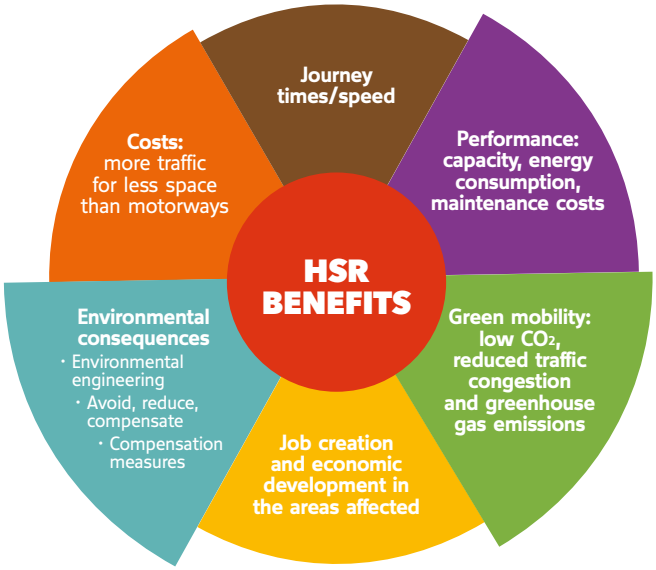
SYSTRA SOLUTIONS

Blazing a trail to HIGH SPEED RAIL worldwide

PRODUCING LITTLE CO_2, THEY HELP REDUCE POLLUTION, GREENHOUSE GAS EMISSIONS, TRAFFIC CONGESTION AND HAVE PROVED TO BE DRIVERS FOR ECONOMIC REGENERATION.

High speed railways have transformed our perceptions of time and space. Where we used to measure distances between towns in kilometres, now we measure them in hours. Urban areas are transforming their boundaries and forming connected communities.

To match this streamlined new transport network, we must utilise technological advances to invent solutions for evolving commercial needs, their geographical requirements, traffic density and special operating conditions.



>> **30 lines worldwide,** including **9** in France (out of a total 13 in service or in build)

>> **3 high speed railways** opened in France in 2017 South Europe Atlantic (SEA), Brittany-Loire Valley (BPL), Nîmes-Montpellier Bypass (CNM)

>> **10,000 km** of line worldwide, including **1,850 km** in France and **8,150** in other countries

>> **574.8 km/h,** the world speed record on rails, won in 2007 by SYSTRA on phase 1 of the East European high speed railway

>> South Europe Atlantic high speed railway **302 km** of original design and Europe's greatest public private partnership for a railway

TRUST
THE WORLD LEADER

Our finest projects around the world

Backed by 30 years of experience gained on more than half of the world's high speed railways, SYSTRA is blazing a trail for new high speed rail.

DESIGNS FOR HIGH SPEED LINES THAT ARE SAFE, EFFICIENT AND SIMPLE TO OPERATE

SYSTRA, THE WORLD LEADER FOR HIGH SPEED RAIL, HAS DESIGNED HALF OF THE WORLD'S HSRS IN SERVICE.

Our engineers have delivered projects in arduous climes, under the equatorial skies of Gabon, near the icy hinterland of the Arctic circle, in the heart of the Mauritanian desert.
For decades, we have been amassing best practices and innovations, so that our clients, wherever they are, can reap the benefits.
We can bring our unrivalled international experience to bear on your projects.

1
PROJECT DEFINITION FEASIBILITY

- Ridership simulation and forecast: feasibility studies, models of ridership and fare policies.
- Draft and optimise the railway corridor.
- Operating plan and design of the initial infrastructure: defining service needs, locating stations, depots and ancillary services.
- Ensure consistency between international standards and local rules for service, the environment etc.

2
DESIGN

Optimal line performance requires systems designed to augment line capacity by reducing the headway between trains, running at constant speeds to save energy and cut rolling-stock maintenance costs.

