Creating a new impetus for cooperation and innovation in the Group around a shared vision of what mobility will be in the future: the SNCF innovation and research management function is evolving down to its roots.

15 LABS & MINI-LABS EN 2017 FOR INNOVATIVE DESIGN

SNCF Innovation & Research has the task of managing innovation for the entire public railway group. To do so, the division has since 2010 deployed a series of Labs and Minilabs focusing on major issues for the Group such as "Infrastructure maintenance in dense zones", "Energy", "Mass transit", "Mobility of senior citizens", and "Eco-design"… These workgroups have a lifetime of just several months and are founded on a collaborative innovative design approach developed with the Mines ParisTech engineering school, which aims to achieve disruptive innovation. The labs convene regularly for knowledge-sharing sessions which receive additional input from specialists invited from outside the organisation. At the end of these sessions, members meet at an innovative design seminar to identify innovation opportunities which will be the budding shoots of future research and development programmes.

SNCF Synapses is a community of scientific and technical experts. The aim of which is to develop the Group’s individual and collective competencies and reinforce their role in the construction and delivery of the innovation and research programme. Involved in the activities of innovation and research clusters, the Network, launched in 2010, has a membership of 400 experts in 2017. Employing a system approach, it helps to connect up specialists and scientific and technical bodies throughout the whole of the public railway group.

THE SNCF INNOVATION & RESEARCH DEPARTMENT WORKS FOR THE BENEFIT OF ALL OF THE ACTIVITIES OF THE PUBLIC RAILWAY GROUP.
The second edition of Inventor’s Awards, which was held on 19 October 2016, provided an opportunity to the creators of the six inventions patented in 2013 and 2014 to present the economic benefits that they could contribute to the railway group. The two winning patents are the pantograph de-icing system proposed by SNCF Mobilités, and a mechanism to mitigate electricity loss at substations, designed by SNCF Réseau.

Since 1983, SNCF has played host to more than 230 doctoral students. Under the framework of the process of the Industrial Convention for Research-based Training (CIFRE), their projects benefit from technical and scientific supervision under the provisions of a three-year contract. This dynamic is continuing to grow, with 66 theses in 2016, 70% of which related to one of the 7 research clusters.

Working for the benefit of the public railway group, the single patents and innovations platform (GUBI) analyses the innovations put forward by the engineers from the three EPIC* in 2016, 32 patent applications were submitted. The GUBI oversees the patents for the three EPIC based on the delegations of authority it receives. A governance process has been introduced at SNCF Réseau and Matériel, because although the decisions relating to patents are examined and implemented by the GUBI, the owning EPIC have the final word.

SNCF had a portfolio of almost 200 inventions protected by patents in France and various other countries. Finally, the GUBI registers software with APP (French Programme Protection agency) so that the railway group’s entities may assert their right over the software that they have produced or acquired.

* public service company with an industrial and commercial mission
"TRANSITIONING FROM A MONOPOLY TO AN OPEN WORLD, MOVING FROM A TRADITIONAL INDUSTRIAL POSITION TO ASSUMING A MAJOR ROLE IN INNOVATION AND DIGITAL TECHNOLOGY... ALL OF THIS HAPPENS FIRST AND FOREMOST IN YOUR CORPORATE CULTURE."

GUILLAUME PEPY
Chairman of Executive Board of Group SNCF, Chairman of SNCF MOBILITÉS
14 JUNE 2017, AFP

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INTERVIEW WITH CAROLE DESNOST
CEO, SNCF Innovation and Research

Modifications in behaviour and in usage, the emergence of new technology, the development of autonomous vehicles, the necessity of the energy transition: mobility is experiencing profound transformation. SNCF welcomes this pivotal moment and will be proactive in this change.

The mission of the SNCF Innovation & Research department is to seize technological opportunities and harness them in a perspective of progress and development over the next ten years for the benefit of the entire public railway group, and more broadly that of the railway industry. The central issues are those of efficiency, service, safety, agility and scalability.

This approach naturally addresses the French scope as a priority, but also has European and worldwide ramifications. In our course of action, we use two levers.

The first is Openness. Being wide open. For many years, SNCF has been working with acknowledged market players from the rail industry, be they the Japanese railway research institute RTRI - both our partner and our rival in high speed -, Deutsche Bahn or Alstom. Building the future of sustainable mobility requires the strengthening of the European rail industry – and we are active contributors to the European programme Shift2Rail which gathers together a number of different players from the rail industry. Over and beyond these considerations, our openness also applies today to other industrial sectors. We are engaging in synergies with the automotive, aviation and even aerospace industries.

