2024 Olympic Games and then continued until 31 March 2025. Subsequent work carried out with the DTIPG focused on establishing a new legal framework and improving the performance of the tested tools for the most complex use cases (abandoned luggage, weapons detection, etc.). VLMs, whose development has accelerated rapidly since 2024, are being studied. By combining generative AI and computer vision, they can provide advanced comprehension of video and images by generating textual responses. Initial tests have shown strong potential for improving the exploitation of video surveillance images. However, this technology faces numerous challenges, including sovereignty, regulatory compliance, ethics, and the efficiency of algorithmic models.



A GPT security assistant to support SUGE operations

Following the deployment of SNCF Group's GPT tool in March 2025, the Security department, in collaboration with e.SNCF Solutions, developed its own AI assistant based on its full body of documentation (regulations, service notes, training materials, etc.). Operational rail security staff can instantly access the information they need through a conversational agent. This tool is not intended to replace professional expertise, but to make it available more rapidly in the field. Some 20 agents are currently evaluating the solution in operational conditions ahead of a potential rollout in 2026.

Working at the right scale through partnerships

To create links between fundamental research and rail applications and to operate at a larger scale, academic and industrial partners unite their visions and talents through diverse kinds of collaboration.

CHAIRS

SNCF Group collaborates in some twenty chairs, either through bilateral partnerships with academic institutions or multilaterally with other industrial entities. These chairs, which last between three and five years, are in multiple fields: modeling, risk and resilience of complex systems, artificial intelligence, robotics, telecommunications, innovation management and design theory, cybersecurity, digital twins, design, spatial planning, and sustainable mobility. They are a valuable way to pool skills and resources to reach the critical mass required to produce research, to share risks, and to develop a systems-level perspective that goes beyond the rail sector. They also make the Group more attractive to students.

The “Resilience of Complex Systems” chair, in which CentraleSupélec, EDF, Orange, Natran, GRTgaz, and SNCF Group have teamed up, is a perfect example. Through their work on modeling, risk analysis, and resilience optimization, these partners deepen their understanding of interdependencies between systems (“system of systems”).

FRAMEWORK

AGREEMENTS

These agreements formalize ongoing and preferred partnerships with representatives of the academic community, thus creating multiple opportunities for collaboration. In 2025, SNCF Group signed several framework agreements with institutions such as Université Gustave Eiffel and the École des Mines de Saint-Étienne. Others are planned with CentraleSupélec and the Institut Polytechnique de Paris.

CIFRE DOCTORATES

CIFRE agreements (Industrial Agreements for Training through Research) are three-party contracts between an academic laboratory, the National Association for Research and Technology, and SNCF Group. Doctoral students who wish to conduct research related to rail transport are given a three-year contract to do so in the Group. In 2025, there were 60 such students.

TECHNOLOGICAL

RESEARCH INSTITUTES

(IRT)

These centers of excellence certified by the French government under the Investments for the Future program, are innovation accelerators. SNCF Group collaborates with several of them:

- **IRT Railenium** (see sidebar opposite)
- **IRT Saint-Exupéry**, focused on artificial intelligence
- **SystemX**, specialized in modeling, particularly in relation to SERM projects
- **MP2**, focused on materials and processes, e.g., the Additive4Rail project (see p. 40)

“Since 2014, CORIFER has supported the rail sector's ambition to develop and accelerate innovations to advance its transformation.”

Carole Desnost,
President of CORIFER

A New Phase for CORIFER

SNCF Group's research and innovation activities are also part of the rail sector's innovation strategy defined and led by CORIFER (Council for Rail Research and Innovation). For the 2026–2030 period, the French government has identified four main priorities:

Priority 1

Climate and Environmental Resilience

Adapting the rail system to the effects of climate change and extreme events (floods, heatwaves, storms, changes in the behavior of fauna and flora, etc.).

Priority 2

Workforce and Operational Adaptability

Responding to pressures on human and material resources (network congestion, staff shortages, unavailability of equipment).

Priority 3

Contribution of Rail to Crisis Management

Positioning rail as a strategic tool in times of crisis (health, security, logistics, defense).

Priority 4

Economic Performance and Intermodality

Strengthening the competitiveness and attractiveness of rail in an integrated mobility system.

In 2025, CORIFER identified priorities on which future projects will need to focus.

Railenium: supporting the rail sector



Luc Laroche
president of IRT Railenium

“The IRT Railenium contributes to the French rail sector's capacity for innovation. Its objectives are to help ensure future employment and the availability of skills;

excellence at a global level; and ultimately the sovereignty of France and Europe in rail transport. Railenium provides the link between academia and industry to mobilize the expertise required for successful innovation projects. We ensure that everyone in the sector, including SMEs, has the opportunity to participate in these projects. Railenium was created in 2012 as part of the Investments for the Future Program. As such, we receive government financing through France 2030, with funds from the National Research Agency (ANR). We also participate in projects supported by CORIFER and, at the European level, by Europe's Rail. We provide and develop expertise in areas such as perception and autonomy, certification, digital traceability, and organizational and human

factors (see p. 44). We have general and scientific expertise in energy, simulation, asset management, artificial intelligence, and data science. Since our creation, we have carried out more than 80 projects with 140 partners and 90 employees.

With SNCF Group, we have done extensive work on autonomous trains. In 2025, we began partnering with SNCF Réseau in three new projects: MARS LGV, an autonomous mobile system for safely inspecting high-speed lines; ASTRRA, for rapid recharging of battery-powered trains by catenary while at a standstill (see p. 44); and LOCOMOTHYVE, a study of ways to use and store hydrogen to decarbonize infrastructure vehicles. And, of course, we remain open to participating in more projects with SNCF Group entities.”

Rail in Europe

Rail research and innovation in Europe are driven by two mutually reinforcing ambitions: first, to create a single European rail area based on a competitive, sustainable, and efficient transport system, with the aim of doubling rail's modal share by 2050; and second, to support the competitiveness of the European rail sector.

Europe's Rail (EU-Rail) is one of the most active organizations working to achieve these ambitions. Since 2022, this partnership has brought together stakeholders in the sector who are willing to invest alongside the European Commission. They include academic institutions and research centers, industrials, SMEs, infrastructure managers, and rail operators. EU-Rail is building the architecture of the rail system and providing solutions in terms of digitalization and integration of new technologies.

Scheduled to wind up its activities no later than 31 December 2031, EU-Rail has now reached its midpoint. The year 2025 was dedicated to preparing the second wave of projects, whose applications were submitted in February 2026. Two objectives will be pursued in these projects: first, reducing costs, notably through large-scale introduction of new technologies in rail asset management; and second, ensuring the technological and economic sustainability of major transitions required by the Single European Railway Area, particularly FRMCS in the short term and DAC in the longer term.

On 5 and 6 February 2025, ADIF, the Spanish equivalent of SNCF Réseau, hosted the FP2-R2DATO Midterm Event at its research center in Malaga. With a total of €160 million allocated to its activities, it is the largest flagship project launched by Europe's Rail in its Innovation pillar in 2023.



A focus on system vision with EU-Rail

The major functions – operations, management of rolling stock and infrastructure assets, and energy management – are being harmonized to move toward the Single European Railway Area (SERA). The regulatory framework is defined by Technical Specifications for Interoperability (TSIs), supplemented by a multitude of voluntary specifications: French,

European, and international standards, Eurospecs, and other documents produced in the System pillar. In this pillar, SNCF Group advocates aiming for modular and scalable solutions as well as defining clear and realistic migration steps. In 2025, a first version of the list of applicable deliverables was published, along with cybersecurity-related rules.

In this pillar, SNCF Group advocates aiming for modular and scalable solutions as well as defining clear and realistic migration steps.



The future operating and control-command system

An innovative architecture for trackside signaling is being defined. The ARGOS technology, developed through an innovation partnership between SNCF Réseau, Hitachi Rail, Alstom, and Compagnie des Signaux, appears set to play a role at the European level. Its suitability, which is supported by initial work with German infrastructure manager DB InfraGO and Italy's RFI, is due to its modularity: in France, ARGOS consists of three products from different suppliers, all based on the same principles.

Meanwhile, the revolution in on-board signaling driven by the Open CCS On-board Reference Architecture (OCORA) initiative is progressing, with major changes in business models highlighted. A first architecture proposed for on-board safety and signaling equipment and validated in December 2025 offers alternatives to current speed control systems that are compatible with ERTMS. It meets the same criteria of modularity, scalability, and independence between hardware and software components. These developments have led to proposals for revising the CCS TSI (control-command and signaling).

Harmonization of operational rules

The harmonization work led by SNCF Group and DB following their signature of a cooperation agreement in 2025 and other initiatives, particularly by Denmark, have resulted in a proposal of changes to the OPE TSI (rail operations). These efforts rely on ETCS Level 2 functionalities. These operational rules are intended for drivers and infrastructure staff in the event of incidents on the network, e.g., passing through level crossings in failure mode or coupling rolling stock. However, some of these rules remain complex to harmonize. In France, they will be fully applied when ERTMS is deployed in the Marseille-Ventimiglia High Performance project.

