

# STEERING ACROSS SYSTEM CHALLENGES

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# SYSTR

**SYSTRA**

# Summary

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**HOW WE CAN HELP: OUR PORTFOLIO OF SERVICES**



# The challenges of integrating complex systems

Mobility projects are becoming more complex as technology enables new options and transport services become more sophisticated and interconnected. Delivering new transport systems requires broad and deep skills across the entire spectrum of technical disciplines, as well as collaboration and negotiation skills to deal with an increasing array of stakeholders, and to find optimal multi-criteria solutions.

You are confronted with a complex and multidimensional environment. The road to reach an in-operation transportation system can be long! Strong system engineering and integration skills will be vital to the successful delivery of tomorrow's sustainable transport and mobility services. These skills are essential to completing complex projects on time, on budget and with the expected quality for a perfect client service.

# Transport systems must adapt to complex and rapidly evolving demands



To address the issues in a diverse and complex environment, you must think globally. Taking a holistic approach to transport systems is key to providing a robust, competitive & innovative solution, accounting for all present and future challenges.

Perfectly understanding your challenges and objectives to deliver safe, attractive and accessible transport for all is our first priority.

Our system engineering approach find solutions to build and maintain these systems, optimise your resources and maximise passenger satisfaction.

Lessons learnt in migrating systems in a live transport network help reduce technical risks and ensure that the renewal of systems has minimal impact on operations.



# A global team of experts

Over  
**1 000**  
system specialists  
deployed worldwide

Designed  
**1 out 2**  
metros in the world

**50%**  
of the world's high speed  
rail lines

Managing complex systems is at the heart of all we do and we are passionate about delivering attractive and sustainable transport for generations to come. SYSTRA has been a world leader in the field of transportation infrastructure for 60 years. Systems are a cornerstone of our technical excellence in providing safe, efficient, and cost effective solutions.

With more than 1,000 highly skilled experts in 30 countries, SYSTRA covers the full range of technical disciplines in transport systems. To leverage the best of this know-how and global workforce capacity, SYSTRA has set-up a unique approach by connecting all these experts through a common Business Line: **the SYSTEM GROUP.**



# A global footprint

Wherever you are in the world you will have access to the whole Group know-how and capacity thanks to this common Business Line



# 60 years into our pursuit of excellence ...

Our proven approach is the result of methods and processes, available today in digital tools for an agile and robust deployment on any project around the world.

Our expertise of integration is supported by a mature System Engineering Framework (SEF) that places the client's core needs – operations, maintenance and safety – at its root. SYSTRA's knowledge is capitalised in a friendly database of functional and technical requirements, allowing significant time and risk reduction thus streamlining our project delivery around the globe.

Building a new transportation solution is a long term and structuring project, design choices are meant to deliver a long lasting infrastructure that evolves over its lifetime.

We are continuously offering to our clients what we have learnt and experienced from projects across the globe and from our contribution to international standardisation bodies.

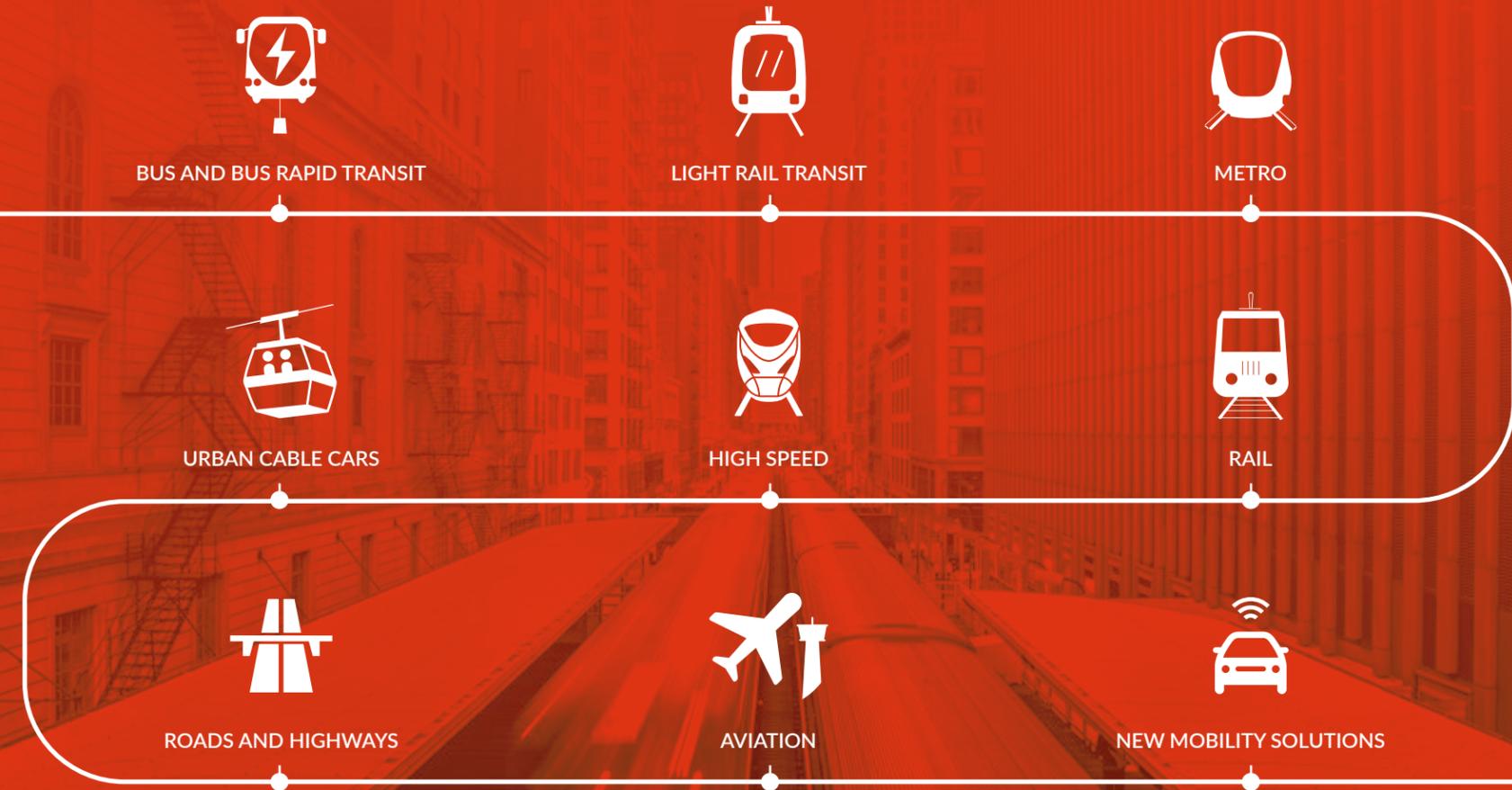


 **SYSTRA specified the world's first catenary-free tram in Bordeaux.**

**The lessons learnt from this project were used to specify the world's longest catenary-free tram in Dubai.**



# ... for all transportation solutions



# We accompany you every step of the way

Delivering transport systems requires a common vision addressing the multiple stakeholder viewpoints, improving operational outcomes and securing optimum stakeholder objectives throughout the project life-cycle.