The second lever is Disruption. Accepting the notion of thinking disruptively. Our teams take the liberty of thinking “out of the box”. In this spirit, we have set up the technological renovation programme “TECH4RAIL” with dedicated teams, established in a dynamic and collaborative work space. The project focuses on technological subjects which are set to transform the mobility of the future; automated systems, artificial intelligence for operations, safety, energy, etc. And we are convinced that a great many innovations will result from its research work and help the transport world to move forward.

So with its long-upheld values and its newly-revisited methods, this is how SNCF contributes to reinventing the railway system and mobility in an economically sustainable approach and with the customer as the ultimate judge.

In the following pages, the reader can discover the first steps in this enthralling adventure.
TECH4RAIL, ACCELERATING INNOVATION

Invent the rail system of tomorrow

Operations enhanced by artificial intelligence
Downscaled signalling
Autonomous train

DEVELOPING NEW OPPORTUNITIES

TECH4RAIL

Internet of Things, connected and autonomous vehicles, robotics, additive manufacturing, big data and artificial intelligence are all technologies that have instigated major changes in a large number of industries. With the speed of their development, they are also shaking up the mobility market and blurring the boundaries of what exists today. SNCF plays an integral part in this trend and has placed technological excellence at the centre of its ambition through the programme TECH4RAIL. The aim is to effect a genuine technological step change in order to boost the performance of railways and mobility. This programme also takes the liberty of exploring new disruptive technologies.

GO FASTER, EXPLORE, TRANSFORM

Train location
Crash-proof level crossings
Energy: storage and new sources
Smart materials
New shapes of mobility
In 2016 the programme was formally outlined and projects were launched. The programme was put together in an approach of collective intelligence. 560 forward-looking ideas emerged from a preliminary consultation on a social platform. They were priority-ranked and transformed into eight projects before a speed lab phase which evaluated their impact in relation to customer service criteria: safety, capacity, competitiveness. New technological innovation themes were built in by opening the process to other industrial sectors and technology research institutes (IRT), industrial players and start-ups. By developing more open innovation methods, the goal is to better understand and anticipate the changes around the corner. Another key to acceleration is being daring and deploying innovation methods focused more on impact, and moving to test phase quickly. By mixing agile and structured methods at the same time, innovation can happen both faster and on a larger scale.

BUILD THE FUTURE OF THE RAILWAYS

Trains automation is one of the essential building blocks in developing the railways of the future. This is a new development and a source of genuine progress, an ambition we share with our counterparts in Europe. Automatic metros have been operational for many years, but so far there are no automatic passenger trains in commercial service in a conventional railway environment. The technological leap to be effected is sizeable: from a metro, in a hermetically-sealed zone over short distances with closely-spaced stops and limited speeds, to a train in an open environment over long distances. This is the ambition of the project Autonomous Train.

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NEW METHODS TO INNOVATE

The programme, made up of a small cluster of project teams, functions purposefully as a network: an internal network with the SYNAPSES experts in particular, but also an external network through the development of an ambitious research ecosystem built around research. 2017 is the year in which the first demonstrators will illustrate the projects as they progress.

In an increasingly complex decision making process, artificial intelligence constitutes a highly appropriate solution, accompanied by in-depth research into cognitive functions, human-machine interfaces and the transformation of job functions. These tools will go towards making operations more flexible and more effective.

One project is dedicated to the issue of energy, an essential issue from both economic and sustainability perspectives. The goal is to revisit power supply through two main drivers. The first, energy storage on board vehicles or in fixed installations, will deliver energy savings of around 20%, lower emissions and noise pollution in urban zones, reduced installation...
HYPERLOOP ONE
An “out of the box” partnership

Testimony from Rob Lloyd, CEO of Hyperloop One at a meeting with SNCF directors in the autumn 2016.

“Hyperloop is a new means of transport that will change our lives in several ways. The main thing is to connect up all of the existing means of transport so as to be the backbone of high-speed transport, breaking down the barriers of time and distance. SNCF has gone outside of its core business by investing in our Californian start-up. This is a brave move. Its reputation and expertise provide us with stronger credibility. This partnership should help us to accelerate the development of our programme to make it a reality. We are concentrating on analysing the certification process and we have a lot to learn from one of the foremost operators in the world.