From 2G to 5G with FRMCS

FRMCS (Future Railway Mobile Communication System), which is designed with a modular, scalable approach and a separation between radio communications and rail applications, will gradually replace GSM-R after 2030. Based on 5G and MCx technologies (call prioritization, group calls, etc.), it will provide added-value services such as video-assisted shunting and remote driving. Prototypes will be tested in late 2026 on the Paris–Brussels and Metz–Luxembourg lines. SNCF Réseau has already used the technical specifications to compile a catalog of products to be developed with industry partners from 2027 onward. This is a major transition: 5,000 vehicles in France and 50,000 in Europe must be made compatible, and 200,000 km of track must migrate. These developments come out of the French and European projects FP2-R2DATO, 5GREMORA, 5G-RACOM, and Coeur 5G SNCF.

SNCF Réseau has already used the technical specifications to compile a catalog of products to be developed with industry partners from 2027 onward.

Focus on three advances in the Innovation pillar

FP2-R2DATO

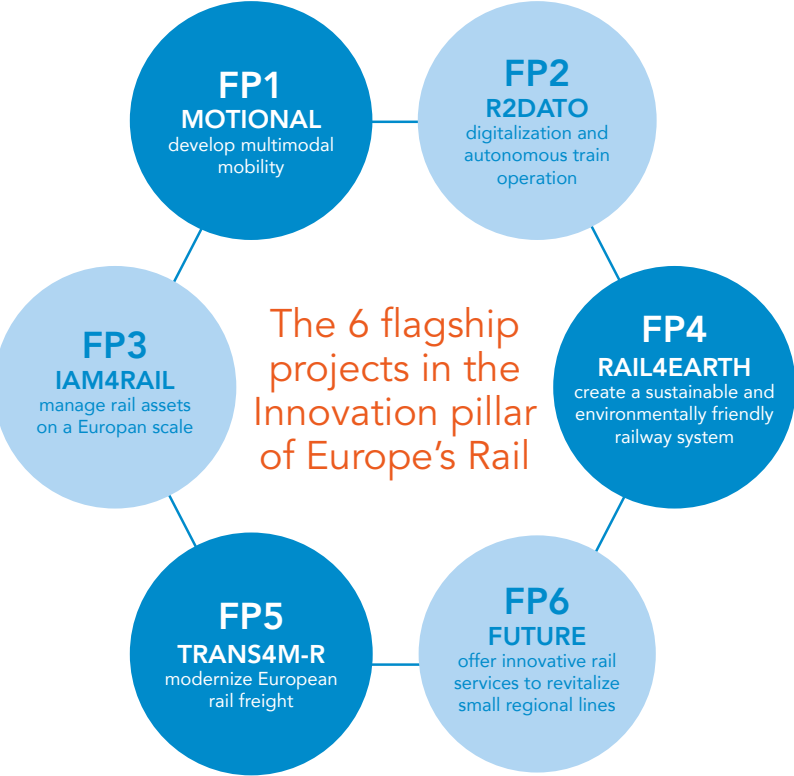
Coordinated by SNCF Group, this project defines use cases for autonomous trains and the required technologies. Most prototypes are nearing completion, and demonstrators have been tested for key technological components: perception for obstacle detection, digital signaling with moving blocks, geolocation, communications, and IT platforms. Several demonstrators have confirmed the relevance of these solutions for moving trams autonomously to their depot or trains on mixed-use tracks between a depot and the nearest station.

FP6-FUTURE

The objective of this project is to design a regional transport model for low-density areas that is economically, socially, and environmentally sustainable and that can be used across Europe. Frugal signaling is a key issue. The idea is to leverage ETCS functionalities to achieve suitable performance levels for each line. SNCF Group is producing safety pre-analyses for CCS and telecom solutions (technological bricks and demonstrators). In 2025, it shared the work done with Hitachi Rail in the TELLi project concerning frugal signaling and with Texelis on onboard-ground connectivity (see page 28).

FP3-IAM4RAIL

This project on intelligent asset management validates approaches for modeling and gaining a better understanding of the aging and deterioration of infrastructure and rolling stock as well as for improving resilience and optimizing maintenance. SNCF Group is particularly interested in additive manufacturing, which can be used for the on-demand production of spare parts for rolling stock, and for the development of robotics for infrastructure. In the area of additive manufacturing (see p. 9), partners are studying materials that meet the safety criteria for rolling stock as well as cost criteria (under €100/kg). They are also investigating its ability to produce large components with a dimension of about one meter. At the end of 2025, two composite materials had been qualified. Two prototype TGV sanitary modules are being manufactured at IPC, an industrial technical center for plastics and composites, and at Lines Manufacturing, a French start-up. They will be tested in 2026. The PRIME infrastructure inspection robot has attained Technology Readiness Level 6. Within five years, SNCF and its Swedish and Norwegian partners aim to greatly expand the use of this solution. Equipped with laser sensors and cameras, PRIME measures track profiles and catenary contact wire wear. Thanks to its modular design, new accessories will be added in 2026 for vegetation control along tracks, corrosion removal, and the repainting of catenary poles.



After EU-Rail

A new decade to transform research and innovation investments into solutions.

The Draghi report emphasized that preserving the competitiveness of the European Union was essential considering that it would be contending with competition from China, geopolitical tensions, and resource shortages. Rail must maintain its rank as a key player, including for military mobility, and overcome the obstacles to obtaining the investments required for its renewal and modernization. Reducing costs, simplifying systems, ensuring economical sustainability of technological change, and strengthening resilience to climate change and cybersecurity are key issues in thinking about how to construct the rail component of the Horizon Europe 2028–2034 program. All these subjects are influencing preparations for the successor to Europe's Rail. The EU-Rail governing board, whose members are industrial firms, transport operators, and the European Commission, has estimated the funding needed at €3 billion for research and innovation, partly coming from the EU, and €15 billion for pre-deployment of innovations. By comparison, the aviation sector estimates it would need €66 billion if its economic weight were equivalent.

* <https://www.la Tribune.fr/entreprises-finance/industrie/aeronautique-defense/l-aviation-europeenne-a-besoin-de-66-milliards-d-euros-pour-sortir-l-innovation-de-la-vallee-de-la-mort-1027521.html>

Strategic priorities of the EU-Rail governing board after 2028

At the European Commission's request, EU-Rail's governing board identified four priorities for a future partnership:

- Continue simplifying and integrating the European railway system
- Modernize rail operations, particularly with digitalization of freight transport
- Work on the resilience of the rail system regarding climate change, cybersecurity and military mobility to achieve greater robustness and control
- Facilitate through innovation the development of a coherent European network of high-speed corridors by connecting existing networks (Lyon-Turin tunnel, Fréjus, Brenner, etc.)

Challenges identified by ERRAC

The European Rail Research Advisory Council (ERRAC), an open organization bringing together all European parties for the purpose of guiding EU funding, laid out its position in the document Future Track – Vision and Goals for Rail Transport Research & Innovation in a Changing Europe, which was approved on 4 December 2025. It is structured around several challenges:

- Increasing capacity and improving the agility of the railway system
- Making rail transport more sustainable and resilient
- Meeting the needs of freight customers as well as urban and regional transport users
- Developing a supportive digital ecosystem
- Promoting harmonized and standardized approaches to facilitate rail operations

European seminar: "Reduce costs, harmonize rules and processes, and find innovative solutions to promote market-oriented railways"

About 100 representatives from across the European railway sector, including SNCF Group represented by the DTIPG, met in Copenhagen in late 2025 to discuss ways of improving the competitiveness and efficiency of rail transport in Europe. With costs rising and investment needs growing, a clear consensus emerged: it was essential to simplify the rail network, reduce costs, and leverage innovation to construct a more attractive, sustainable, and interoperable railway sector capable of doubling its share in passenger and freight mobility.

**Interview with
Kian Gavage**
Deputy Managing Director,
Engineering, Asset Management
and Maintenance, SNCF Réseau



Innovation is a key means of addressing a dual challenge: combating the aging of the national rail network and shaping its future with the aim of significantly increasing traffic. To better maintain infrastructure without excessively disrupting operations, predictive maintenance is essential. The key issue is using the vast volumes of data collected on the condition of the network, notably with our 3D Factory, as well as satellite data such as the detection of earth movements. Thanks to the development of algorithms and decision-support tools, we can more accurately predict how network systems and components will evolve. Totatis, for earthworks, and Platipus, for foundations in aquatic environments, are excellent examples. We are also focused on designing more efficient, durable, and easily maintainable systems that inherently take account of factors related to climate change.

For the network of the future, digitalization of signaling is a prerequisite for safely increasing traffic. This digitalization is being accomplished with ERTMS, NExTEO, and ATS+ in the Paris region, as well as with ARGOS, a new interlocking technology.

For small regional lines, we are working on more streamlined digital signaling solutions with adapted functionalities.

Innovation also means less physically demanding work for our staff with no compromise of safety and developing network monitoring systems that consume fewer resources and feature major innovations such as MARS LGV. To prevent disruptions, wildlife deterrent systems show great promise, as does SURFO, a fiber-optic monitoring system used to detect infrastructure defects or intrusions. Its deployment as part of the Marseille–Ventimiglia High Performance project for rail monitoring will support a new maintenance method on this line, where signaling will be fully digitalized, with next-generation axle counters replacing track circuits.