|  | 1 FEASIBILITY STAGE   | 2 DESIGN STAGE  | 3 IMPLEMENTATION STAGE  | 4 IN OPERATION   |
|--|---|---|---|--|
| <b>FOR MOBILITY AUTHORITIES</b>              | <ul style="list-style-type: none"> <li>Credible CAPEX and IRR estimation</li> <li>Overall business case preparation</li> <li>KPI definition</li> </ul>                  | <ul style="list-style-type: none"> <li>Technical advisory</li> <li>Procurement strategy definition</li> <li>Data management plans</li> </ul>                                      | <ul style="list-style-type: none"> <li>Technical advisory</li> <li>Data modelling and analysis</li> <li>Requirements management</li> </ul>          | <ul style="list-style-type: none"> <li>Technical audits</li> <li>Performance audits</li> <li>Air quality analysis</li> </ul>                                     |
| <b>FOR TRANSPORT INFRASTRUCTURE MANAGERS</b> | <ul style="list-style-type: none"> <li>Migration strategy definition</li> <li>Realistic time schedule preparation</li> </ul>  | <ul style="list-style-type: none"> <li>Functional and technical design</li> <li>Tender specification preparation</li> <li>Tender evaluation &amp; contract negotiation</li> </ul> | <ul style="list-style-type: none"> <li>Technical conformity verification</li> <li>Contractor management</li> <li>Deliverables validation</li> </ul> | <ul style="list-style-type: none"> <li>Technical advisory</li> <li>OPEX optimisation audits</li> <li>Security audits</li> </ul>                                  |
| <b>FOR TRANSPORT OPERATORS</b>               | <ul style="list-style-type: none"> <li>Migration strategy definition</li> <li>Investment strategy definition</li> <li>Preparation for arrival of competition</li> </ul> | <ul style="list-style-type: none"> <li>Preparation for operations and maintenance</li> <li>KPI definition</li> <li>Rolling stock investment case</li> </ul>                       | <ul style="list-style-type: none"> <li>Provision of training for operations staff</li> <li>Provision of training for maintenance staff</li> </ul>   | <ul style="list-style-type: none"> <li>Technical advisory</li> <li>OPEX optimisation audits</li> <li>Operations &amp; maintenance optimisation audits</li> </ul> |
| <b>FOR CONTRACTORS</b>                       | <ul style="list-style-type: none"> <li>Feasibility studies</li> <li>Value engineering studies</li> <li>Optimised tender design</li> </ul>                               | <ul style="list-style-type: none"> <li>Basic and detailed design</li> <li>Requirement &amp; interface management</li> <li>Independent verifier &amp; system assurance</li> </ul>  | <ul style="list-style-type: none"> <li>Integration</li> <li>Test &amp; commissioning</li> <li>Migration preparation</li> </ul>                      | <ul style="list-style-type: none"> <li>Technical advisory</li> <li>OPEX optimisation audits</li> <li>Operations &amp; maintenance optimisation audits</li> </ul> |



# We optimise performance and value from existing and new assets ...

## NEW-BUILD

We partner with our clients to offer a safe, sustainable, attractive and effective transport service for passengers.

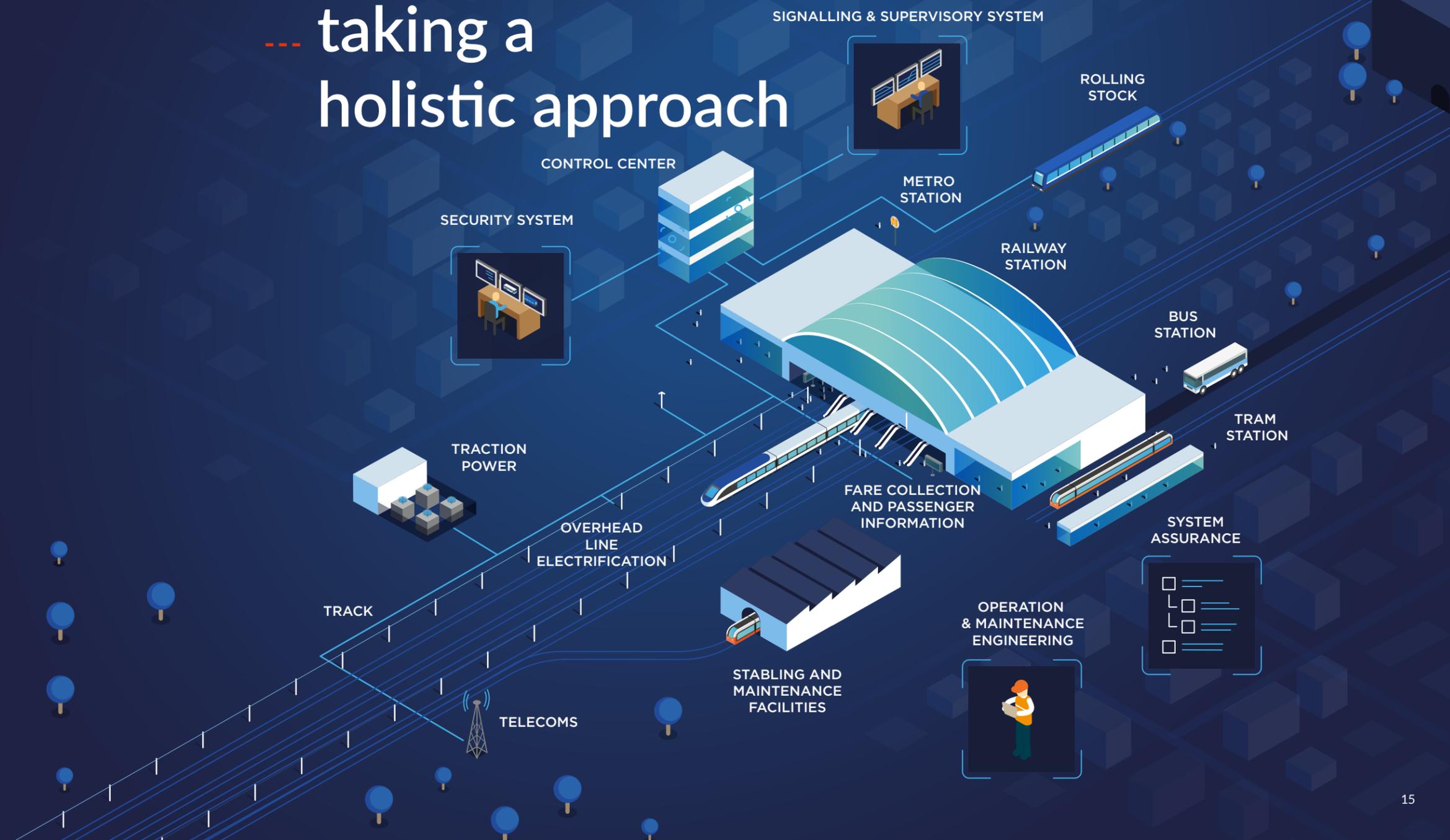
Building a new transportation system, from urban to very high speed rail requires a significant experience in delivering such complex projects with a robust system engineering approach.

## MODERNISATION

The modernisation of existing transport systems extends the lifecycle of your assets, reduces its OPEX and enhances its attractiveness and resilience.

- Transportation system automation and **migration** of signalling, telecom, fare collection and passenger information.
- Digitalisation of assets (**BIM**), digital twin and condition based maintenance.
- **Rolling stock** modernisation.
- **Air quality** improvement for infrastructure and rolling stock.
- **Electrification** of railway and bus fleets.
- **Cybersecurity** vulnerability assessment.

# ... taking a holistic approach



# Improving mobility through new technology

Technology is moving fast and provides opportunities to improve our transport, bringing more safety, efficiency and passenger comfort.

At SYSTRA we are connected with the innovation ecosystem through our fab lab named QETO, and continuously assess new solutions with reputed universities, innovative start ups and established industry players.

**WE HELP INTRODUCE NEW TECHNOLOGY IN A CONTROLLED WAY TO FUNDAMENTALLY CHANGE HOW MOBILITY SERVICES ARE PROVIDED AND EXPERIENCED.**

- Take the best advantage of **data and machine learning** to improve operations & maintenance through better prediction.
- Connect information systems with **hypervision** to better coordinate transport.
- Design and implement **Mobility as a Service (MaaS)** solutions for cities and regions.
- Plan and introduce **new telecommunication solutions** such as 5G to dive into new possibilities offered.



# How we can help

## OUR PORTFOLIO OF SERVICES



### OPTIMISE SYSTEM ENGINEERING & INTEGRATION

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| System engineering | 20 |
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### OPTIMISE CAPACITY, PERFORMANCE & COST

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### DELIVER SPECIFIC EXPERTISE

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# System Engineering

- #OPERATIONS
- #MAINTENANCE
- #SAFETY
- #COST
- #RISK
- #PERFORMANCE
- #REQUIREMENTS
- #INTERFACES

SYSTRA's unique approach to system engineering first defines operations, maintenance, safety, performance and then uses a database to identify functional and then technical requirements right at the beginning of the project thus reducing risk, saving time and money.

## How we can help

SYSTRA's considerable knowledge base allows us to reduce the duration of the design phase by efficiently transcribing the client's needs into our system model, to better manage interfaces & integration and to finally reduce risks. This is supported by robust & shared processes.