The railways are a major sector of the European economy but are facing increasing pressure from international competition. To guarantee Europe’s status as the leader in maintaining and creating jobs in this area, the European and national authorities have mobilised alongside all industry stakeholders. The joint undertaking Shift2Rail, launched in 2014, embodies this huge effort within the European research and innovation funding programme Horizon 2020. This takes the form of a public-private partnership between the European Commission, manufacturers, infrastructure managers and, more recently, operators such as SNCF which joined the initiative in 2015 as an associate member on three innovation programmes (IP).

The Horizon 2020 programme funds Shift2Rail to the tune of €450 million, nearly trebling the investment of the previous programme. €470 million of additional funding is provided by the founding members and associates.

Its objectives are to conduct the research necessary to lead up to demonstrators of innovative technologies in order to improve the railways’ performance and reduce their costs. Subjects such as command-control and signalling, in particular in dense zones, are being investigated with a view to making more intense use of existing infrastructure. Another leading theme is the autonomous train which SNCF and its partners, the foremost of them DB (Germany), consider to be the future of rail transport on existing infrastructure. The stakes are high: a demonstrator in semi-automatic mode (GoA 2) is planned for 2019; a demonstrator in unattended operation mode (GoA 4) on semi-open infrastructure is expected for 2021-2022.

All of these subjects are founded on specific research and development themes, the rationalisation of funding, genuine cooperation between manufacturers, research centres, universities, infrastructure managers and transport operators. All of the players share the same concern: today, tomorrow, in a world of changing paradigms, how can rail be, in a sustainable way, competitive and attractive?

DEVELOP NEW MOBILITIES
TECH4RAIL is also involved in the sphere of new mobility systems through the implementation of partnerships so as to anticipate new technologies, imagine their uses, and position SNCF on new mobility markets. Among the systems studied are Hyperloop One and autonomous shuttles. The work initiated with these new players additionally offers a chance to draw inspiration from new methods of developing innovative projects.

Shift2Rail
For an efficient rail transport and a competitive industry

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costs and ultimately an energy management tool. The second conviction is hydrogen as a new energy vector that might eventually replace diesel. The first fixed storage installations are currently being tested. New materials are also part of the scope, with a project aiming to reduce train weights.

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GO FASTER, EXPLORE, TRANSFORM
CONCEIVING THE FUTURE OF MOBILITY

Simplifying or enhancing the passenger experience: by studying its customers’ behaviour and expectations before, during and after their journeys, SNCF can adjust both its operating modes and its service offering. SNCF Innovation & Research contributes to meeting this objective by boosting projects that tackle two major challenges: improving industrial performance and offering a more comprehensible and innovative range of mobility services.

A REMODELED TRAVEL OFFER

IN A BIG DATA ERA, PLAN AHEAD TO ADJUST
Capturing insight from passenger journey searches on websites and apps could, in the future, help in designing more closely-suited mobility services in a given region. This is the rationale behind the ValoIti project (standing for the French for “exploiting route queries”) conducted in partnership with the SNCF Mobilités subsidiary Keolis in two experimental travel zones: Île-de-France and Greater Lyon. ValoIti involved the development of methods to acquire, cross-reference and analyse huge quantities of spatial and temporal data, with more than 8 million queries per week processed. The project concluded with the development of a forecasting model and a data visualization prototype.

MODELLING AND SIMULATION OF MULTI-MODAL TRANSPORT: A FIRST
The collaborative programme MIC (Modelling, Interoperability, Cooperation), which received its finishing touches in 2016, works towards the same objective of passenger satisfaction. In cooperation with Alstom and Renault, original digital models were developed to evaluate and optimise rail-bus connections, passenger information in the event of disruption and the deployment of a car-sharing scheme. These models will be used for other optimisation projects on stations in the Grand Paris network.
or the urban development of the future, in association with the Institute for Technological Research SystemX. For SNCF Innovation Research and SNCF Mobilités (Transilien), the goal was to design a ridership and passenger flow simulation model incorporating the other modes of transport used as back-up solutions. Two complementary approaches were explored:
– the simulation of different means of mobility through an innovative approach simulating “systems of systems”,
– understanding and modelling passenger behaviour during disruption (wait for the next train, change transport mode to buses or metro, etc.), drawing on a survey conducted by IFSTTAR.
This research led to the design of visual tools, powered by a simulator designed by the small business, The Cosmo Company, allowing transport service and regulation teams to quantify routes based on scientific reasoning. They are provided with multi-modal solutions which adapt to passenger behaviour in the event of unforeseen circumstances or planned engineering works.