- **Set out the principles for the complex design of the infrastructure and rolling stock.** We deliver the civil engineering for railway bridges, tunnels and viaducts.
- **Guarantee reliability, availability, maintainability and safety on the line.** We plan for maintenance at the start, by creating a maintenance access plan and planning the supply chain for the depot and workshop.
- **Control the project's lifecycle costs.** Our engineers conduct special studies to optimise costs: aerodynamic studies to find the best tunnel cross sections and prescribe the distance between track centrelines. Thorough studies of the longitudinal profile.
- **Structures.** We factor in the vibrations from trains running at high speed, and the interaction between rails and structures.
- **Integrated network.** Combined freight and high speed lines, ETCS for HSR, railway interoperability, connections to the conventional network.

3.
CONSTRUCTION

Earthworks and civil engineering for a high speed line cost more than 70% of the total, so they must be optimised. Several methods are possible:

- Optimise all configurations for civil engineering (cross sections, trackbed width etc.) and systems (adjust the aerodynamic profile of rolling stock to reduce tunnel cross sections or catenary pylon spacing, optimise rolling-stock traction to cope with steeper gradients and so influence the longitudinal profile, etc.).
- Choose standardised, precast structures to speed up construction and work schedules.

4.
TESTING AND COMMISSIONING

Our teams help lead, organise and conduct all phases of static and dynamic testing, for individual technologies and for the overall integration of the high speed line. Our comprehensive knowledge of HSR testing and integration processes ensures that tests are exhaustive, installations are commissioned in the best possible conditions, and that the required proofs are submitted for the validation of systems and the approval of infrastructure. While dynamic testing is taking place, we also manage temporary service along the line, which is vital for safe and successful test schedules.

5.
OPERATION AND MAINTENANCE

During the design and construction of HSR projects, our teams plan carefully for the needs of the future operator and maintainer.

Our teams operate and maintain high speed railways during construction work and trials, before handing over to the final infrastructure manager. Their duties include writing all the temporary operating instructions, training all the construction and testing staff, and guaranteeing their safety while they are working on the line in service. As active members of MESEA, the company in charge of maintaining the South Europe Atlantic high speed railway, we are constantly learning about the needs, techniques and methods for HSR maintenance. We apply new methods relying on multi-skilled professionals, innovative equipment and operating specifications that were formulated at the start of the design process. Big data and digital technology have opened up new opportunities to collect data from your networks (detection and surveillance of incidents, faults and breakdowns), to relay, process and analyse it in real time. This speeds up your decision making and your ability to take prompt corrective action or plan timely repairs.

Our team of rolling stock experts work on the exploratory phase and the procurement process. They stay beside you during testing and commissioning, as well as operating and maintenance. Our teams work closely with the architects and contractors who design depots.

6.
SAFETY

Our experts help HSR operators to write their procedures and operating manuals, to audit safety and train operating staff.

7.
THE ENVIRONMENT

We conduct detailed environmental studies to minimise the visual, acoustic and carbon impact of railway infrastructure.

SYSTRA +

- We have helped write the European standards for ultra-high-speed railways.
- We have initiated new concepts such as slab track or short-span bridges, suitable for trains running at 350-400 km/h.
- We are working on the future of high speed rail, and inventing solutions to bring down the price, speed up construction, improve the resilience and maintainability of infrastructure.
- We calculate costs for the entire lifecycle of the infrastructure. We have developed simulations to predict the lifetime of track materials and the dynamics of the structure.

FOCUS ON INNOVATION

INCREASE THE SUSTAINABILITY AND EFFICIENCY OF RAILWAY CONNECTIONS

We are shaping the future of HSR, by designing economical solutions to accelerate construction, build more robustly and simplify maintenance.

Ballast or slab track? Having worked on projects the world over and put more than 4,700km of railtrack into service over the past 3 years, our experts have all the techniques at their fingertips. They can help you choose the best technology for your project.

Today, there are two coexisting solutions:

- **Ballast track,** the oldest and most widespread solution.
- **Slab track,** (or ballastless track), a more recent development used primarily for high speed and urban lines. The latter technology includes several different systems, compared to the fairly standardised architecture of ballast track.

While ballast track is quick and cost-effective to build, slab track is reliable and long lasting. However ballast track generates high maintenance costs and slab track has high initial construction cost. In short, both solutions have their strong points. The costs of investment and service (CAPEX-OPEX), in their specific building and operating contexts, must be examined carefully before making a choice.