- **Requirements management:** ensures that all needs are covered, requirements being traced from O&M requirements and safety policy identification down to subsystems design.
- **Configuration management:** guarantees that each delivered baseline matches the expected content meaning that changes are agreed, controlled and shared among stakeholders in a synchronous manner.
- **Functional apportionment:** ensures the absence of overlaps, loopholes and/or inconsistencies.
- **Interface management:** process enhancement through responsibility allocation according to technical discipline delivery scope.

- **V-cycle, quality gates:** ensures an adequate level of maturity before proceeding into the next phase of delivery during the whole project lifecycle.
- **System assurance:** guarantees the operating performance thus contributing to on-time and on-cost delivery. It embeds Reliability Availability Maintainability (RAM), system safety, cybersecurity, human factors & ergonomics and security assurance.

## Toulouse Metro line 3, France

NEW-BUILD

CLIENT : Tisseo    OUR ROLE : Technical consultant    DATE : Since 2020

M3 is a strategic driverless metro line linking two Airbus industrial centres (Colomiers and Labège), passing through the city centre and ensuring major connections to rail, metro, tramway and bus networks as well as to the South Urban Cable Car, the Matabiau HSR station and the Blagnac Airport, via the airport express line.



## ACTIVITIES

- System integration
- Depot
- Track
- Electrical power supply
- Fares/ticketing
- Centralised control and passenger information
- Signalling
- Platform screen doors
- Rolling stock
- Telecommunications
- Safety

# Tours-Bordeaux high speed rail, France

NEW-BUILD

**CLIENT :** Réseau Ferré de France (RFF) - LISEA (consortium)  
**OUR ROLE :** D&B Engineering lead - O&M shareholder     **DATE :** 2007 - 2017

For this 302 km high-speed line built as part of a concession, SYSTRA was involved in all stages of the project through a number of partnerships from basic design through works supervision to testing and commissioning and maintenance. Working as a tier-1 contractor, SYSTRA was jointly responsible for:

- project management: member of the project management team for the whole project;
- overall design: lead engineer for civil engineering and railway systems;
- power: design, validation, works supervision, testing and safety management;
- superstructure (including track and overhead line electrification): design, validation and construction as well as railhead operation management;
- signalling and telecommunications: engineering management, design, verification and validation, works supervision;
- overall integration testing: integration of sub-systems and systems, dynamic testing, definition of operating rules.

SYSTRA's involvement will continue until 2061: the Group has a 30% stake in MESEA, the contractor responsible for the operation and maintenance of the HSL. With a team of over 100 staff, SYSTRA's role includes the setting up of the maintenance organisation, life-cycle cost optimisation (integrating RAMS requirements and contractual penalties) and maintenance of equipment.



## ACTIVITIES

- Design
- Installation
- Test & commissioning
- Bringing into service



# System integration

- #INTEGRATION
- #COMPLEX
- #TESTING
- #REQUIREMENTS
- #INTERFACES
- #PERFORMANCE
- #HANDOVER

All projects may encounter unexpected pitfalls, at any stage of the project lifecycle. A robust system integration helps the client prevent reworks caused by such unexpected events.

System integration ensures that, after assembly, the system fulfils initial expectations, within the defined time and budget.

SYSTRA uses experience from projects worldwide over the last 60 years to ensure that systems are fully integrated at every stage of the project from design through to test and commissioning.

## How we can help

The design of complex systems entails integration of multiple technologies. A system engineering approach delivers optimal performance, guarantees efficient service, and meets the requirements. SYSTRA's understanding of integration is backed up by a mature system engineering framework, experienced project management office, and processes which are the result of our know-how, proven methodology and decades of experience gained on signature projects all over the world. SYSTRA's unique experience in complex interconnected systems derives from numerous bus, light rail, metro, conventional rail as well as high-speed rail projects.

Our dedicated testing and commissioning (T&C) experts plan, direct and drive the effort of the overall testing process through:

- definition of activities from factory testing, their sequence and associated time schedule;
- T&C task supervision and control until handover to the Client and start of revenue service;
- system test readiness (test environment, stakeholders needs, safety...).

## Crossrail, London, UK

NEW-BUILD

CLIENT : Crossrail Limited    OUR ROLE : Technical expert    DATE : 2009 - 2021

For this 118 km line, SYSTRA's primary role is to provide expertise in railway systems and operations, such as signalling, communications, traction power, track and overhead line equipment, as well as expertise in tunnelling, noise and vibration control, BIM, planning, commercial management, project management and construction site management. We are specifically responsible for managing systems installation and integration.

SYSTRA is heavily involved with the Routeway/Systemwide Rail systems and plays a leading role in the integration of these systems, for example the OHLE and Tunnel Safety Systems with the SCADA communication network.

SYSTRA has helped optimise the choice of signaling system for Crossrail's central section, assessing both the European Train Control System (ETCS) currently being rolled out by Network Rail and Communications-Based Train Control system (CBTC) of the type commonly deployed on new metro lines.



## ACTIVITIES

ETCS & CBTC

Telecommunications & SCADA

Traction power

Track & overhead line equipment

BIM





# Automation

#MIGRATION

#OPERATIONS

#INTEGRATION

By migrating to modern signalling systems, transport infrastructure managers and operators can increase capacity by reducing headway and enhancing resilience in the transport network, as well as reducing human intervention and OPEX.

An automated urban or suburban line can also cut down power consumption and therefore carbon footprint.

To ensure successful migration, SYSTRA defines the strategy right at the beginning of the project and ensures that expertise from all relevant sub-systems are used throughout the project lifecycle taking into account obsolescence, operations and cost.

## How we can help

Having a complete understanding of the technology gap between conventional signaling systems and CBTC technology, for example, is essential for migration to a driverless system to be successful. SYSTRA can:

- develop investment strategies and plans;
- prepare a robust operating plan for a line, a group of lines, a complete network;
- assess the condition of the existing lines in terms of technology obsolescence, unused remaining capacity;
- estimate cost and carry out value analysis;
- carry out preliminary and basic design;
- supervise construction;
- optimize phasing to reduce operational impacts;
- integrate sub-systems;
- produce test strategies and plans;
- carry our factory and site acceptance testing;

- assess the acceptance by the rolling stock of new on-board technologies;
- undertake static and dynamic testing;
- assess the requirements for enhancing other systems in the frame of the reinforcement of the transport offer;
- prepare and carry out the migration to Grade of Automation level 2 to 4 (driverless).

## Brussels Metro Lines 1 and 5, Belgium

MODERNISATION

CLIENT : STIB    OUR ROLE : Technical Expert Consultant    DATE : 2012 - 2024

The modernisation programme for the Brussels metro system comprises:

- renewal signalling on lines 1-5, including the study to automate driving and demonstrate it on a section of the network;
- Introduction of new rolling stock;
- construction of a new depot near Erasme station;
- conversion of the existing Delta depot;
- installation of platform screen doors on the demonstration section;
- upgrade of the various plant rooms.

Unattended operation is planned on the whole line (except in the workshops) (CBTC type GoA4 (UTO): fully driverless operation with automatic wake up and parking.

The major constraint of this project is not to impede daily running of trains. The work therefore takes place at night and the necessary station closures (when installing platform screen doors) or line closures (during test phases) are kept as brief as possible. Interfacing with the client's other projects is a major expectation.

SYSTRA is providing technical, supervisory and project management support from the detailed design phase through to entry into service. This includes supervising and testing signalling and the new rolling stock as well as support for the creation of a new depot, located at the Erasme station, western terminus of line 5.



## ACTIVITIES

Driverless

Test & commissioning

Migration

Signalling

Rolling stock

Depot





# Enhanced Asset Management

#MONITORING

#PREDICTIVE

#MAINTENANCE

#OPEX

#DATA

#MACHINE-LEARNING

Identifying and monitoring the components of the transport system, their state of use on a continuous basis allows a better planning of their maintenance and replacement which guarantee optimum performance at an optimized CAPEX / OPEX cost.

Managing the information relative to the transport system requires the grouping of heterogeneous sources of information in a central database that can be called a digital twin, and possibly the creation of missing data by instrumenting the equipment in conventional or IoT-based systems. The processing and use of this information requires data skills, but also the combination of data management/ machine learning with input from technical experts. Doing so will considerably increase savings and contribute to optimize operations and maintenance.