For the network of the future, the digitalization of signaling is a prerequisite for safely increasing traffic.

Innovation goes hand in hand with collaboration: all these challenges are addressed thanks to the strength of the Group and partnerships with industrial players, start-ups, SMEs, and more. The Rail Open Lab enables efficient innovation “sprints,” and the Alliance of Industry and Engineering for Rail Networks mobilizes the sector in connection with the Rail Open Lab and elsewhere. And let’s not forget the academic and scientific world: the stimulating participation of engineering students in our research is the best guarantee of a dynamic and growing innovation activity.



A dirigible drone for track monitoring

Track monitoring vehicles, drones, and helicopters are among the means used to monitor rail infrastructure. SNCF Réseau is also exploring other technologies such as the HyLighter, a dirigible drone designed by the start-up HyLight. Less intrusive than a track monitoring vehicle, which requires train paths, and more environmentally friendly than a helicopter, it carries more measuring instruments than a conventional drone and can cover longer distances. The HyLighter operates on batteries. It is piloted from a control center in Brétigny-sur-Orge and by operators positioned approximately every 10 km.

In addition to its high-definition cameras (thermal, infrared, etc.), SNCF Réseau added a 3D LiDAR system for its first test in June 2025, where 100 km of the East High-Speed Line were inspected over 3.5 days. The condition of tracks and embankments, bird nests on pylons... nothing escaped the cameras. The 3D point clouds generated by the LiDAR were also used to feed the 3D Factory production chain (see sidebar). A second test is planned in 2026 on the Paris–Marseille high-speed line. The HyLighter could also prove useful on small regional lines and in hard-to-access areas such as mountainous regions.

PARTNERS
HyLight, Riegl (3D LiDAR)

3D Factory: highly detailed knowledge of railway assets

The 3D Factory brings together SNCF Réseau, Altametrus, and TREALIS for the processing of LiDAR data for rail operations. From data acquisition to exploitation, the goal is to obtain highly detailed asset descriptions and develop innovative applications for maintenance teams and asset managers. After focusing on catenary geometry, ballast profiles and volumes, and clearance analysis, the 3D Factory is now exploring other use cases such as the monitoring of fences and retaining walls and analysis of vegetation.

Smarter beacons for speed control

Train speeds are checked by trackside “KVB” beacons that send signals captured by onboard antennas. This technology, deployed nearly 30 years ago, remains the most widely used. However, these beacons lack unique identifiers, and their exact locations are not recorded. The Sherlock tool (Heuristic Expert System for Recognition, Localization, and Optimization of KVB Control) is designed to address these issues. It is also intended to extend the capabilities of KVB remote diagnostics by modeling the occurrence of failures for both onboard and trackside systems. In the event of a speed control failure, it will be possible to determine whether the fault originates with the beacon system or the train and identify the specific beacon involved. The Sherlock database catalogs beacons, tracks, and failure histories. It relies on, among other things, a rail localization module that uses map matching to correct imprecise GPS data and thereby provide a precise track location. Another module reconstructs the operating history of beacons based on remote diagnostic data. After two years of development, the tool has proven its effectiveness using simulated data. The next step? To compare results with real-world data before possible deployment.

PARTNER
Eumetry SAS

100,000
KVB-type beacons
on the network

More cost-efficient signaling for small regional lines

The Technology, Innovation and Group Projects Department, and its industrial partners, including SNCF Réseau, are developing “frugal” signaling solutions. Their performance and safety levels will be adapted to future light trains (TELLi, DRAISY... see p. 47) operating on small regional lines. These solutions will rely on secure public telecom networks rather than SNCF Réseau’s wired networks. For TELLi, signaling will be fully digitalized, with interlocking systems centralized on remote servers such as ARGOS (see p. 9). Onboard systems will be preferred over trackside equipment: signals, track circuits, and axle counters will disappear, and there will be fewer beacons. For DRAISY, operating rules will halve the number of signals and their unit cost. They will be authorized and tested starting in 2027 on the Sarralbe–Kalhausen line (Grand Est), with commercial operations planned as of 2028. Identifying possibilities for reducing signaling system costs is crucial to making small regional lines financially viable again.



Scheduling and traffic management

Techniques such as discrete-event simulation*, operations research, machine learning, and innovative human-machine interfaces have already proven effective in solving complex problems in multiple industries. SNCF Réseau is interested in them to support controllers who manage traffic in real time and schedulers who plan and adapt theoretical timetables for longer periods. Among the projects underway are two carried out by the Technology, Innovation and Group Projects Department. The aim of the ETR (Real-Time Operations) program

is to develop new predictive and decision-support tools for operations management. Some of these are already being tested, including: automatic and predictive detection of conflicts between trains and between trains and works; algorithms for train rescheduling recommendations; and visualization interfaces for simulations on a time-space graphic. The goal of the HARPE project is to reconstruct timetables rapidly after high-impact incidents. Several modules have been developed and tested:

- A visualization module to describe the incident and its impact
- A module to break down the problem into several sub-problems to be solved separately
- A module to aggregate the results of the sub-problems to produce a valid timetable

In 2025, both projects pointed to the need for more accurate simulations, multi-scale traffic forecasting and modeling, and simplified data visualization. Work will be done on these subjects in 2026.

* Modeling of changes in the status of a system due to a series of events occurring at precise times.

5G/MCx hybridization for FRMCS and Industry 4.0

The “Coeur 5G SNCF” project consists in exploring private 5G mobile networks and Mission Critical Services (MCx) layers and testing possibilities for hybridization. This project has two components: the replacement of GSM-R (based on 2G) by the Future Railway Mobile Communication System (FRMCS) starting in 2030, and the increase in Industry 4.0-type needs in maintenance centers. The goal is thus to anticipate a future ecosystem combining FRMCS private networks with railway networks to ensure seamless service continuity. After studying SNCF use cases and telecom architectures, the development teams completed prototypes of two 5G cores and two MCx layers in mid-2025, along with their hybridization. The third and final phase, testing of these solutions in the SNCF ecosystem, began in 2026.

PARTNERS

Kontron, Obvios (from IRT b-com), Airbus
Project funded by the French state (France 2030), administered by Bpifrance

More accurate localization

Global Navigation Satellite Systems (GNSS) have many applications, from infrastructure monitoring to signaling. However, to ensure performance meets the requirements of a rail environment, they must be combined with inertial navigation technologies and data mapping. Here are two of the main projects.

Localization to guarantee optimal railway safety

In the CLUG, CLUG 2.0, and R2DATO projects, European GNSS systems (Galileo and EGNOS) are integrated into train localization solutions to achieve the highest safety level (SIL4). The solutions in question are being developed for the future European signaling system, ETCS, and particularly its Level 3, which is based on digitalized block sections and moving blocks. A prototype from CLUG 2.0 was tested using real data collected onboard two commercial trains in Switzerland and France. It will be strengthened along with seven other solutions developed by rail industry players by May 2026 in the R2DATO program. The results will help validate achievable operational performance and consolidate the shared architecture of these solutions.

ERTMS Laboratory in France (LEF)

Security localization solutions based on GNSS and EGNOS will be introduced by means of European technical specifications. In the meantime, the LEF is developing a test bench for these solutions, along with functionalities related to autonomous driving and cybersecurity. The laboratory is thus preparing to certify the various systems that will make up ETCS and its interface with trains. From the end of 2026, it will work with its European counterparts and the European Space Agency to define test scenarios for critical failure events affecting GNSS and inertial sensors as well as a protocol for the qualification and certification of secure localization solutions at the European level.

* Thanks to a network of 40 measurement stations across Europe, EGNOS (European Geostationary Navigation Overlay Service) guarantees the reliability of GPS positioning signals, and soon those of Galileo signals too, by validating their integrity in real time. Originally developed for aviation navigation, EGNOS is now demonstrating its usefulness for rail operations. The service is provided by the certified operator ESSP (European Satellite Service Provider).

Localization for better monitoring

New localization sensors based on GNSS technologies and inertial measurement units are currently being deployed in early 2026 on three track monitoring vehicles. Their measurements achieve sub-meter accuracy, thus allowing maintenance teams to determine as precisely as possible where work is required, including in tunnels. As part of the Commercial Train Monitoring program (STC), trainsets used to measure track geometry (and soon, catenary geometry as well) will also be equipped with instruments combining GNSS and inertial systems, which are more accurate than their current GNSS receivers. SNCF Réseau and the Technology, Innovation and Group Projects Department (DTIPG) are working together to select and exploit these essential components for onboard monitoring.