The ValoIti project provided confirmation of the correlation between Web-based journey queries and train ridership.

**AN EASIER STATION**

**A STEP TOWARDS CUSTOMISED MOBILITY MANAGEMENT**
Stations are a key factor in passengers’ appreciation of the service: passengers who themselves are passing through stations in ever-increasing numbers. To deal with the constraints weighing down on the extension of stations, Gares & Connexions SNCF continuously seeks to optimise their layout and operation. This is how SNCF Innovation & Research came to support the Mobilabo project. Its objective is to understand and measure the everyday flows within a station. To do so, two solutions were studied: the acquisition and statistical analysis of Wi-Fi data left by the smartphones of passengers, and counting people using laser sensors which are triggered every time someone walks past. The combination of these enables the precise and dynamic measurement of flows instead of static and approximate knowledge based on manual counts and periodic customer surveys. Mobilabo’s concepts for measuring entries and exits, analysing journeys and detecting overcrowding hotspots have proven successful, resulting in Gares & Connexions SNCF deciding to mass-implement Wi-Fi data acquisition and analysis in major stations. In due course, this type of approach will enable continuous, active and personalised mobility management to become a reality. This will also offer benefits in several other areas such as operations and...
LYON PART-DIEU, A LAB FOR MOBILABO

The Lyon Part-Dieu station, the busiest station in Europe in terms of connecting passengers, was selected as an experimental ground. Here, two complementary technological approaches were tested and prototyped: the capture of Wi-Fi data left by passengers with a connected smartphone, and laser sensors which are triggered whenever someone walks past a tag. The latter enables data from the Wi-Fi system to be adjusted in order to integrate in the measures the flow of passengers without smartphones or those whose phone was offline.

STATIONS CATERING TO ALL TYPES OF VULNERABILITY

Not all passengers are equal when they arrive in a station. In spite of the progress made over the past few years, people with disabilities (visually impaired, hard of hearing, people with reduced mobility, etc.) may have trouble in moving around or obtaining information. The “My Lantern” project aims to remove these obstacles by developing the prototype of a station wayfinding and journey planning tool for smartphones, customised to the type of handicap, adapted to context (geolocation and dialogue) and featuring an advanced multisensory interface (vocal, visual and tactile). This prototype, which uses complex technology such as speech synthesis and recognition, was validated at the end of 2016 by SNCF’s Accessibility Department, and will be tested in 2017 at Gare de Lyon in Paris. This station was selected because it has a complex layout, but also because geolocation tags are installed inside it. It can be noted that these tags emerged from the project “Door-to-door geolocation” conducted by SNCF Innovation & Research which aimed to identify and test various geolocation technologies to assist passengers throughout their journey.

People with disabilities may encounter problems getting around stations and obtaining information in them.

A simpler, more reassuring station

The Environment and Cognitive Accessibility programme, and aims to make stations more straightforward, understandable and reassuring by leveraging its environment, produced its first results in 2016. In addition to observing other heavily crowded amenities (airports, sports grounds, shopping centres, etc.), research helped to identify sensory levers to give passengers directions and reassurance. A partnership was also set up with the industrial design college ENSCI around the concept of Mobility Plus: how to separate the flows of passengers between those in a hurry and those with time on their hands. To answer this challenge, students developed about ten concepts for new layouts and services. One of these, OASIS, aims to attract passengers with time to spare towards interactive installations situated out of the way of foot traffic. This alternate route is made up of three modular elements which can be modified over time. Thirty students from ENSCI and the Le Mans Fine Arts College came together for a workshop to explore with the Institute for Research and Coordination in Acoustics/Music (IRCAM) the ways of using sound design to streamline door-to-door routes and accompany new uses.
CONTROLLING THE JOURNEY

Punctuality remains a key factor affecting passenger satisfaction. This is a particularly sensitive subject for Mass transit services in dense areas. SNCF has proven expertise on the subject and demand for this type of transport is rising exponentially all over the world.