## How we can help

- Carry out CAPEX/OPEX trade-off, risk/cost analysis and what-if scenarios to help define the best time interval for renewal of the assets considering the fulfilment of the agreed Service Levels.
- Define a decision-making process for the end-of-life management of the assets, with the objective of extracting the required value, at the lowest lifecycle cost, in a sustainable way.
- Implement an asset management system (AMS) that could lead to an ISO 55001 certification in asset management.
- Undertake audits.
- Define maintenance strategies.
- Define maintenance organization.
- Help digitize maintenance using IoT, monitoring & supervision, predictive and conditional maintenance and hypervision (consolidated supervisory systems).

## Chilean Railways, Chile

MODERNISATION

CLIENT : Empresa de los Ferrocarriles del Estado (EFE)

OUR ROLE : Technical advisor      DATE : 2018 - 2019

The aim of the project is to build an obsolescence model for Chilean railways to provide EFE with the means to manage its assets, by monitoring their ages and controlling their obsolescence, and analysing the impacts of deterioration, in terms of the risks to reliability, availability, maintainability defining and prioritising investments.

### SYSTRA was responsible for:

- stage 1 - creating a complete register of railway assets, identifying coherent groups (technology, age, conditions of use), and conducting a field audit to ensure the reliability of the asset database and assess the state of the assets;
- stage 2 - assessing the state of assets according to 5 criteria determined by the client: useful life, technology, performance, environment and standard-related issues;
- stage 3 - building an obsolescence model: a cross-functional overview of the state of all assets and an ageing model, to estimate how much life is left in the assets;
- stage 4 - an analysis of railway risks linked to asset obsolescence;
- stage 5 - the analysis of RAMS linked to asset obsolescence;
- stage 6 - suggesting an investment programme to deal with the obsolescence of assets.



## ACTIVITIES

Asset register creation

Audits

Asset state assessment

Create obsolescence model

Risk evaluation

RAMS analysis

Investment programme proposition



# Preparation for operations and maintenance

#SUPPORT #OPERATION #MAINTENANCE #ORGANISATION #TRANSITION

When a new or an upgraded line is ready to take passengers, the smooth transition to the transport operator can be guaranteed if it is prepared well in advance.

By having a shadow operator in place before the principal operator takes over means that operations have already been organised and dimensioned correctly. The shadow operator will define and/or optimise operations, set resources levels and prepare the timetabling.

## How we can help

- Perform operating studies including complex simulations of lines or networks.
- Provide specific expertise in rail traffic management.
- Define the systems interfaces.
- Provide operator training.
- Size service facilities (depots, garages).
- Assist to correct any emergent faults and provide maintenance, driver and operator/controller training.
- Provide advice for selecting the operator.
- Define the key performance indicators.
- Produce preliminary operation and maintenance plans.

## Bogota L1, Colombia

NEW-BUILD

CLIENT : Financiera de Desarrollo Nacional (FDN) OUR ROLE : Technical Consultant  
DATE : 2017 - 2020

This is the first metro line in Bogota.

The line consists of a 23.96 km length viaduct, a 30 Ha depot and an estimated capacity of 54.000 pph.

SYSTRA provided the following services:

- design (including BIM production);
- produce technical specifications for all technical disciplines including traction power, signalling, control systems, communications systems, fare collection, rolling stock, RAMS, operations, maintenance;
- provide technical assistance for transaction scheme and concession bidding.



## ACTIVITIES

Concession tender preparation & evaluation

Simulation of operations

Dimensioning



# Secure & high-performance communications

#MIGRATION

#TECHNOLOGIES

#IMPLEMENTATION

#OBSOLESCENCE

Modern telecommunications systems enhance real-time connectivity between all parts of the operational transport network. This also helps to reduce operational expenditure as operations and maintenance are optimized.

Understanding the complexity of introducing modern telecommunications systems, that constantly evolve, into an operational environment will help reduce the impact on train movements.

## How we can help

- Develop investment strategies and plans for new technologies such as 5G.
  - Carry out preliminary and basic design including radio network coverage planning.
  - Supervise construction.
  - Integrate sub-systems.
  - Produce test strategies and plans.
  - Help and define performance thresholds, service quality targets, functional and technical requirements for new systems including when telecom services need to be shared between different types of users.
  - Establish and execute a clearly defined migration plan.
  - Investigate possible interference with neighboring radio systems outside the transport network and resolve them.
  - Carry out technical and functional testing of telecommunications systems including dynamic testing.
- Bring knowledge directly from standardization groups where SYSTRA contributes and implement it in the context of an operational transport network. Examples of groups include: UIC/UGFA, CEPT, ETSI Rail Telecommunications.

## Nimes-Montpellier mixed conventional/ high speed rail, France

NEW-BUILD

CLIENT : Réseau Ferré de France (RFF) - GIE Oc'Via

OUR ROLE : General Consultant - Lead Consultant

DATE : 2012 - 2017

SYSTRA was in charge of an integrated project management consortium on behalf of the OC'VIA Construction consortium. This was the first "mixed" and scalable new line, designed to accommodate both passenger and freight traffic. This HSR is 80km long (a main section of 60km between Manduel and Lattes and 20km of connection sections).

As part of this 25-year public-private partnership (PPP) SYSTRA was responsible for:

- the preliminary, basic and detailed design for alignment, structures, systems and earthworks;
- revised preliminary design;
- systems engineering;
- integration and dynamic testing – general management of the test and commissioning activities;
- management of construction work, safety training, assurance.

SYSTRA was jointly responsible for the design, the procurement, the installation, the testing and the bringing into service of all of the operational telecommunications systems for this new line.



## ACTIVITIES

Design

Procurement

Installation

Test & commissioning

Bringing into service

Operations

Maintenance



# Transition to clean bus transport

#OPERATIONS

#MIGRATION

DIMENSIONING

Transport authorities and operators are transitioning existing diesel powered buses to provide a mobility service with zero or low CO2 emissions and noise pollution transportation solutions.

Starting from the transportation needs and accurate energy consumption forecasts, the challenge is to make the best choice of energy sources (electric, natural gas, hydrogen) based on state of the art solutions and revisit it regularly, given the rapid evolution of technology.

The main parameters considered to optimize CAPEX and OPEX are: range, bus unit cost, infrastructure installation cost, energy cost, charging/refuelling times and possibly regulatory constraints.

## How we can help

- Undertake feasibility studies, comparing energy sources options.
- Based on commercial service need and projections:
  - estimate energy consumption forecasts and vehicle range;
  - define the bus fleet and the charging / refuelling infrastructure.
- Optimise charging / refuelling strategy to optimise CAPEX & OPEX and limit impact of regulatory constraints:
  - slow and fast charging solutions;
  - charging scheduling to limit peaks and charging / refuelling infrastructure sizing.
- Support energy contracts negotiation with providers.
- Prepare preliminary and detailed designs.
- Prepare calls for tenders and carrying out tender evaluation.
- Undertake implementation management as well as verification and validation until commercial operation.

## Orléans Métropole, France

□ MODERNISATION

CLIENT : Orleans Métropole

OUR ROLE : Technical consultant

DATE : 2019 - 2023

The project is to start migration to buses that run on clean energy. The current fleet is comprised of 214 buses, including 76 articulated, 87 rigids, 51 others (midi and minibuses). Purchasing, assisting with acceptance, phasing the deployment of buses over the life of the project, are included in the operation. SYSTRA is responsible for managing the deployment of the slow charge system in the depot as well as providing financial and legal services. SYSTRA is also responsible for contract management.



## ACTIVITIES

Adapt depots

Procurement of vehicles

Electromobility





# Energy management & optimisation

#ENERGY #OPTIMISATION #CONSUMPTION

Typically, 7% of OPEX is linked to energy. Energy bill savings can be made with minimum investment using measurements and analysis (compared with other methodologies, more expensive and time consuming).

By measuring real-time consumption at a vehicle level as well as at the infrastructure level, potential improvements areas can be identified.

## How we can help

Map the energy consumption and provide optimisation services based on minimum non-intrusive measurements and machine learning.

Provide the following levels of service, using an energy efficiency diagnosis tool, energy measurements, data platform and applications.

- **Basic:** instrumentation only + data hosting + reporting dashboards (necessary for audits and follow up).
- **Advanced:** Basic plus traction system simulation (necessary for system deep energy flows understanding).
- **Advanced+:** Advanced plus energy efficiency improvement scenarios simulations (necessary for new business plans).

## SYSTRA's approach

### MODERNISATION

SYSTRA aims to give clients a complete view of their energy consumption in relation to traffic levels and provide predictions based on various operational scenarios.