Securing and scaling up worksites

To keep pace with the growing amount of work needed on the rail network and to maximize the time available to do it, SNCF Réseau must accelerate procedures for securing worksites, a prerequisite for carrying out any operations on the tracks. This is the purpose of the **SI Travaux** system, which combines solutions developed by SNCF Réseau with its teams in the field. This system replaces procedures previously performed by phone or on paper with a shared digital workflow for everyone involved. It guides them step by step through the essential stages, such as closing a track to traffic or cutting off power to the catenaries. SI Travaux is based on three complementary innovations:

- **A collaborative platform** that centralizes procedures and coordinates participants
- **Connected safety equipment**, which can be activated remotely and monitored in real time
- **A geolocation service** for construction machinery to improve supervision and prevent incidents

Following a pilot phase in 2024 in Alsace and the Paris region, nationwide deployment is underway now. There are numerous proven benefits: enhanced safety, time savings for workers, and smoother coordination between teams performing different jobs.

PARTNERS
Sopra Steria, INTM, Axy

4,000 requests for track closings every month

160 km/h after a turnout replacement

Seven turnouts were replaced on the Paris–Lyon high-speed line near Solers as part of operations carried out in May and June 2025. Between each operation, trains were able to run at 160 km/h instead of the usual 120 km/h – a world first! This performance is the result of the analysis of data collected during work at Montanay, north of Lyon, in 2021. There, SNCF Réseau had installed numerous sensors to collect as much data as possible, and analysis of this data confirmed the feasibility of increasing the speed to 160 km/h. Experts were able to develop the appropriate methodology based on numerical modeling and track tests. In 2025, sensors reinstalled on the Solers worksite monitored in real time the events surrounding the reopening of the tracks and validated projections. This methodology was applied again in January 2026 during the replacement of an expansion joint device on the Bretagne–Pays de la Loire high-speed line, foreshadowing a fundamental change in the way such operations will be carried out at future worksites.

PARTNER
Eiffage Rail

14 train paths maintained at 160 km/h compared with 11 at 120 km/h



Preventive rail reprofiling

Although highly effective in reducing rail fatigue defects caused by wheel–rail contact, preventive reprofiling is a very time-consuming operation. To adapt maintenance cycles to actual needs, the **Prédirail** software was developed to identify rail segments most at risk of incurring defects. The Prédirail software is based on a machine learning model that incorporates observations collected during inspection rounds and on stochastic calculation instruments (the study of random phenomena). It produces a multi-criteria analysis based on data related to infrastructure characteristics (curves, gradients, rail type, etc.), traffic intensity, and external factors such as weather.

The relevance and consistency of the software were confirmed in April 2025 following on-foot inspections conducted near Tours with the Infrapôle Centre. In October, in the same area, Prédirail detected early-stage cracks that were undetectable using conventional ultrasonic technologies. The next steps are to co-develop suitable visualization interfaces with operational teams and to revise maintenance standards. The predictive model could also have other applications such as adapting monitoring rules.

PARTNERS
ENS Paris-Saclay, Eurobios, Mews Labs

+15% lifespan for rails **#** **-15%** contact fatigue defects



Understanding the dynamics of rail lubrication

Lubricating the wheel–rail contact protects against wear and cracking. Lubricant is sprayed every 30 seconds onto the wheels of moving trains and then deposited on the rails.

The **Lubrail** project aims to better understand this phenomenon and assess the impact of lubrication on rail resistance to contact fatigue. The objective is to determine

optimal lubrication in terms of quantity, quality, and frequency to improve both technical and economic efficiency. In particular, the project is comparing the performance of bituminous oil with biodegradable greases that are increasingly used by SNCF Voyageurs. From 2024 to 2025, lubricant performance tests for oil and greases were carried out in the laboratory using a 1/10 scale test bench reproducing curved wheel-rail contact. Initial results will soon be compared with effects observed in real operating conditions by maintenance teams. At the same time, Lubrail is entering a second phase involving the testing of lubricants deliberately degraded with contaminants (dust, sand, silica, etc.) to replicate real conditions more closely. Lubricants are also artificially aged to evaluate the biodegradable properties of new products.



Recycling catenary contact wires

Copper is an essential component of the 50,000 km of catenary lines in the French rail network. In today's very tight market, securing supplies of this water- and energy-intensive resource that is costly to extract is critical. This is the objective of the CAT-FIC project, launched in 2023. Two approaches were studied: closed-loop recycling of catenary contact wires and reuse on secondary lines in the network. Only the first approach was retained. Laboratory teams demonstrated that the electrical, mechanical, and microstructural properties of recycled wires are equivalent to those of new wires. The process? Contact wires would be delivered to the SNCF Réseau industrial site in Le Mans and processed by a machine specially designed by MTB Recycling to produce pure copper granules. These would then be used to manufacture new wires. The quality control process, which takes account of the effects of recycling, is currently being validated. The next step is to obtain authorization to test this loop under real conditions with the aim of conducting a measurement campaign by the end of 2027.

PARTNERS
MTB Recycling, CIMES, LamCube Centrale Lille
Certified by the TEAM2 competitiveness cluster

- 50%
carbon emitted
with recycling vs.
production of new wire



Monitoring the thickness of catenary contact wires

Wear on catenary contact wires is regularly monitored to plan maintenance, schedule replacements, and prevent breakages. Out of 400 catenary-related incidents per year, an average of five to ten are caused by excessive wear. The aim of the CAMESCAT project, launched in 2015, was to replace half of the fleet of 17 aging inspection vehicles with a more efficient system that would be faster and less costly. CAMESCAT is based on laser profilometry and combines three sensors, each equipped with two lasers and two cameras. Mounted on a pantograph, they can reconstruct the contact wire at a rate of 6,000 images per second on vehicles traveling up to 120 km/h (compared with 5 to 15 km/h previously) and assess the remaining

surface area with a precision of 3 mm². Maintenance teams now have access to an interface displaying both measurements and visual representations of the contact wire. After an upscaling phase conducted with Infrabel, CAMESCAT is now installed on a TREALIS (formerly Eurailscout France) vehicle that surveys the network once a year. A second unit is to be equipped with the system by 2030. In 2025, data were collected under real operating conditions, and delivery processes were established, paving the way for production in 2026.

PARTNERS
Upscaling: TREALIS (ex-Eurailscout France), Infrabel
Development phase: i-TRANS-certified project (FUI program)

1,500 to 2,000
minutes lost per catenary incident on average



Catenaries under close surveillance

A catenary break severely disrupts train operations and requires long and costly repairs. As part of rolling stock certification campaigns, SNCF Réseau installed automatic catenary measurement stations (PMCA), which measure catenary uplift at four consecutive points as trains pass.

These results are supplemented with contextual data: train characteristics (trainset type, train composition, number of pantographs, etc.) and weather conditions (temperature, humidity, wind speed and direction). To better exploit these data, SNCF Réseau and the Technology, Innovation and Group Projects Department launched the PMCA project, using data science and statistical learning techniques. In 2025, teams developed algorithms to predict maximum uplift values and to estimate missing or unreliable data in case of sensor failure. PMCA has now entered the pre-upscaling phase. In 2026, predictive models will be used to simulate catenary uplift based on contextual factors (rolling stock, weather, etc.) and to build an alert system for abnormal uplift events.

PARTNERS
Signals and Systems Laboratory, CentraleSupélec

Next-Generation public level crossings

Improving safety at level crossings in stations without footbridges or underpasses requires a better understanding of passenger behavior. The NG Next-Generation Public Level Crossings (TVP NG) project drew on expertise in behavioral, cognitive, and biomechanical sciences (gaze, movement, reaction time, etc.). Seven solutions were designed and tested from April to July 2025 on a mixed-reality platform created by IRT Railenium in Valenciennes. Participants equipped with sensors and VR headsets moved through life-size recreated stations. The experiment made it possible to observe how different solutions influenced risk-taking behavior. Recommendations for safety system

design were validated, particularly regarding the type of information (visual, auditory), content, and placement in the environment. Two solutions fully demonstrated their capacity for drastically reducing accidents. Prototyping is underway, with trials scheduled in Vaires-sur-Marne in May 2026.

PARTNERS
IRT Railenium, SCLE, LAMIH / Polytechnic University Hauts-de-France

- 90% risk-taking



Preparing essential skills for tomorrow's network

In 2025, SNCF Réseau, Vossloh, Colas Rail, and TSO, with support from the Occitanie Region, created the association UBIRAIL. It brings together industry players, training organizations, schools, clusters, and public agencies to share educational content. All rail professionals in France have access to it. Its digital platform already offers over 60 modules using virtual reality, 360° videos, and 3D models. Presented at the VivaTech exhibition, UBIRAIL won the "Skills and Jobs of the Future" call for projects in the France 2030 program, qualifying it to receive State funding.

From the Rail Open Lab to the Alliance for Rail Network Industry and Engineering

In just a few years, the Rail Open Lab (ROL) has become a key accelerator for open innovation in rail infrastructure. Created in 2018 by SNCF Réseau, RATP, the Fédération des Industries Ferroviaires, and SERCE (which represents companies focused on the energy and digital transition), it brings together industrial companies, start-ups, infrastructure managers, and academic/research actors. Since 2025, Infrabel, the Belgian infrastructure manager, has also been among its 43 members, pointing to the interest it has aroused outside France.

Its role? To assess innovation projects proposed by members, who are infrastructure managers or industrial players. When at least one industrial partner and one infrastructure manager collaborate, 4-month, real-world experiments are conducted, with each participant funding their own contribution. Intellectual property protection is rigorous, and successful use cases often lead to large-scale deployment outside the ROL.