TRAFFIC REGULATION: A DISRUPTIVE APPROACH

Two major projects to improve punctuality have mobilised the energies of the teams at Innovation & Research: service fluidity and convergence. The first aims to keep rail traffic moving smoothly in dense areas by, where necessary, holding up trains in stations to reinstate sufficient headway so as to ensure that they only come across “clear” signals on their way to the next station. This principle avoids slowdowns that cause service congestion which can lead to service cancellations. In addition, making services more fluid can also help to increase the number of services deployed.

To reach this goal, SNCF Innovation & Research has developed algorithms to calculate in-station dwell times. After having been successfully tested on a virtual line using a train simulator, these algorithms were tested at the beginning of 2017 in real time in several stations in the west of Paris on the RER A line and line L3. Further experiments, coupled with the second project, will in particular extend the punctuality improvement objective to the line section operated by RATP.

The second project, Convergence, also aims to improve service punctuality but this time by adjusting train service running order. Operations in dense zones typically comprise transport plans with large service volumes which in practice often experience disruption. These risks to train times, associated with high service frequency, could lead to the theoretical running sequence being rescheduled at rail convergence points. Instead of obliging regulation staff to make decisions on quickly in real time by giving priority to late-running trains, the idea is to develop an application capable of recommending a running order in real time to maximise the passenger service punctuality of a whole line.

AIMING FOR PUNCTUALITY 3.0

At peak commuting times, trains are sometimes forced to observe longer dwell times, causing an impact on service regularity. The Reluance project, started up in 2016 and conducted with Transilien and Voyages in partnership with ENS Cachan, aims to develop an algorithm to automatically predict in real time the arrival time and ridership aboard trains drawing on a wide range of data sources. The challenge is to work on a complex system problem requiring a global vision which incorporates the infrastructure manager and railway undertakings.

Beyond the potential advantages in terms of traffic regulation, this type of predictive tool could help to provide passengers with more reliable information on both train times and passenger crowding on board and in stations. The first prototype was tested in early 2017. It will initially work from historical data, before a solution is designed based on real-time data.

IMPROVING TRAFFIC IN DENSE ZONES

The Mass Transit Lab, coordinated by Innovation & Research identified several workstreams to improve traffic in dense zones:

+ Work on streamlining and adaptability of the operating system to improve agility and increase capacity
+ Gain better upstream knowledge of high customer demand to fulfil their expectations and synchronise them with the performances of the transport system
+ Make stations easier to move around by managing passenger flow better, understanding their needs and developing added value services
+ Make progress on the principles of co-construction with customers.

These studies led to the creation of a new entity at Transilien, the MT Cab’Transilien to which SNCF Innovation & Research contributes in subjects such as flow modelling and the deployment of decision aid tools for real-time rail operation management.
RAILWAY SYSTEM PERFORMANCE

SNCF is revisiting its production with the introduction of new technology and industrial digital innovation. These focus on the maintenance of infrastructure and rolling stock, energy efficiency, environmental performance and traffic regulation.

SURVEILLANCE AND MAINTENANCE: A NEW AGE

Aiming for maintenance cost savings, network capacity enhancement and improvements in operating flexibility, punctuality and customer satisfaction, SNCF Innovation & Research’s works predominantly relate to interactions between moving items and fixed infrastructure (catenary and pantograph, vehicle and track, wheel and rail, the noise and vibration they create, the energy they carry and consume). In 2016, a large number of initiatives were conducted on wider-ranging topics such as robotising maintenance processes and additive manufacturing.

Considering the amount of money devoted to it, maintenance remains an essential research lever to optimise the railway transport economic model. While zero-maintenance is as yet a manufacturer’s pipe dream, several projects have revealed the potential of major productivity gains. About twenty were conducted in 2016, eight of which subsequently progressed to production. The general idea is to aim for maintenance which has the least possible impact on euros, on infrastructure and rolling stock capacity and on transport system disruption.
MODELLING, SIMULATING, CALCULATING: THE LAW OF BIG NUMBERS

One of the categories of study relates to modelling the ageing of system components. In the field of electrical power supply, digital tools simulating the pantograph-catenary interaction are in the process of being supplemented by new methods which introduce variability into the model. In this area, a thesis currently underway with Arts et Métiers ParisTech represents a major breakthrough that will enable better forecasting and insight into the complex phenomena occurring in the operative coupling of system components. The research for example demonstrated the importance of the variability of the tension in the messenger wire, which deserves to be more closely monitored to reduce the occurrence of incidents. More generally, the different analyses brought to light several catenary design ideas which could improve its performance.