Using digital technology and data platforms, SYSTRA maps electricity consumption based on non-intrusive measurements. This data is then analysed using machine learning and combined with analysis by experts to provide detailed recommendations which could include modifying driving styles or operations at certain times to intelligently and dynamically reduce energy consumption.



## ACTIVITIES

IoT

Data analysis

Machine learning



Energy consumption in relation to operations



# Electrification

- #MIGRATION
- #TECHNICAL
- #OPTIMISATION
- #CAPEX
- #OPEX
- #EMC
- #AESTHETICS
- #ENERGY EFFICIENCY

Electrification is a global solution for:

- obtaining enhanced performance (frequency, commercial speed etc.);
- giving a better sustainable response to global warming;
- operations on rail segments allows us to mesh a network;

Balancing cost and benefits by optimising technical choices helps ensure the most appropriate technology and solution is chosen.

## How we can help

SYSTRA has considerable experience of electrification for all types of transport modes, in mainline railway (regional, high speed and very high speed) as well as in urban areas (trolleybus, tram/light rail, metro and suburban rail).

Our services include:

- develop investment strategies and plans;
- estimate cost and carry out value analysis;
- perform static and dynamic simulations;
- produce feeding and sectioning diagrams;
- design overhead line and power supply systems;
- design optimized solutions mixing overhead contact lines and embedded energy;
- carry out preliminary and basic design;
- carry out detailed designs;
- undertake gauging studies for overhead line infrastructure;
- prepare earthing specifications;
- perform EMC studies;

- supervise construction;
- integrate sub-systems;
- produce test strategies and plans;
- carry out factory and site acceptance testing;
- undertake static and dynamic testing.

## Edinburgh to Glasgow improvement program, UK

□ MODERNISATION

**CLIENT :** Costain    **OUR ROLE :** Lead Electrification Designer    **DATE :** 2014 - 2018

The project is the first major project on UK mainline rail network. After helping the contractor JV Alstom, Babcock and Costain to win the tender, SYSTRA became the exclusive designer of Costain to deliver the electrification engineering. Under an innovative Alliance scheme whereby our client Costain has design and built responsibilities for the implementation of the project, SYSTRA is in charge of engineering, design for construction and site engineering support for:

- Overhead Line Electrification (OLE);
- Power Supply (limited);
- Civil works (OLE supports and foundations and civil engineering works for switching stations), 3000 foundations & 2600 structures.

SYSTRA was responsible for:

- |   |                                   |
|---|-----------------------------------|
| ■ <b>concept design</b>                 | ■ <b>detailed design</b>          |
| - OLE Preliminary design specification. | - OLE Construction design.        |
| - OLE Preliminary design drawings.      | - Substation Final layout design. |
| - Substation Preliminary layout design. |                                   |



## ACTIVITIES

Detailed design

Overhead line electrification / catenary

Electromagnetic compatibility





# Catenary-free trams

#CAPEX #OPERATIONS

Trams traditionally get their power from an overhead contact wire fed by the traction power system. In areas where aesthetics are a particularly important factor, such as in historic parts of a town, the overhead infrastructure can be considered unsightly. In order to protect architectural heritage, trams can be powered in a different way: either by ground-based infrastructure, such as a third rail, or on-board systems such as super capacitors or batteries.

## How we can help

- Develop investment strategies and plans.
- Estimate cost and carry out value analysis.
- Perform power supply simulation.
- Design optimized solutions mixing overhead contact lines and embedded energy.
- Perform operations simulations if charging is required at stations, for example.
- Carry out preliminary and basic design.
- Carry out detailed designs.
- Supervise construction.
- Integrate sub-systems.
- Produce test strategies and plans.
- Carry out factory and site acceptance testing.
- Undertake static and dynamic testing.

## Dubai tram, UAE

NEW-BUILD

**CLIENT :** Roads & Transport Authority      **OUR ROLE :** Employer's representative  
**DATE :** 2007 - 2014

SYSTRA was responsible for the feasibility study, preparation and examination of the call for tenders, assistance to client during the negotiations prior to the signing of the contract. During the implementation stage SYSTRA was responsible for design review and works supervision.

The project was the first in the world to have catenary-free operation for the entire length of the route. Each of the stations were completely enclosed and were equipped with platform screen doors (another world first).



## ACTIVITIES

- System design
- Project management
- Technical management
- Construction supervision



# Cybersecurity

- #THREATS
- #CONTROL
- #RISKS
- #VULNERABILITY
- #SECURITY

By identifying the systems involved, the types of risks and setting up the organizational human and technological measures, vulnerabilities can be reduced. This can help to avoid theft of sensitive customer data, potential shutdown of the complete system, collisions and accidents, stopping or reducing operations, transmission of incorrect information, blocking passenger flows or opening accesses or even service stoppage.

## How we can help

- **Governance:** carry out risk analysis, write security policies and raise awareness of the main issues in order to make better decisions and increase resilience.
- **Security by design:** define cybersecurity requirements, undertake design reviews of various systems and perform implementation reviews.
- **Integration of solutions:** identify relevant solutions with studies, design and implementation in order to ensure a smooth integration as well as change management.
- **Vulnerability assessment:** carry out inventory to identify assets and known vulnerabilities, undertake inventory to secure legacy systems and finally carry out compliance against current regulations.

## Cybersecurity services, USA

MODERNISATION

OUR ROLE : Technical Advisor      DATE : Since 2018

SYSTRA performs the following tasks:

- client needs analysis (Operation and Engineering);
- threat and vulnerability analysis, Key Management Plan;
- preliminary hazard analysis;
- system and sub-system level requirements;
- system and sub-system test definition and implementation;
- FRA (Federal Railroad Administration) demonstration within the certification process;
- implementation of back-office (CIS benchmark for OS);
- operator training;
- operational procedure modification assistance.



## ACTIVITIES

- Secure signalling development
- Threat and vulnerability analysis
- Requirements definition
- Agile management
- Procurement on-board signalling equipment
- Source code analysis
- Public Key Infrastructure (PKI)



# Physical security

- #THREATS
- #CONTROL
- #RISKS
- #VULNERABILITY
- #SECURITY
- #COST

Protection of railway infrastructure such as lines, tunnels, bridges and stations from physical intrusion and attack helps ensure safety of passengers as well as availability of the service.

Choosing the most appropriate solutions for the specific context can help reduce the likelihood and severity of physical attack and therefore improve safety as well as minimising the impact on operational cost. Solutions include: access control, intrusion detection systems and intelligent video surveillance systems.

## How we can help

- Undertake threat and vulnerability assessments.
- Coordinate between all relevant stakeholders including emergency services to define the requirements.
- Develop investment strategies and plans, building benchmarks of solutions combined with upcoming innovation.
- Carry out preliminary and basic design.
- Supervise construction.
- Integrate sub-systems.
- Produce test strategies and plans.
- Help and define performance thresholds and service quality targets.

## High-speed 1, UK

NEW-BUILD

**CLIENT :** Rail Link Engineering      **OUR ROLE :** Employer's representative  
**DATE :** 2001 - 2006

This high-speed line project (108 km including 25 in tunnels and 2 intermediate stations) links the Channel Tunnel to central London.

SYSTRA's main services for this project lied in its ability to integrate specific requirements to optimize civil engineering structure design and its knowledge of railway systems. These include system-wide, test & commissioning, specific studies (civil works) and interaction between rail and structures.

SYSTRA's role included the preparation of all of the technical specifications for the systems. As part of this project, CCTV cameras were installed over the line and in the stations. These were all connected via fibre-optic cabling and feeds were sent to the operational control centres.



## ACTIVITIES

CCTV



# System assurance

- #COMPLIANCE
- #PERFORMANCE
- #RELIABILITY
- #AVAILABILITY
- #MAINTAINABILITY
- #SAFETY
- #INTEGRATION
- #INTERFACES

System Assurance aims to plan the systematic set of engineering activities necessary to assure that products conform with all applicable System requirements as a System wide overall approach not limited to RAMS such as human factors or fire life and safety.

An overall System Assurance approach ensures that each sub-system/contractor will provide the same level of System Assurance evidence from the design to its implementation and limits discrepancies and gaps during System Integration.

### How we can help

- Independent safety expertise.
- Independent RAM expertise.
- Involved in all subsystems as well as the rail system.
- Early intervention: taking the Systems requirements such as RAMS, Human Factors or Fire Life and Safety into account in the design phase.
- Demonstration of Performance (RAM, Safety) at an early stage.
- Risk reduction.
- Human factors.
- Fire Life and Safety.