Among the notable projects in 2025: SNCF Réseau worked with LUNAAR on connected glasses with AI and voice control that enable maintenance operators to obtain diagrams of the installation or equipment they are working on, even in no-network zones. Vapé Rail International came up with EaVision, an AI-enabled camera that detects incorrect switch positions and alerts operators in the cab of the work vehicle with a visual and audible signal. Another promising innovation from RATP and the start-up Dotflow is a radio-based positioning system for maintenance vehicles without GPS, which is especially useful in tunnels.



A strong network created with the Alliance de l'industrie et de l'ingénierie pour les réseaux ferrés

The AIIRF (Industry and Engineering Alliance for Rail Networks) was created in June 2025 by SNCF Réseau, RATP Infrastructures, the Fédération des Industries Ferroviaires, the Syndicat des Entrepreneurs de Travaux de Voies Ferrées de France (SETV), and Syntec-Ingénierie, with SERCE joining in late 2025.

The aims of the Alliance are to accelerate the modernization and development of rail infrastructures, to preserve and develop the know-how essential to the network to support French industrial sovereignty, and to promote best practices in safety, the ecological transition, and other areas. The Rail Open Lab is one of the primary partners of the Alliance and in particular its "Efficiency" working group, which is focused on innovation and data sharing issues.



Pierre Daburon,
President of the
Rail Open Lab,
SNCF Réseau

There is no client-supplier relationship in Rail Open Lab. Dialogue between partners puts everyone on equal footing. Everyone presents ideas, and if added value is identified, there will naturally be a partner ready to test it."

Interview with Cédric Allio

Director of Strategy, Operational Excellence and Innovation, SNCF Gares & Connexions



Our innovation policy is structured around the major challenges we will face over the next ten years.

In the transport sector, which is France's largest emitter of greenhouse gases, our aim is to reconcile mobility needs with environmental protection by developing rail transport. Significant work lies ahead to adapt assets dating back many years and to make stations resilient to climate change.

We will therefore accelerate our investments in the renewal and modernization of our assets to ensure excellent societal, environmental, and economic performance over the long term.

This is leading us, for example, to design our infrastructure in a standardized and resource-efficient way, as seen in the footbridges and platforms we now create with this approach.

Through choices of materials, design, and construction methods, we are innovating with support from our subsidiary AREP, which possesses expertise in engineering, planning, urbanism, design, architecture, and project management. We are also improving our knowledge of our assets to optimize investment and maintenance operations, notably through programs such as A7Management.

This pursuit of performance is also intended to benefit railway operators and Mobility Organizing Authorities by reducing the overall cost of the rail system and improving its competitiveness.

With the opening of the rail market to competition, the rules of the game are changing. Our new role as an integrator of passenger information, flow management, safety, and accessibility is another major challenge. We must organize interfaces between transport operators so that transport services are presented clearly and journeys are optimized for all customers. Examples include the unified accessibility platform Assist'en Gare, trials of guidance solutions for people with disabilities or reduced mobility via the "Ma Gare" app, and deployment of LIVE, LIVE Mass Transit and LIVE Multimodal, which consolidate information for several transport modes

Continually anticipating evolving societal needs is part of our value proposition.

Continually anticipating evolving societal needs is part of our value proposition. Digitalization has transformed how we operate, but we remain mindful that stations must continue to be vibrant and appealing places. And more broadly, we must ensure that our innovation strategy encourages intermodality and addresses the specific characteristics of each region. This obliges us to join with all our stakeholders to think about these issues in a responsible way.

Lyon Part-Dieu: Wi-Fi tracing to improve flow management

The Lyon Part-Dieu train station, a major multimodal hub at the heart of France's second-largest business district, is completing its transformation by implementing several innovative solutions on an unprecedented scale. In terms of flow management, everything has been redesigned to reduce congestion, improve access to the station and platforms, and streamline connections to public transport. Among the innovations: retractable furniture allows layouts to be modified during disruptions or to redirect passenger flows at the request of a transport operator. To predict flows, analysis of Wi-Fi

traces has proven particularly effective (85% of people leave Wi-Fi enabled on their mobile phones). Thanks to antennas installed in the station, it is possible to measure entries and exits, monitor occupancy levels, and identify congestion points. The assumptions made during the design phase have been confirmed as the project progresses, particularly for the new access gallery linking the station and the city, where a 17% increase in usage has already been recorded, with 20% estimated over the long term.

150,000 travelers per day, one quarter of whom merely walk through the station



A simulator for better crowd management in the Paris region

In 2025, Transilien SNCF Voyageurs, a specialist in mass transit, began using a tool to anticipate and better manage passenger flows. The Garoflux simulation table gives decision-makers a system-wide view of stations with the aim of enhancing safety, improving flow, and ensuring punctuality. It is also useful for staff training. Designed in partnership with the Mass Transit Academy and with assistance from CNRS researchers, this table offers two simulation games: one for managing platform flows during peak hours and another

for handling flows when events are happening nearby. Each scenario is based on algorithms developed from real data. They simulate the impact of measures taken, with consideration of human behavior, and assess their effectiveness (passenger satisfaction, punctuality, etc.). In 2026, new functionalities will be added to the Garoflux table to make the experience more immersive.

PARTNER
Signactif

LIVE Multimodal: for reliable and uniform information

This digital solution, developed with SNCF Connect & Tech Services, organizes the dissemination of multimodal information across station media (screens, kiosks) and, starting in June 2026, via the Ma Gare app. LIVE Multimodal aggregates a wide range of data, compiling in real time information for conventional public transport (buses, coaches, trams), "soft mobility" options (bike-sharing, scooters) as well as the availability of spaces in bicycle parking facilities. To ensure data are uniform and accurate, SNCF Gares & Connexions prioritizes exchanging data via APIs with regional Mobility Organizing Authorities.

In December 2025, Drancy became the first station to present multimodal data via LIVE Multimodal. Since then, it has successfully displayed bus departures. The system is to be deployed at some 200 stations in the Paris region by the end of 2026. It has also been in use at the Libourne station in the Nouvelle-Aquitaine region since February 2026, with plans to integrate bicycle traffic data there by the end the year. The aim is to serve the entire region by the end of 2026. Other Mobility Organizing Authorities are interested too, as are certain businesses and transport operators seeking to provide connection information onboard.

The service is to be introduced at some **200** stations in the Paris region by the end of 2026.



A7Management program: SNCF Gares & Connexions expands its data capabilities

Since 2025, asset managers in each of the nine regional station divisions have been monitoring the station assets in their geographic areas. Alongside them, a data manager oversees data (inventories, space occupancy and vacancy, revenue, obsolescence, etc.) and audits their quality. Thanks to this program, asset managers can make informed investment decisions and prioritize actions (renewal, development) in ways that balance economic efficiency and service quality. Their information system for leveraging inventory, technical, and financial data was developed by SNCF Gares & Connexions, a strategic choice to remain independent from external software vendors in data management. By emphasizing the added value of data management for infrastructure, the A7Management program has laid the foundations for a data-driven culture within SNCF Gares & Connexions.

The post-carbon future of rail with AREP

AREP, a wholly owned subsidiary of SNCF Gares & Connexions, is a multidisciplinary agency specializing in mobility spaces. Among its activities in 2025:

IMAGINING GRENOBLE IN 2040
Presentation of a forward-looking approach to envision Grenoble in 2040, carried out with the National School of Architecture in Grenoble, the municipality, and the Grenoble Urban Planning Agency. This study outlines climate, social, and urban challenges and the choices available to build a more resilient, inclusive, and attractive city.

CONTINUING WORK ON THE MOBILITY PLATFORM AT THE SCALE OF GREATER GENEVA
This platform combines multi-scale mobility modeling with carbon footprint assessment to analyze mobility practices, test decarbonization strategies, provide a forward-looking framework for public decision-making, and guide regions toward more sustainable, multimodal, and low-carbon mobility.

DEVELOPING AN EMC2B INDICATOR (energy, materials, climate, carbon, biodiversity)
This indicator evaluates thermal discomfort in stations and semi-open spaces based on research involving simulations, analysis, and representations of physical phenomena contributing to discomfort.

The future of remote customer relations



Remote host

Technology can sometimes provide more direct communication than expected. This is demonstrated by the remote host concept, whose POC projects were completed in 2025 at the Montpellier Sud de France and Nogent-sur-Seine train stations. The concept is based on a kiosk installed in the station that integrates a video connection solution developed by the Luxembourg-based start-up Inui Studio. For smartphone users, a simple poster with a QR code is also provided. These systems do not replace staff but do offer an additional direct point of contact when needed.

In Montpellier, the experiment involved understanding customer inquiries in a multi-transport operator context. The kiosk serves as a single contact point that redirects users to a remote advisor of the chosen operator. In Nogent-sur-Seine, the aim was to evaluate

customer satisfaction when redirected to a remote advisor or to staff at a nearby station outside ticket office hours. Both POC projects highlighted a priority need in ticketing services. The kiosk provides a contact for travelers in some stations without separate sales areas for each operator or when staff are absent. With these more accessible, connected, and human-centered services, customer relations appear less stressful.