In terms of track-vehicle interaction, SNCF develops multi-scale models which go from mechanisms causing rails cracks several hundred microns wide to the behaviour of components at macroscopic scale. Gaining better insight into the kinetics of these faults will help to better define surveillance and maintenance rules. Today, track maintenance is carried out according to easily measurable geometric criteria. Adding mathematical models and digital simulations will give access to other physical quantities which influence deterioration more directly. These are finer and contribute to change in practices and in maintenance guidelines. Two theses on these subjects have been written.

ROBOTS MAKE THEIR DEBUT

Maintenance operations carried out by robots has already begun. This robotisation enables physical installation-free maintenance and leads to time savings on tasks by carrying out tasks simultaneously or in hard-to-reach places; thereby increasing the availability of trains and the network.

INTERNET OF THINGS WIDENS THE SCOPE OF POSSIBILITIES...

One example of the application of these developed methods of signal treatment is the STC project (Surveillance by commercial trains). Launched by Innovation and Research, then taken up by Maintenance & Works Division to carry forward operational requirements work, this project aims to monitoring faults and their change over time, thanks to sensors installed on several commercial trainsets. This principle of monitoring by commercial trains has generated a step change in terms of knowledge of assets and in the track maintenance approach, improving efficiency and regularity. The possibilities offered by the analysis of dynamic vehicle-track interaction for the maintenance of train suspension components are also explored. While the direct analysis

Traindroid: open innovation for tomorrow’s maintenance

In 2016 SNCF invited its employees interested in technology and innovation to design robots to improve two regular maintenance operations. The door opening and closing system checking mechanisms and the visual inspection of detection brushes, a device installed under trains to display driving indicators in the cab, were selected. This six-month programme dedicated to human-machine interaction allowed them to test their prototypes in real operating conditions. Four finalist projects thus proved the feasibility of the low-cost development of robotic assistants from “open hardware” bricks and 3D printing and laser cutting techniques.
An agile supply chain project is being developed using 3D printing technologies. To reduce train downtime often caused by supply lead times for hard-to-find parts, some metal replacement parts for rolling stock will henceforth be able to be manufactured by 3D printing. This will help to achieve reductions in inventory volumes and their associated costs, and reduce train downtimes caused by unavailable parts. The first POC: a casting was produced in this way with a lead time of five days instead of five weeks. It remains to be seen whether the mechanical properties of these 3D printed parts are at least equivalent, or even superior, to those obtained by traditional manufacturing methods. In parallel, laser 3D printing technology is also being appraised to rebuild damaged parts. This research is being carried out as part of a thesis with École Polytechnique, in association with federal aviation administration.

Traction accounts for 80% of SNCF’s electricity bill.

KEYS TO SUSTAINABLE ENERGY OPTIMISATION

SNCF is the leading energy consumer in France. 80% of its consumption powers train traction, while the remaining 20% is supplied to buildings and industrial processes. One of the priorities at SNCF Innovation and Research is to contribute new opportunities in terms of energy efficiency. One of the areas developed is the recovery of braking energy, which leads to the design of mixed-energy solutions for both fixed facilities and rolling stock.

A REGENERATIVE BRAKING SIMULATOR
Almost a third of the braking energy of trains is lost into the atmosphere. Recovering 95% of it would reduce the rail network’s electricity bill by between 5 and 20%. SNCF is aiming for this theoretical target by building a reversible electricity sub-station on the 1,500 V DC network capable of recovering braking energy and injecting it into the electricity grid at peak times in order to cater to power surges. A demonstrator will be operational in Masséna station in Paris between now and the end of 2017. This initiative also comprises a collaborative project aiming to statistically model braking energy from the analysis of data supplied by the future demonstrator, and the simulation of the reuse of this energy in a railway smart grid. By 2018-2019, these two programmes will conclude whether the long-term benefit warrants the investments.
required to convert all of the country's substations. SNCF Innovation & Research also contributes its technical expertise in lithium battery storage to the SIGALI project: a demonstrator is commissioned in Sarcelles St Brice station (95) in summer 2017 to assess the feasibility of a micro-grid and its economic advisability for a station's power needs and back-up signalling.

+ If the project to recover braking energy is conclusive, SNCF will proceed with the development of a veritable smart grid for railways.