## Grand Paris Express L15-17, France

NEW-BUILD

**CLIENT :** Société du Grand Paris      **OUR ROLE :** Technical advisor, systems  
**DATE :** Since 2013

Plans for the Grand Paris transport network involve the construction of up to 205 km of new line and 72 new stations, mostly interconnecting with present and future transport networks.

SYSTRA provides technical assistance for all systems to the "systems and safety" department of the Société du Grand Paris. In particular, it includes functional analysis, integration management, risk management, RAMS, coordinating interfaces, assessment of the environmental impact, project management. It involves managing and coordinating all safety activities and contributing to safety administration.



### ACTIVITIES

- Reliability
- Availability
- Maintainability
- Safety



# MaaS

#SEAMLESS

#MOBILITY

#EXPERIENCE

Mobility as a Service (MaaS) helps individuals have access to mobility where and when they need it, and meet their expectations that are naturally shifting to a higher level, in particular the ability to shop for, plan, book, pay and track mobility through a single service in the form of an app.

The implementation of a service-based digital system at a city or regional level is a significant opportunity to enrich, implement and measure the impact of public policy aimed at creating a sustainable mobility system that is accessible to all as well as reducing congestion and pollution.

## How we can help

The MaaS ecosystem is built up from different angles. The more assertive players aim at owning the customer relationship – and therefore a larger share of the mobility pot – via multi-modal apps. These players are either transport service operators, which add new modes to their offerings in order to cover a broader market or software platforms, which aggregate third party services and provide a full rider interface from planning to tracking.

SYSTRA can build upon its capacity to:

- design multimodal mobility;
- assess the economic challenges and propose a suitable governance;
- tackle the ticketing evolution, for interoperability, payment openness and digital transformation;
- enhance the value of data in an open architecture whilst maintaining cybersecurity.

## SYSTRA's range of services

### Feasibility & design stage

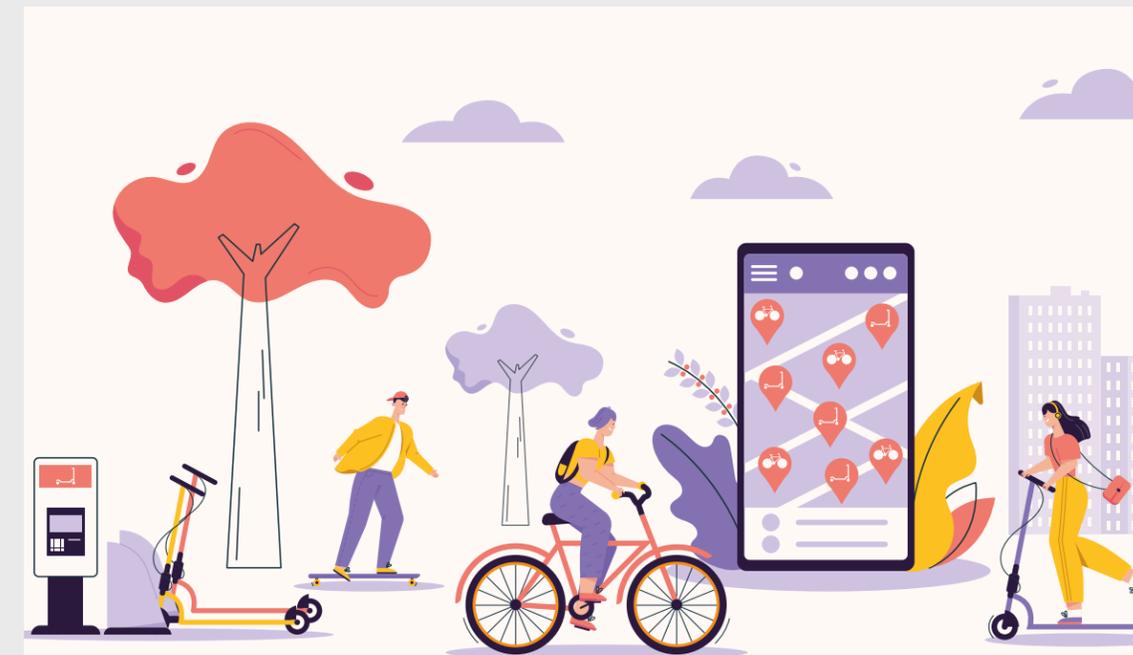
- Propose governance model.
- Define MaaS objectives & KPIs.
- Identify mobility needs & define Smart Urban Mobility Plan (mix of mobility modes).
- Define data & information system architecture (API & data format, integration platform, data exchange).
- Define tarification & cash compensation.
- Define functional and technical requirements.
- Identify and manage technical interfaces.

### Implementation stage

- Requirements management.
- Validate technical solution.

### In operation

- Collect and analyze mobility data.
- Measure KPIs vs MaaS objectives.
- Modelise mobility offer change (modes, capacity, tariffs) to improve KPIs.



## ACTIVITIES

Governance

Technical requirements

Interoperability

Data analysis





# Air quality

#POLLUTION

#COVID19

#HEALTH

#ENVIRONMENT

To offer a transport service with air quality that meets current standards and passenger expectations, particularly with regard to pollutants, bacteria and viruses. This can reassure travellers and restore confidence in public transport to increase commercial service and revenues.

Improving air circulation by air conditioning can reduce the mixing of bacteria and viruses depending on the distance between the air inlet and outlet and the passengers as well as the length of the journey (urban, suburban and interurban).

## How we can help

SYSTRA is a specialist in transport systems and has analysed, for each contributor to the spread of pollutant or bacteria and viruses, the means of measuring and reducing the levels of pollutant, bacteria or viruses.

SYSTRA works with transport operators to establish, through a System audit, an inventory of air quality and surface cleanliness, and to define an improvement plan aimed at dealing with the essential elements:

- implementation of measures;
- installation of filters for the air inlets;
- installation of cleaning systems for key surfaces (handrails, seats, shelves, toilets).

## SYSTRA's approach

### Analyse current situation

- Identify pollution source and nature
- Analyse pollution measurement results
- Understand infrastructure design and ventilation
- Study the dynamic of dispersion by simulation

### Evaluate performance of solutions

- Integration in environment
- Performance evaluation by simulation
- Assist and support during implementation and test phases

### Evaluate air quality improvement solutions

- Global or local air treatment
- Combination of local treatment solution with global ventilation
- Technology benchmark
- Prepare requirements specification



## ACTIVITIES

Air quality measurement

Analysis & simulation

Evaluation of technical solutions





# Hypervision & data analysis

#INTEGRATION

#INTERFACE

#DATA

#OPTIMISATION

#ANALYSIS

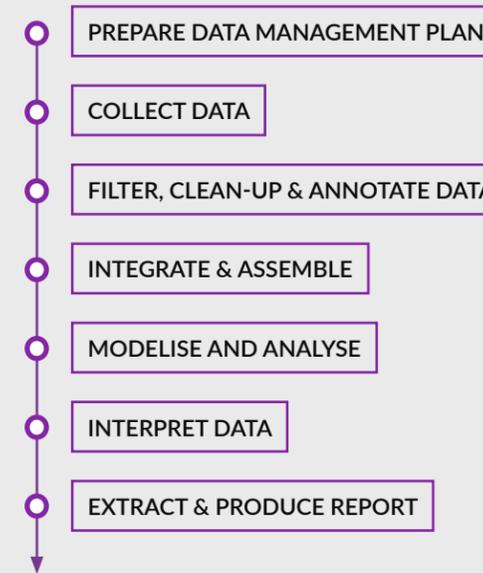
A hypervision solution is an aggregator of various supervisory systems used in operational control centres. It provides a real-time summary overview of a whole transport network or even a city which can speed up reaction to incidents. It allows the sharing of global real-time information with users, allowing for new services and improving the mobility experience.

## How we can help

- Produce data management plans.
- Identify various sources of existing and new data and define how they are to be aggregated and presented.
- Identify the relevant stakeholders.
- Specify hypervision systems for a citywide authority providing a realtime view of public transport, road traffic, air quality, energy consumption.
- Collect and analyse data using data platforms and input from transport system experts.
- Provide detailed reports based on data analysis.
- Propose tailored improvements including investment in new systems where these will result in cost savings and/or service improvements.