PARTNER
Inui Studio

85.7%
of customers were very satisfied during the two trials



Launch of a WhatsApp channel in stations

To improve customer relations, SNCF Group began offering a new channel via WhatsApp on 3 November 2025. SNCF Gares & Connexions relies on an SaaS solution providing access to an AI-powered bot developed by Mistral AI, with a connection to a remote advisor if needed. The bot resolves 50% of information requests without calling on a human advisor, confirming its effectiveness. The next step is to improve its ability to guide customers in other tasks (for example, filling out lost-item reports, tracking case progress, etc.). The benefits for remote advisors are clear: they can focus on requests requiring greater assistance. Further developments such as AI-generated summaries of conversations or suggested responses will boost efficiency even more.



“Ma Gare” to improve station accessibility

To improve the station experience, SNCF Gares & Connexions is expanding the features of the Ma Gare app. After implementing Virtual Positioning System (VPS) technology, which geolocates and guides users with precision of one meter using images captured by the phone’s camera and processed by AI algorithms, SNCF Gares & Connexions is now focusing on solutions for guiding people with reduced mobility and disabilities.

Two software solutions have been tested in the app since June 2025: Evelity, developed by the start-up Okeenea on iOS, in the Lyon Saint-Exupéry and Paris-Nord stations; and StreetNav, developed by Almob on iOS and Android, in the Lyon Saint-Exupéry, Paris-Nord, and Paris-Montparnasse stations. These solutions provide highly precise routes tailored to each type of disability, with features such as haptic (touch-based) and voice feedback to improve user experience and provide reassurance throughout the journey. The aim of the trial is to better understand the difficulties and constraints faced by these users in order to address them more effectively. Carried out in collaboration with SNCF Group’s Accessibility Department and partner advocacy organizations, it will run until June 2026.

Some 1,500 routes are currently being analyzed, along with the results of qualitative surveys conducted at the Paris-Nord station.

PARTNERS
Okeenea, Almob

Adapting stations to climate change: from strategy to action

SNCF Gares & Connexions has carried out a macroscopic analysis of 3,000 French stations to identify the most significant risks and vulnerabilities by 2030, 2050, and 2100. Flooding, clay shrink-swell, extreme heat, drought, vegetation fires, landslides... all risks have been studied. An adaptation plan based on this work with a target horizon of 2050 was drawn up, along with a roadmap for adaptations of station operations, maintenance, and upkeep. Among the solutions is the greening of station forecourts. Following work at Avignon, a “cool island” is being created on the rue Bercy platform at Paris Gare de Lyon. A practical guide to forecourt greening, published in 2025 with AREP, also provides recommendations for selecting plant species suited to future climate conditions. Another approach involves reusing groundwater rising into station basements, as occurs at Lille Europe, for sanitation, floor cleaning, or irrigation. The main challenge lies in adopting solutions suited to the specific environment of each station (operational constraints, public access, architectural heritage) and in defining investment priorities.

In design phases, SNCF Gares & Connexions builds on AREP’s EMC2B methodology (energy, materials, climate, carbon, biodiversity). The station designed by AREP at the Nice airport is elevated to mitigate flood risk and built to withstand heavy rainfall, wind, and drought, while offering improved thermal comfort. A rainwater harvesting system irrigates a 4,200-m² garden that forms a natural cooling island. In the future, every major investment project (renovation of old buildings, construction of new stations, etc.) will incorporate a site-specific climate risk assessment based on the French reference trajectory forecasting an average warming of +4°C by 2100.

Adaptation at the regional level has been identified as a priority area for work to be carried out with all stakeholders. SNCF Gares & Connexions is involved in institutional initiatives such as vulnerability studies in the Paris region and the South region and participates in regional climate conferences (COPs).

Interview with Xavier Quin Director of Passenger Safety and Industrial Director, SNCF Voyageurs



The desire to travel by train remains very strong. This has prompted us to significantly increase the utilization rate of rolling stock by concentrating maintenance during off-peak periods, i.e., at night or on weekends, and more broadly, by adopting a maintenance policy that is more predictive and more digital.

We are deploying sensors on most of our rolling stock to enable predictive maintenance. So far, 1,200 trainsets have been equipped. Staff are using apps that supply information in real-time, allowing them to speed up the ordering of spare parts. We also continue to integrate features that did not exist 20 years ago such as 4G, Wi-Fi, real-time passenger information, passenger flow counting, and more. Innovation also means improving working conditions. We have made substantial investments in collaborative robots, whereas exoskeletons and smart glasses are not finding users. We are very attentive regarding savings of resources and energy.

By extending the lifespan of our trains, we reduce the consumption of raw materials. During mid-life overhauls, we integrate energy-saving solutions, for example in air conditioning systems.

In 2025, the Charentes-Périgord industrial Technicentre used additive manufacturing and WAAM (Wire Arc Additive Manufacturing) technology to successfully produce a crossbeam pivot, a component weighing several dozen kilograms that connects the bogie to the train chassis and is thus highly stressed. It will be tested for three years on TER trains. This is a world first, developed with SNCF Voyageurs partners as part of the Additive4Rail project supported by France 2030. We also use additive manufacturing to produce parts no longer available from suppliers.

We are testing composite materials to produce seats, thus reducing train weight, and more impact-resistant train noses, potentially reducing repairs and increasing availability.

We are very attentive regarding savings of resources and energy.

Last, by developing hybrid and battery-powered train models as well as a range of lightweight trains with DRAISY and TELLi, we are contributing to decarbonization and making rail transport more affordable.

For new rolling stock, we integrate innovation directly into design specifications. The new TGV Inoui will be by far the most connected TGV ever. We wanted it to collect and transmit data to the ground, to have automatic onboard monitoring to reduce workshop visits, to be cheaper to produce and maintain, to be more energy-efficient – particularly through aerodynamics and reduced weight – and to be more recyclable.

Future developments will focus mainly on modular interior layouts to allow the standard body to be reconfigured for diverse needs. Technologically, modular systems and components are also things in which operators are very interested. Last, AI has advanced our work on image recognition for autonomous trains, although the need is not yet immediate.

Composite materials: from manufacturing to parts repair

The TechLab Composites, a laboratory of the Railway Testing Agency, and the Technology, Innovation and Group Projects Department (DTIPG) are continuing trials of the manufacturing and qualification of composite materials. They have worked with the Rouen Quatre-Mares industrial Technicentre, a center of excellence for producing large components using infusion, a process in which composite materials are impregnated with thermosetting resin under vacuum to produce parts in a single operation.

Another success in 2025: in the FAMM (Fast Additive Manufacturing Moulding) project, carried out with SNCF Voyageurs Rolling Stock Engineering and the manufacturer CARACOL, molds were designed for TGV fairings using additive manufacturing. Production time for molds should thus be reduced from eight to four weeks, with significantly lower costs. These materials also



offer better shock absorption, allowing quicker resumption of service after incidents such as animal collisions. A second test mold is currently being developed for TER rolling stock. Another focus at the Technicentre is the reparability of composite parts, particularly

pre-impregnated materials (a process derived from aeronautics) used for fairings, as improved reparability could reduce maintenance costs. The TechLab and DTIPG are also studying the fatigue resistance of these materials in the RAIL4EARTH program (see page 24).

SCOOT: lighter seats for OUIGO and Transilien trains

Train weight is subject to strict limits, making seat optimization a key issue. Reducing weight can allow more passengers, batteries, and comfort features, while lowering energy consumption and CO₂ emissions. A new composite seat architecture is being tested for OUIGO as part of the SCOOT project (Optimized Composite Seat for OUIGO and Transilien) led by SNCF Voyageurs Rolling Stock Engineering and the Technology, Innovation and Group Projects Department, in partnership with EXPLISEAT and the Institute for Technological Research Materials, Metallurgy and Processes (IRT M2P). The seat consists of a self-supporting monolithic composite shell and an understructure incorporating carbon fiber tubes and epoxy resin with aluminum joints. The dimensions of the seat are still being determined, with the weight being further reduced. After numerical validation and assembly, bench testing will be done by the end of 2026, with commercial deployment planned from 2027.





Remote diagnostics and corrective maintenance planning

The arrival of the next-generation TGV is transforming corrective maintenance. Tasks are increasing and diversifying, particularly due to remote diagnostics.

New organizational structures, facilities, and tailored maintenance schedules for the Technicentres are being introduced. Planning itself is evolving. Prototype software called **PROMPT** (Robust and Optimized Planning of Maintenance through Remote Diagnostics) is being developed for TGV Intercités trains by the DTIPG and its partners. The software, which is based on optimization technologies, facilitates maintenance scheduling by integrating multiple types of input data: maintenance requests (type and deadlines), maintenance calendars, and task “ranges” (length of the operation, required skills, procedures, operating methods, etc.). Initially developed using maintenance data from rolling stock in service, the prototype incorporated data from the next-generation TGV Inoui following the arrival of the first trainset at the Southeast European Technicentre in December 2025. The software continues to evolve as new trainsets arrive, with operational testing planned soon.