In the rolling stock field, on-board energy storage opens up new perspectives for hybrid engines. And as early as tomorrow! The idea is to combine diesel and/or electric traction with lithium batteries and supercapacitors which can recover braking energy. The aim is to power traction and on-board accessories. The final upshot is improved energy efficiency, better regularity, and higher capacity. But while the technology is mature, there is very little return on experience as regards the sizing of storage systems.

The design of a decision aid tool was launched in autumn 2016 to specify the installations required for the optimal operation of hybrid trains throughout their lifecycle. The selected economic model comprises the rolling stock and infrastructure but also environmental impact (noise, pollution, etc.). The first findings on locomotive sizing will emerge in autumn 2017, following which a first hybrid regional trainset will be designed.

Hydrogen: an option to replace diesel?

Technical obstacles still remain, in particular in storage safety. Existing solutions are as yet insufficient to power a train. This is a very open subject, and part of the TECH4RAIL project. Beyond the technological challenge, the aim is to build an ecosystem which is viable for SNCF. A fuel cell demonstrator will be up and running, as part of discussions entered into with Air Liquide and several start-ups. A first carbon-free hydrogen production and consumption system will start up in 2018 at the Espondeilhan substation near Béziers, to power auxiliaries.

Investigating new materials

Discussions have commenced with Airbus and Alstom to accelerate the integration of new composite materials in railway equipment. The aim here is to achieve lighter trains, which would consume less or accommodate more passengers. In both cases, this would be economically profitable.

Railway system performance

How can you make the station a hub comprising a wide range of energy services and infrastructure relating to mobility? This is the purpose of the open innovation programme Smart Station (Smart Gare in French), a study and exploration site designed by SNCF Innovation and Research focussing on the Versailles Chantiers station (64,000 passengers and more than 500 trains per day). A chart was produced mapping out the energy potentials of the businesses and housing located around the station. Electric mobility is analysed in terms of traffic and of the impact of electric vehicle charging on stations’ energy bills. SNCF is investigating the recovery and storage of braking energy. Things may well evolve radically with the future arrival of new generation batteries. Tomorrow, stations will be better integrated into the electricity grid and their surroundings. Research into energy saving in stations aims to achieve the convergence of increasing mobility and the developing sustainable cities.
AUGMENTING RAIL’S ENVIRONMENTAL PERFORMANCE

SNCF also intends to assert its difference through its environmental performances: projects centred on the eco-design of rolling stock, infrastructure and stations environmentally friendly throughout their life cycle. One of the items on the agenda is reducing the various emissions generated by the railway system: a mapping and modelling exercise of human exposition to low frequency electromagnetic fields is being carried out as part of the project ELFE RAIL. In a similar vein, the reduction of noise pollution caused by rolling stock is being studied by a European project, ACOUTRAIN.

INVENTING THE AUTONOMOUS TRAIN

A NEW GENERATION OF OPERATION

Research is continuing to deliver results in terms of automated technology and artificial intelligence to develop the existing technological bricks – ERTMS, Nexteo, geolocation, etc. – aiming to achieve more efficient, safe and regular operations. The research initiated into the autonomous train under the auspices of Tech4Rail is its guiding theme. The aim here is to achieve a technological leap of a similar scale to that of the TGV. This is a response to the saturation of some sections of infrastructure. An automatic driving assistance system on densely-occupied high-speed lines would help to increase the number of trains on the track every hour. This is also an essential issue in Île-de-France, where the number of trains running at the same time has almost reached maximum capacity. SNCF has appointed IRT Railenium to carry out studies on the train drone (remote driving) and artificial intelligence.

A partnership was also signed with Alstom and IRT SystemX on 7 April 2017. This relates to the creation of an automatic train environment perception system, drawing on a combination of sensors, cameras and radars to detect obstacles along the track and signalling. SNCF is also launching a partnership approach with a five-year objective of producing autonomous prototypes of passenger trains and of one freight train. An exchange protocol was signed in September 2016 by SNCF and Deutsche Bahn. It stipulates that each firm shall conduct its own project and that they shall share the findings of their research at regular intervals.

Another aspect is improving the accuracy of train localisation, whether relating to passenger-train co-regulation, signalling or level crossing safety. There are still plenty of technological challenges out there, and work is being stepped up in cooperation with CNES and IFSTTAR.