**SYSTRA produces a cartography of all data sources in a transport system and defines appropriate systems to harness the potential of real-time data.**

## SYSTRA's methodology for data analysis



## ACTIVITIES

Aggregation of data

Analysis

Recommendations



# Passenger information

#CONNECTIVITY #INFORMATION

As passengers embark on their journey they want to make the most of the time they spend in the public transport network. Waiting for a tram at a station or taking a long-distance train trip, passengers require real-time information about their journey as well as have the opportunity to work and play. The passenger experience can be improved by passenger information displays for example as well as continuous internet connections including in underground stations and tunnels. This can help to dramatically increase customer satisfaction independently of public transport operations.

## How we can help

- Develop investment strategies and plans.
- Put together agreements with third parties such as mobile network operators.
- Carry out preliminary and basic design including radio network coverage planning.
- Supervise construction.
- Integrate sub-systems.
- Produce test strategies and plans.
- Help and define performance thresholds and service quality targets.

## Mumbai Metro line 1, India

NEW-BUILD

CLIENT : Mumbai Metro line 1    OUR ROLE : Technical advisor  
DATE : 2007 - 2014

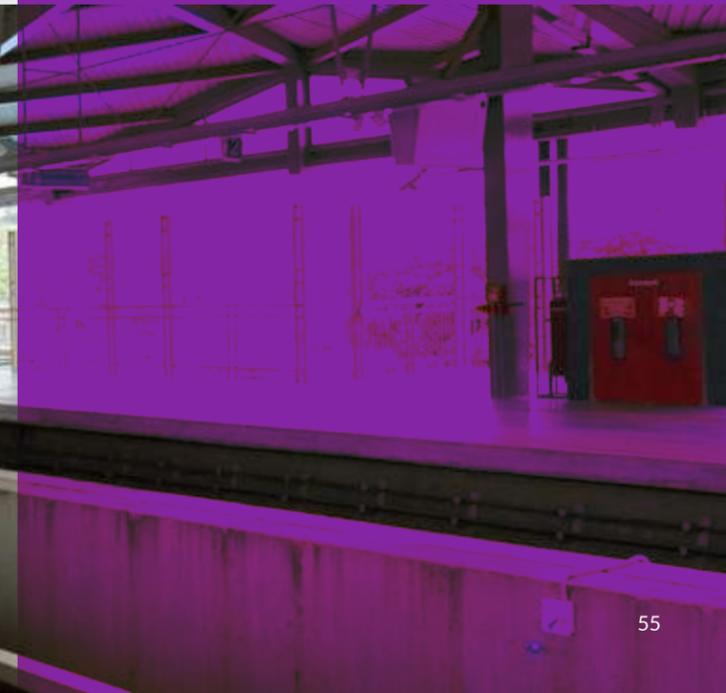
Mumbai metro line 1 is an elevated corridor of 11.5km with 12 stations (from Versova, via Andheri to Ghatkopar). It provides connectivity from Eastern & Western Suburbs to Western & Central Railway, and facilitate smooth and efficient interchange between suburban rail system and MRT System at Andheri and Ghatkopar stations.

SYSTRA was appointed to provide design and construction engineering and project management services including producing detailed designs for all the systems including the passenger information and public address systems.



## ACTIVITIES

- Master plan
- Preliminary design
- Tender documents
- Preliminary integrated system design
- Bid process management
- Tender evaluation
- Review & proof checking
- System Integration



# Rolling stock

#CAPACITY

#PERFORMANCE

#CAPEX

#OPEX

#SAFETY

#PASSENGER EXPERIENCE

Rolling stock is the key major investment decision for operators. With a 30 to 40 year lifecycle and being a key differentiator for passenger experience, this CAPEX is vital to operator's commercial success.

Safety, performance and comfort, as well as reliability and lifecycle costs will make customer business profitable.

## How we can help

SYSTRA's experience and knowledge of all types of rolling stock allows us to:

- act as Independent Safety Assessor;
- develop investment strategies and plans;
- support feasibility studies with up-to-date information regarding vehicle availability, including state-of-the art functionalities, performance, comfort level, CAPEX and OPEX;
- carry out preliminary design, with optimized performance;
- prepare tender specifications;
- supervise construction;
- produce test strategies and plans;
- assess existing rolling stock in operation.

**As we are close to our customers with regard to Operation and Maintenance, we are able to propose solutions that perfectly fit with their business.**

## Grand Paris Express, France

□ NEW-BUILD

**CLIENT :** Société du Grand Paris

**OUR ROLE :** Technical consultant

**DATE :** Since 2013

Plans for the Grand Paris transport network involve the construction of up to 205 km of new line and 72 new stations, mostly interconnecting with present and future transport networks. SYSTRA is in charge of Technical Systems Assistance (ATS), Operation Management (COP) of Systems Project Management (MOE) and Project Management for Rolling Stock & Automated Train Control (MOE, MR/AC).

SYSTRA is providing three separate services.

- **Technical Systems Assistance:** functional analysis, integration management, risk management, RAMS, coordinating interfaces, assessment of the environmental impact, project management.
- **Operation Management of Systems:** supervising the systems project management contract and the procurement and works contracts.
- **Project Management** for Rolling Stock & Automated Train Control.

As part of the rolling stock project management, SYSTRA produced the specifications, monitored the design of the trains, which involved defining the design and issuing invitations to tender. Prior to the building of the trains a full-scale model of the interior of the train designed by SYSTRA was built to get a better idea of the passenger experience and to iron out any issues.



## ACTIVITIES

Functional analysis

Integration management

Technical specifications

Full-scale model design



# ATS & SCADA supervisory systems

#OPERATION #AVAILABILITY #CAPEX

Supervisory systems for energy and transport are essential to the smooth preparation and delivery of service, to OPEX and customer service optimization. In particular, they:

- facilitate complex operations with efficient supervisory systems and friendly human-machine interface;
- help operators take the right decision quickly with accurate, real-time and manageable information in case of incidents and alarm flows;
- facilitate data analysis for accurate reporting and performance enhancement solution identification.

## How we can help

- Use knowledge of market solutions and constant screening of innovative solutions to propose relevant solutions.
- Propose long term investment and maintenance plans, managing obsolescence and systems interoperability.
- Prepare and undertake integration of new systems and migration whilst ensuring continuity of service.
- Propose virtualisation and long-term evolution plans, limiting the dependency on proprietary systems.
- Prepare and implement robust verification and validation plans.

**SYSTRA defines new and improves existing supervisory systems to enhance real-time decision-making and operations.**

## Paris lines B & D, France

□ MODERNISATION

CLIENT : SNCF    OUR ROLE : Technical consultant    DATE : Since 2018

Two high-density suburban railway lines in Paris are being upgraded (lines B and D). As part of this modernisation programme a new automatic train supervision (ATS+) is being developed that will work in both the urban and suburban sections of the lines providing automated driving. This innovative supervisory system adapts the service according to the environment.



## ACTIVITIES

Automatic train supervision

Mixed urban and suburban lines

Innovation



# Signalling systems

#OPERATION #OPEX #AVAILABILITY #SAFETY

Signalling systems are essential to the transportation systems safety and performance.

Enhancing signalling systems, whilst complex, is the most efficient way to increase passenger service and revenues with minimized CAPEX.

## How we can help

- Assist in the migration of existing systems to enhanced or maintained Grades of Automation, right up to fully automated metro lines.
- Use knowledge of market solutions and constant screening of innovative solutions to propose relevant solutions.
- Propose long term investment and maintenance plans, managing obsolescence and systems interoperability.
- Prepare and undertake integration of new systems and migration whilst ensuring continuity of service.
- Propose virtualisation and long-term evolution plans, limiting the dependency on proprietary systems.
- Prepare and implement robust verification and validation plans.
- Propose mixing various types of signalling solutions for urban and interurban to provide a smooth and optimized journey.

## Advanced Train Control System (ATCS), Sydney, Australia

NEW-BUILD

**CLIENT :** Transport for New South Wales (TfNSW)      **OUR ROLE :** Technical Advisor  
**DATE :** 2014-2015

The Advanced Train Control System (ATCS) Programme to modernise Sydney's rail network involved gradually migrating trains to ERTMS-2 train control and deploying other performance enhancing features. SYSTRA provided the client with strategic support throughout the design phase and was specifically responsible for the coordination of all the activities of the specialist teams.