Eco-friendly cleaning of TGV trains

Aside from upgrading the stationary washing stations for TGV trains, SNCF Voyageurs is exploring mobile solutions that use even less water.

At the East European Technicentre, SNCF is testing a prototype machine that has been in development since October 2025 by Nordic Aerowash Equipment, a dry aircraft cleaning specialist. The project is called **DREI** (Cleaning that Preserves Water Resources through Innovation). The machine’s brushes clean using a biodegradable product, absorb the residues, and then polish the train. Cleaning is done without rinsing, making it independent of climate conditions (heatwaves, freezing) and operational constraints in the Technicentres (suitable tracks, simultaneous activities, etc.). The machine moves using 3D LiDAR to detect the train and its surfaces. Its autonomous robotic arms allow it to adapt to all types of rolling stock.

Cleaning trials conducted in December 2025 and March 2026 have been promising. Further testing is needed for the robotics and the machine’s ability to distinguish each train component (doors, windows, etc.). The final prototype is to be ready in 2026 for adjustments and real-world testing. Upscaling would then begin with the construction of three machines.

37%
of SNCF Group's water consumption is attributable to SNCF Voyageurs

4,000 liters per trainset with manual cleaning



Comprehensive energy modeling of trains

SNCF Voyageurs Rolling Stock Engineering has developed MORPHEE (Optimization Module for Researching a Speed Profile that Meets Schedules and Is Energy Efficient), based on an algorithm to optimize train operation and energy consumption. The module was first developed using a virtual model of the Nantes–Angers line, including gradients and speed limits, combined with TER timetable constraints. In 2025, it was applied to the Paris–Lyon high-speed line, with adjustments made to the algorithm and code to achieve similar efficiency. MORPHEE draws on the recommendations of driver assistance tools and integrates naturally into digital twins for evaluating energy consumption and into driving simulators for training purposes.

Digital twins of trains

The arrival of new rolling stock is prepared years in advance. To facilitate collaboration with manufacturers during the design phase as well as to define operating scenarios and train staff before initial deployment, SNCF Voyageurs Rolling Stock Engineering has developed a digital twin. This is a complete virtual environment simulating train behavior in interaction with drivers, onboard staff, and maintenance teams. Human-machine interfaces (HMIs) modeled in 2D to simulate possible actions are integrated into a 3D environment replicating the driver’s cab, passenger areas, and onboard systems. The simulator can be accessed via a computer or tablet, and a virtual reality headset can be added for full immersion. The training component includes multiple



scenarios: standard operations (such as train startup) and more complex degraded situations (onboard incidents, loss of catenary power, system failures). Highly complex scenarios that are difficult to reproduce on real trains, even during

testing, are also included. Thanks to its modular architecture, the digital twin can be adapted for all types of rolling stock. Finalized in early 2025, it is currently being deployed to meet the needs of SNCF Voyageurs TGV-Intercités

Decarbonized trains

The TER regional fleets include around 1,000 diesel-powered trainsets operating on non-electrified lines. Since it is less costly to decarbonize trains than to electrify these lines, SNCF has been exploring various technologies for several years.



HYBRID TRAINS

The hybrid train, which is more energy-efficient and emits less CO₂ thanks to onboard batteries that store braking energy for reuse during acceleration, is in commercial service for a two-year period starting in 2025 on the Montréjeau–Luchon line in the Occitanie region. It has met all expectations: safety, reliability, punctuality, fuel savings of about 20%, and a range of over 1,000 km. Thanks to an intelligent onboard energy management system, fuel savings should reach 30%. Today, drivers can already activate “zero-emission mode” when they know they can rely on nearby catenary lines to recharge the batteries; in the future, activation could be done automatically with AI.

BATTERY-POWERED TRAINS

Lithium-ion batteries provide a range of at least 80 km and energy savings of about 20% compared with conventional power systems owing to the recovery of braking energy. In late 2025, a certification application was submitted for the first time to the French railway safety authority for a battery-powered train. Two bi-mode AGC trainsets have already been converted, with a third to be delivered in mid-2026. They will be tested in commercial service in the regions Sud (Avignon–Carpentras, Marseille–Miramas via the Côte Bleue), Nouvelle-Aquitaine (Bordeaux to Mont-de-Marsan, Saint-Mariens, and Le Verdon), and Occitanie (Nîmes–Vauvert).

To enable this train to continue operating without interruption, DTIPG, IRT Railenium, and their partners are designing a streamlined fast-charging station. Inspired by the automotive sector, the station is connected to the public electricity grid and paired with ground-based batteries to deliver maximum current intensity. This project, called ASTRRA (Power Supply with Storage for Trains During Rapid Charging at Standstill), is supported by SNCF Réseau and receives funding from the French National Research Agency (ANR).

HYDROGEN TRAINS

The traction system of the hydrogen train uses fuel cells to generate electricity from hydrogen stored in special tanks, with no CO₂ emitted. These fuel cells work alongside the batteries to provide additional power during acceleration and to recover braking energy. The train has a range of 600 km. In 2025, tests of the pre-series trainset at 160 km/h on the Velim test track in Czech Republic were successful. The bodies of the production trainsets have already been manufactured.



Interview with Tanguy Cotte-Martinon, General Secretary, SNCF Voyageurs



Our priority is to be present where the customer expects us. AI and big data now enable us to better detect changes in behaviors and expectations. Identifying the drivers of satisfaction, or, conversely, the obstacles to travel, helps us prioritize our actions, create new products, and optimize our onboard services. Most important, however, customers must be able to fully benefit from the basic service they expect. Irregularity remains the main source of dissatisfaction. The challenge is not merely punctuality. We must do better anticipating delays and providing personalized information to give customers a sense of autonomy so they can reorganize the rest of their journey. Now that the number of outside participants in the system is increasing owing to market liberalization, and that information is more fragmented, we are working to develop a platform capable of supplying our passenger information and assistance services automatically. For the customer, the experience must be not only simple, but also useful and agreeable: a time to oneself, whether productive or relaxing, along with a feeling of safety and comfort; a smooth journey with no need to think about every step of it. Public transport becomes truly attractive when it integrates naturally into daily routines, when it fits with people’s workplaces and lifestyles as well as other forms of mobility.

The best European practices are those aiming to make rail the backbone of an intermodal “Mobility as a Service” system through interoperable systems (real-time information, journey planning, dynamic connection optimization, etc.), with combined pricing and multimodal hubs.

And because they help preserve the planet, making public transport systems more appealing is a critical strategic issue. Also now in play is SNCF Voyageurs’ resilience considering climate projections to 2050: costs linked to climate events already exceed 60 million euros a year. To foresee more precisely the risks to rolling stock, we are modeling the impact of extreme heat on sensitive electronic equipment to determine the actions required ahead of the mid-life maintenance of our trains. We are also working on operational resilience under extreme conditions (heatwaves, floods, storms) using models that combine weather and operational data to dynamically adapt our transport plans.

Because they help preserve the planet, making public transport systems more appealing is a critical strategic issue.

Rolling stock robustness, energy optimization, protection of passengers and employees, and modeling the costs of inaction are central to our R&D efforts. These efforts are shared across European ecosystems, as illustrated by the work being done within Europe’s Rail through the Rail4EARTH project, which brings together no fewer than 70 stakeholders to tackle the challenge of adapting the railway system.



80
passengers,
including
30 seated

DRAISY: an ideal light train system

DRAISY is an innovative rail system designed for small regional lines that combines light trains with simplified signaling and infrastructure. It aims to drastically reduce investment as well as operating and maintenance costs, while offering the possibility of reopening closed lines at a significantly lower cost than with conventional rail and having the ability to run on interoperable segments. A demonstration is planned in the Grand Est region on the Sarralbe–Kalhausen line starting in 2027.

The 100% electric DRAISY train is designed to have a range of 100 km on batteries. Its speed (100 km/h) and “4x4” approach, with two steerable axles and adapted suspension and braking, reduce track wear and improve comfort.



The “mule” during assembly.

Other advantages include accessibility and modular interiors combining passenger transport with space for bicycles and micro-freight. Basic components are being assembled now, and electronic systems are being tested. A sensor-equipped prototype (“mule”)* will be trialed on test tracks in summer 2026 to validate the technologies. A demonstration vehicle will operate in real conditions in 2027 under the supervision of the SNCF rail testing agency.

**A testing stage borrowed from the automotive industry, used here for the first time for the design of railway rolling stock.*

PARTNERS
Lohr Industrie, Stations-e, IRT Railenium

FUNDING
European Union with NextGenerationEU, France 2030

TELLi showcases its innovations at full scale

Designed for small regional lines, TELLi is an ecological and economical mobility solution combining lightweight interoperable rolling stock with simplified digital signaling (see p. 28), thus reducing investment, maintenance, and operating costs. A full-scale model has been on display since May 2025 at the Ferrocampus in Saintes, a European center of excellence for decarbonized rail mobility. Some 100 innovations are presented, including those tested in real conditions on the X73500 laboratory train operating around Limoges (150,000 km to date). Validation of the

most technical aspects will continue until mid-2027, after which regions will issue calls for tender for its production.