Sealing a pact between space and rail

CNES and SNCF signed a first-of-its-kind cooperation agreement in May 2016, creating a “Rail and Space” Coordination Committee. The first of its achievements is the modernisation of the command and control system linking up with the European satellite tracking system Galileo which increases accuracy from 10 metres to one metre and enables trains to navigate. Other possible developments include high speed broadband connectivity on trains using new satellites operating on Ka band, the security of the rail network using optic imagery, and the use of radar for the surveillance of tracks and their surroundings. “Thanks to radar interferometry methods, a satellite positioned 800 km above the Earth can see if tracks move or ballast sinks with an accuracy of two to three millimetres. We use the same technology to monitor the change in sea levels,” adds Jean-Yves Le Gall, President of CNES. Cooperation is also underway in skill sharing relating to the processing, valorisation and provision of data produced by the two partners.
IN ISRAEL, AT THE FOREFRONT OF SMART MOBILITY
SNCF is connected to Israeli start-ups and technologies through the University of Tel Aviv which supports the activities of a start-up incubator dedicated to smart mobility which SNCF has been sponsoring since 2015. Under this arrangement, an SNCF Innovation and Research team accompanied the Israeli start-up RFIsee for four months in 2016. Its project is to develop a detection system using a 3D radar fitted into a chip which is capable of generating “images” that are relatively close to those that remote laser detection (LiDAR) enables today. The new solution offers a clear competitive edge, since radar technology works in all weather and light conditions, which is not the case for lasers. Their team have been involved in a hackaton organized by SNCF and the University of Tel Aviv in May 2017.

IN JAPAN, HISTORICAL LINKS WITH RTRI (RAILWAY TECHNICAL RESEARCH INSTITUTE)
In October 2016, the seventh collaborative research seminar between SNCF and RTRI took place in Japan. The issues covered dealt with predictive catenary maintenance, track monitoring using commercial trains, rail contact fatigue, energy storage in substations, electronic power transformers, vehicle-rail interaction, geolocation, modelling of ballast tamping and operations and passenger behaviour modelling. RTRI’s substantial testing resources and SNCF’s advanced modelling skills form the core of this complementary relationship.

ARTIFICIAL INTELLIGENCE, THE NEW FRONTIER
Artificial intelligence is going to be substantially developed on a group scale in the coming years. Job areas, processes and industrial production and customer relationship solutions will be transformed as a result. Research has already commenced into the management of railway operations, the prediction of customer flows and innovative command and display interfaces. Simulation and machine learning techniques are being explored to predict the future condition of the system, aiming to achieve treatment times that are compatible with operational processes and feed data into decision and functional In-depth technological intelligence is also being conducted to critically analyse available chatbot technology and recommend the ones which are the most appropriate for the intended use.

Another growing trend is that of virtual certification tools which can be used in rolling stock and infrastructure homologation procedures to save time and money. Research is underway into a dynamic clearance gauge simulation approach with the adequate degree of accuracy. The aim is to predict the movements of the most critical points of vehicles and assess their compatibility with special parts of infrastructure.

Japan, North America, Middle East: wide-ranging international partnerships

WITH THE MONTREAL DATA SCIENTIST COMMUNITY
An agreement to support the creation of the IVADO (Institute for Data Valorisation) in Montreal was drawn up at the end of 2016 between SNCF, HEC Montreal, Polytechnique Montreal and the University of Montreal. The agreement, concluded for a five-year term, confirms the partnership with the world’s widest and most prolific community working in Data Science research and operational research applied to transport. Research is already underway relating to the classification of urban passengers, or on the interaction between mobility knowledge and the rapid redesign of the transport service offer. Other topics under consideration include the optimisation of real-time management, in particular using artificial intelligence technologies.

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TOKYO
RAILWAY SYSTEM PERFORMANCE
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(Centrale Paris, Supelec, Paris 11, ENS Cachan, IRT SystemX)
CHAIR «Anthropolis», J. Punchinger
- Simulation of complex systems
- Modelling of rail track behaviour
- Study of wheel/rail shunting and condition of electrical cables

ÉCOLE POLYTECHNIQUE, ENSTA PARISTECH
UNIVERSITÉ PARIS-SACLAY
CHAIR Innovation Management, C. Midler

UNIVERSITÉ PARIS-EST
(Université Marne la Vallée, Université de Créteil, ENPC, ITE Efficacity)
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