A number of innovative solutions were developed such as the introduction of automatic train operations (ATO) that could manage 24 trains per hour – a first using the European Rail Traffic Management System (ERTMS). Furthermore, the project involved management of complex interfaces with other projects in progress, and in particular the modernisation of the Traffic Management System (TMS) and fixed and mobile telecommunication systems.



### ACTIVITIES

Signalling

ETCS 2 (European Train Control System Level 2)

Control/command systems

Rolling Stock

Safety of operations

Operations

Interface management



# Stabling & maintenance facilities for rolling stock

#SAFETY #OPERATION #OPEX #AVAILABILITY

Designing optimised maintenance facilities for rolling stock means efficient operations, high availability and optimisation of fixed assets as well as OPEX. Energy saving can also be achieved through good design.

For operation on non-electrified routes, new fuels and energy sources are breaking through to replace diesel: batteries, natural gas and hydrogen. They require adaptation of existing facilities or the design and construction of new ones.

New regulations require more attention to greener workshops with waste and water management, energy efficiency and pollution avoidance.

## How we can help

- Carry out flow analysis and simulation.
- Undertake functional design based on operation and maintenance plans.
- Produce optimised basic and detailed designs.
- Calculate OPEX optimisation, including energy.
- Produce specification and support the procurement of maintenance equipment.
- Manage modernisation and renewal programmes.

## Jakarta light rail, Indonesia

NEW-BUILD

**CLIENT :** PT ADHI KARYA (Persero) Tbk., Dept of Light Rail Transit  
**OUR ROLE :** Technical consultant     **DATE :** 2016 - 2019

SYSTRA was responsible for:

- definition of the specifications of the main railway systems including the design of the depot;
- preparation of the technical parts of the call for tenders for the selection of the contractors in charge of the supply of each system;
- review of detailed designs of systems produced by contractors;
- assistance in acceptance testing on behalf of the client;
- assistance to the client for the trial running supervision.



## ACTIVITIES

Technical specifications

Tender evaluation

Detailed design review



# Traction power and catenary

#OPERATION #OPEX #AVAILABILITY #DIMENSIONING #ARCHITECTURE #CAPEX #EMC

The choice of traction power source is a major choice for a new build project or for the migration of diesel-powered rolling stock to cleaner energy alternatives.

A stable, reliable and efficient electrical network is essential to operations.

The sizing of the network is based on many external factors and requires complex calculations.

The design of the electrical architecture is key to ensure a high reliability of the transport system, even in degraded mode. On the other hand, overdimensioning the electrical system requires a significant amount of CAPEX.

Finally, EMC phenomena are complex, potentially heavily impacting the stability and the performance of the system.

## How we can help

- Carry out dimensioning and basic designs.
- Produce detailed and implementation designs.
- Supervise works.
- Validate and commission sub-systems and systems.
- Perform maintenance engineering.

## Kénitra-Tangier high speed line, Morocco

NEW-BUILD

**CLIENT :** Office National des Chemins de Fer      **OUR ROLE :** General Consultant - Assistance to the Contracting Authority, Engineering & Project Management services, Integration & Dynamic tests      **DATE :** 2009 - 2018

SYSTRA undertook several feasibility studies (including program definition, alignment, and geology) during the 1st phase of the project. Continuing in the 2nd Phase with preliminary design requirements (especially with Project Definition). Finally, SYSTRA took part in the design & construction phase regarding the Project Management for the civil engineering design & supervision of the 110 km southern section; with a strong involvement in all aspects related to the rail systems (including signalling & telecommunications, track & catenary, and power supply).



## ACTIVITIES

- Design requirements
- Project management
- Design supervision



# Maintenance and lifecycle management

#OPERATION

#OPEX

#AVAILABILITY

#PERFORMANCE

#DIGITALISATION

Efficient maintenance of assets is essential to meet and enhance lifecycle costs, performance and reliability targets.

Setting-up and adapting maintenance plans and resources are key to operations. A deep knowledge of the assets, their actual performance and reliability in operation is an important factor to dimension resources and maintenance plans.

Digitalisation brings additional productivity gains and helps anticipate failures and service impacting corrective maintenance.

## How we can help

- Develop maintenance strategies.
- Propose organisation for maintenance activities.
- Write preventive and corrective maintenance plans.
- Carry out lifecycle cost assessments and optimisations.
- Undertake asset due diligence for maintenance and operation take over.
- Perform audits of maintenance activities and performance.
- Design and implementation maintenance supervision tools.
- Assist in the digitalization of assets and asset management.
- Prepare renewal and modernisation plans.

**SYSTRA carries out audits and defines maintenance strategies.**

## Santiago metro, lines 3 & 6, Chile

NEW-BUILD

CLIENT : Metro SA    OUR ROLE : Technical Assistant    DATE : 2012 - 2017

SYSTRA provided technical assistance for the creation of 2 automated metro lines. SYSTRA carried out basic design and tender specifications, and was involved throughout the project, assisting Santiago Metro with awarding of contracts, reviewing construction design studies, supervising works, testing and commissioning. SYSTRA was responsible for developing a maintenance model for these two line as well as designing the maintenance depot. A computer aided maintenance manager was also implemented for this project.



## ACTIVITIES

Tender assistance

Construction design review

Computer-aided maintenance management

# Operation simulation and preparation

- #OPERATION
- #OPEX
- #AVAILABILITY
- #PERFORMANCE
- #MIGRATION
- #RESOURCES

Planning for traffic evolution, preparing new rolling stock or a signalling system entering in operation requires a high level of expertise and simulation capabilities to take the right decisions and set up the processes and organisation so that it can be a success, thus minimising risk, cost overruns and adverse impacts on service.

Operation simulation and preparation help optimise operations and resources as well as plan investments.

## How we can help

- Carry out complex operations simulations, taking in consideration the systems at stake.
- Define workforce skills and operations training.
- Dimension resources (workshops, workforce etc.) and optimise teams.
- Carry out requirements engineering (and not solutions) and value analysis.
- Ensure consistency between design capacity (made to measure) and investment (economic realism).
- Prepare for commissioning and start of commercial operation: procedures and staff training.
- Perform audit of operations.
- Prepare the bringing into service prior the arrival of the operator.

## Singapore metro North-South & East-West lines

MODERNISATION

CLIENT : LTA (Land Transport Authority)    OUR ROLE : Technical consultant  
 DATE : 2013 - 2018

As part of the signalling system replacement project for the North-South and East-West Lines in the Singapore metro network, SYSTRA was responsible for Independent audit and assessment on the replacement signalling (Detailed Design, T&C, and O&M) including:

- audit of the Design Safety Submission (DSS), Handover Safety Submission (HSS) and Operation Safety Submission (OSS) to determine the adequacy of the safety demonstration;
- identification and provision of detailed assessment on critical areas;
- evaluation of Operator's operational readiness to operate the New Signalling System for passenger service.



## ACTIVITIES

Independent audit of operation safety

Operational readiness assessment



# Outsourcing of technical services

#RESOURCING #OPEX #DESIGN

By outsourcing technical services such as design, integration, project management, validation and test and commissioning organisations can focus on their core activity and call-off on-demand services for projects as and when needed either for short-term or long-term assignments.

## How we can help

SYSTRA has over 1,000 system engineers working around the globe providing system engineering services which can be supplied on a daily basis or on a lump-sum contract for a specific responsibility on a project for example.

The following system engineering disciplines are covered:

- signalling;
- supervisory systems;
- operational communications systems;
- passenger services (fare collection, passenger information);
- security systems;
- rolling stock;
- stabling & maintenance facilities;
- traction power;
- overhead line electrification;
- operation & maintenance engineering;
- system integration.

## RATP (Paris transport operator & asset owner) service centre, France

□ MODERNISATION

CLIENT : RATP    OUR ROLE : Technical consultant

DATE : 2018 - 2021

RATP has outsourced part of its system engineering activities with specific targets for delivery and performance. This framework agreement allows for three-year contracts to be established for design, implementation and test and commissioning in the following areas:

- signalling;
- traffic management;
- train/tram supervision & management.

Services are either carried out on the client's premises or in a SYSTRA office.



## ACTIVITIES

Signalling

Traffic management

Train/tram supervision & management





## Credits :

### **SYSTRA - S.A. with share capital of €33,302,018 - 387 949 530 RCS PARIS**

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