- TELLi features:**
- A range of 200 km, double that of current battery-powered trains, with braking energy recovery and recharging via catenary or at stations, maintenance centers and other facilities;
 - Lightweight design: weighing 50 tonnes, it will be lighter than a conventional TER, thus consuming less energy and suffering less track wear, which means less maintenance;
 - A new type of axle with independent-drive wheels to reduce wheel-track wear and adjust floor height to platforms;
 - Modular interiors to offer more seating or space for other uses (bicycles, parcel transport) and autonomous accessibility for wheelchair users.

PARTNERS
Hitachi Rail, CAF, Alstom, Texelis, Wabtec, Cerema, IRT Railenium, Ferrocampus, Capgemini, Ektacom



150
passengers,
including
74 seated

Wildlife deterrence with acoustic warning systems

Collisions with animals on the rail network have increased significantly in recent years, making them one of the main external factors impacting train punctuality. Large animals, particularly wild boar and deer, are becoming more numerous as milder winters and greater food supply increase their reproduction and survival rates. To deal with this risk, SNCF is developing and testing acoustic warning systems and sharing solutions with European counterparts through IENE (Infrastructure Ecology Network Europe) and with Japan's RTRI (Railway Technical Research Institute). Signals developed in a research thesis proved effective with several species in tests at the Haute-Touche zoological reserve. Since then, loudspeakers installed at the front of some TER trains have been emitting these signals, triggered automatically by geolocation, while onboard cameras record the reactions of wildlife. The system is being tested in Auvergne over a 52 km stretch of rail line until September 2026. After 18 months of testing, none of the equipped trains have had collisions, unlike others operating on the same line. In Pays de la Loire, Alsace, and Normandy, ground-based beacons with speakers placed every 50 meters emit similar signals or natural sounds (the call of jays, hunting horns, barking of dogs, fire alarms, etc.) before a train passes. This system is 90% effective. In March 2026, in Trilport, a speaker and anti-intrusion track panels were installed to create a secure level crossing and prevent wildlife from entering the tracks.

**Industrial research training agreement co-funded by the SNCF DTIPG, SNCF Voyageurs, SNCF Réseau, and the Université de Saint-Étienne.*



14 trains per day on average are delayed because of a collision with a wild boar 

Predictive AI boosting performance for customers

OUIGO and its partner Actionable have developed a predictive analytics tool for customer experience. Based on machine learning algorithms, it combines several types of data (operational, transactional, and data from customer relationship management tools). OUIGO can predict customer satisfaction on a daily basis with over 80% accuracy. It identifies drivers of satisfaction or dissatisfaction as well as key inflection points. This represents a major change compared with long-used methods (surveys, Net Promoter Score, etc.), which provide only a partial and often delayed picture, with no concrete links to other data (delays, pricing, journey details, etc.). Thanks to this innovation, OUIGO can do targeted, large-scale evaluations of the effectiveness of its initiatives (marketing, products, etc.) in terms of satisfaction, repeat purchases, and economic performance. It also makes OUIGO a global pioneer in the application of AI to customer experience in transport, giving it a lasting competitive advantage. OUIGO and Actionable have also won several awards: Gold and the Grand Jury Prize at the 2025 Data Marketing Awards, Silver at the 2025 AI Awards, and Gold at the 2026 Transport Ticketing Global Awards in London.

How crowded is the next Transilien train?

At some stations in the Paris region, screens on the platforms display how crowded upcoming trains are for each carriage and in real time. This allows passengers to board the least crowded cars for a more comfort ride. Improving flow management in this way also optimizes operations. The large-scale deployment of this service is a first in Europe: in 2025, 250 out of 399 stations in the Paris region displayed crowding levels, with 20 more added in 2026. Developed by Transilien SNCF Voyageurs, the system relies on infrared sensors that measure flows at the doors of new Transilien trains (NAT), Regio2N trains, and next-generation RER trains. For rolling stock not equipped with sensors, cameras at the head of platforms scan doors and windows at departure. Using AI, these cameras instantly convert images into density levels. The system also combines two algorithms – one, AI-based, which takes into account habitual



passenger movements in trains, and a second, which incorporates historical boarding and alighting data at each station – that together refine door-level passenger counts. This data feeds real-time displays in stations and digital media. Previously, three crowding levels – low, medium, and high – were indicated, but since 2026, a fourth level appears when fewer than five people per carriage are detected, allowing passengers to group together for those carriages if they wish.

PARTNER
Affluences (AI for the platform camera system)

Programmed obsolescence reversal operations for TGV trainsets

To offer more seating capacity to customers, SNCF Voyageurs is lengthening the lifespan of its trainsets. The O2D program targets 104 trainsets from five TGV series, having an average age of 34 years. The oldest, made of steel, can operate 2 to 4 more years, while the more recent double-decker aluminum Duplex trains can run for an additional 10 to 15 years. Service life will thus reach 40 or even 50 years. For the latter trains, the process began by identifying fragile areas using non-destructive testing: endoscopy, magnetic particle inspection, ultrasound, eddy current testing, and drones for roof inspections. Causes of degradation (notably corrosion and cracks) were then analyzed. Areas requiring treatment were mapped, and repair levels determined through digital simulations. Seals and welding quality were also assessed to prevent aluminum from cracking due to intensive high-speed operation. A specific coating was developed



with the Railway Testing Agency to combat corrosion from toilet chemicals when systems cannot be replaced with clean-water solutions. In line with circular economy principles, more than 10,000 parts (seats, electrical components, etc.) were recovered from decommissioned trains. This represents a saving of

84,049 tonnes of CO₂ equivalent out of the 6.7 million tonnes saved in the entire O2D program. The first trainsets are being modified now. Between 2027 and 2034, the capacity of the TGV fleet in France will increase by 15%, with 22,100 seats added.

Converting TGV Inoui trains into OUIGO trains

OUIGO is totally renewing and expanding its fleet by incorporating TGV Inoui trains following their "mid-life" refurbishment. The fleet will grow from 38 trainsets in 2025 to 50 in 2027. Project name: **TANGO**. Simplicity is key for design and maintenance, but not for safety aspects. Seats are designed for quick maintenance and repair, and textile wall coverings are replaced with easy-to-clean painted metal. The new seats, redesigned interiors by Saguez & Partners, and optimized layouts of TANGO trains increase capacity from 644 to 653 seats.

OUIGO also used customer satisfaction data to redesign interiors, with platform seating removed and a "social space" created. As for climate resilience, athermal glazing reduces solar radiation, and improved air conditioning ensures better thermal comfort. LED strips provide more reliable and energy-efficient lighting. Recycling bins are also installed in each carriage. Another innovation: "grey water" toilets reuse water from handwashing for flushing, providing 48 hours of autonomy without refilling or emptying.



SERM Innovant Program

SNCF Group will contribute to the development of Regional Metropolitan Express Services (SERM). Its SERM Innovant program has attracted interest from Mobility Organizing Authorities in the Bordeaux area, where its first experiments will be conducted.

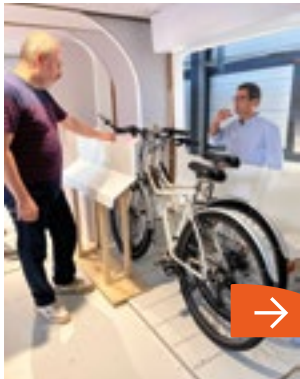
The program explores three areas:

- Studies and decision-support tools to propose optimal mobility solutions and services
- Projects to strengthen rail services
- Solutions to facilitate modal shift and connect rail with other transport modes.

Four examples of projects:

POIESIS

In POIESIS, tools are being developed to design multimodal transport offerings and assess their ability to meet regional needs. Diagnostic and decision-support tools help understand how a region functions and identifies needs, generating future scenarios that are tested through simulation. They evaluate modal shift by testing hypotheses such as the evolution of services and improved intermodal connections. Following a regional assessment of Bordeaux Métropole et de la Gironde, a prospective study for SERM Bordeaux Métropole 2032 is underway, with results expected by the end of 2026. Prototypes of tools will be delivered during 2026.



ADAPTATIVE

In response to passenger growth, ADAPTATIVE aims to maximize TER train capacity. Interior spaces and fittings become flexible: during peak times, they improve flow and facilitate bike boarding without reducing seating; during off-peak times, they allow à la carte configurations. A virtual reality configurator under development reduces design times and assists the Regions in their development decision-making. By the end of 2025, over 90 customers and staff had tested the various configurations in a full-scale mock-up at the Bordeaux station. Layout, modularity, signage, and best practices to avoid conflicts in usage were reviewed, and the configuration that will be tested in service for six months on the Libourne–Arcachon line in 2027 was selected.



JYVAIS & MOBILITY STATIONS

JYVAIS is an on-demand shared transport service with a driver that can connect users to stations, public services, and nearby shops. Mobility Stations are small multimodal hubs that centralize existing transport services around simple infrastructure and offer additional shared and electric mobility options (small cars, bikes, scooters, etc.). Already successfully tested in rural areas, a pilot of these solutions will begin in 2026 in suburban SERM environments to validate their ability to generate rail traffic and encourage modal shift.