SYSTRA used these methods to offer guidance for new High Speed Rail schemes in the UK. SYSTRA also conducted a study for ALSTOM to inspect the design and dimensions of the New Ballastless Track for a new HSR scheme.

SYSTRA is directing design studies for two new types of slab track, for the European Capacity4Rail project.

REINFORCING SYSTEMS' RESILIENCE

Natural risks, particularly flooding, can damage systems causing major social and economic consequences for our clients. They are a primary source of vulnerability today. For this reason SYSTRA has launched a research programme on resilience, defined as the capacity of a system to recover, after undergoing a disruption.

We begin by analysing failure mechanisms. These are similar to complex systems, with multiple internal interdependencies. In the case of flooding, we can study these interdependencies to compare the three traditional layouts for a guided transport system: underground, overground and elevated track. We combine this with a probabilistic simulation. We aim to adopt an overall approach that includes the risk of occurrence, its intensity, the material and indirect damage and the expected functional consequences i.e. contingency procedures for operating the system despite the disruption.

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WE USE BIM TO TRANSFORM THE WAY WE DESIGN, BUILD, OPERATE AND MAINTAIN YOUR TRANSPORT INFRASTRUCTURE.

This collaborative working method makes it easier to identify and manage interfaces between civil engineering, railway equipment, power, alignment and the environment, thereby facilitating decisions. It also enables us to make changes following discussions with town, country planners and wider stakeholder groups.

SYSTRA has proactively developed a unique application, BIM IN 1 CLICK. This innovative approach means that we create BIM models of linear infrastructure, quickly and accurately, providing and efficient service.

With BIM, you can integrate maintenance data and requirements during the design process, and this allows you to plan your maintenance and renewal activities. The benefits are reduced corrective maintenance charges and minimalised interruptions to service.

Combined with predictive maintenance, using BIM offer practical solutions for managing assets.

PREDICTIVE MAINTENANCE

Safety, efficiency and cost control are among the advantages derived from the Internet of Things. When temperature, pressure, voltage and acceleration sensors are installed on track, in tunnels, on viaducts, signalling equipment and rolling stock, the data collected can be analysed in real time to apprehend and monitor every part of a network. The information collected will radically transform maintenance operations and make it possible to anticipate breakdowns and failure points. Maintenance staff can use this selected data to pinpoint the exact problem and deal with it, causing minimal service disruption and its attendant costs. SYSTRA has acquired a unique expertise in designing, installing and operating networks of interconnected sensors. They totally transform the management of operations and maintenance, and benefit our clients' bottom line. The SEA case study showcases how we worked with our client to deploy this.

FOCUS
SOUTH EUROPE ATLANTIC
PARIS TO BORDEAUX IN 2 HOURS 4 MINUTES

A distillate of innovation, from the concession model to building and maintenance techniques.

SEA, three letters to describe the high speed line connecting the Atlantic coast to Europe and the Iberian peninsula. 302 km of new railtrack between Tours and Bordeaux, 38 km of connections. An infrastructure designed to comply with the most stringent European standards for railway interoperability, built to a six-year deadline. The South Europe Atlantic high speed railway incorporates the latest European standards for railway traffic, notably the European Rail Traffic Management System (ERTMS), a standardised system for signalling safety and supervision to ensure interoperability between national rail networks. The target was to create a truly European rail network that will enable all rail operators to run their trains along this high speed line from 2017.

The South Europe Atlantic HSR is a defining piece of infrastructure for the future of mobility in Europe. Since July 2017, the journey time from Paris to Bordeaux has been cut from 3h14 to 2h04, to satisfy the needs of 20 million passengers. Providing connections between the high speed railway and the conventional national rail is vital to economic regeneration of the surrounding areas. It will provide connections for business, employment, tourism and relieve urban and road congestion, while diminishing CO_2 emissions. Beyond the technical challenge, shorter journey times from the main stations along the track (Poitiers, Châtellerault, Angoulême etc.) will bring people and places closer.

The South Europe Atlantic high speed railway is Europe's largest rail construction project and France's greatest public-private partnership (worth 7.8 billion Euros) to date. Considering the far-reaching effects

on town & country planning and access to southern networks, the project needed robust partners, ready and able to effectively manage risks. Sharing the same long-term vision, SYSTRA the guided transport engineering specialist and VINCI, the world class concessionaire and construction company, joined forces to invent a new way of designing and delivering this project to tight deadlines, strict budgets and with a "traffic" risk borne by the concessionaire. The concession contract signed between SNCF Rēseau (rail network) and LISEA (South Europe Atlantic Line), the project company, will run for 50 years, 6 for design and build, 44 for operating and maintenance. COSEA (South Europe Atlantic Construction) managed design and construction. MESEA (South Europe Atlantic Maintenance) is in charge of operations and maintenance. Such a contract made it possible to assemble the private resources and innovators needed to upgrade the French railway network, in line with the granter's instructions, and to build an efficient, environmentally friendly transport system. It enabled the project to be optimised over 44 years of operating and maintenance, with costs guaranteed by the concessionnaire, as stipulated by the contract.

DESIGN AND BUILD PROJECTS

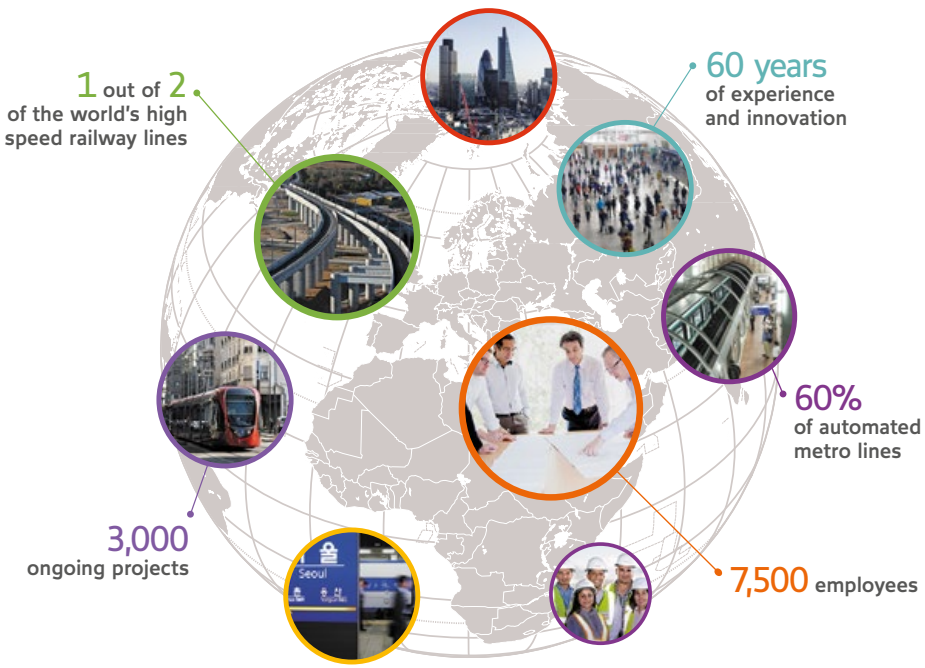
Work can proceed faster under new contract models.

More and more public authorities and network managers are transferring risk to private enterprise and delegating their projects to firms that carry them forward, from building to operating and maintenance, while proposing solutions for funding their work. As a result, major manufacturers are becoming our clients and partners. This is changing our relationships, the scale of our assignments, everything except the attention that we at SYSTRA pay to our clients' needs, and our unwavering belief that steadfast partnerships are founded upon trust.

The South Europe Atlantic HSL connects the South West of France to the European high speed network, cutting the Paris-Bordeaux trip to 2 hours. The line has been designed for speeds of up to 350 km/h. The line is funded by a Public-Private Partnership (PPP), of which SYSTRA is a member, as the holder of 30% of shares in the maintenance company, alongside Vinci Concessions. We are also the guarantors of the project's technology.

CONFIDENCE MOVES THE WORLD

The Group assists growing towns and regions that need reliable, fast, clean transport systems, to make a lasting improvement to their residents' living standards.



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