STEERING ACROSS SYSTEM CHALLENGES

SYSTRA

Summary


RTA


JEAN MAGA
AEROPORT EXPRESS
Toulouse 26°

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.

OPTIMISE SYSTEM ENGINEERING & INTEGRATION

REDUCE CARBON FOOTPRINT & POLLUTION

IMPROVE MOBILITY EXPERIENCE

OPTIMISE CAPACITY, PERFORMANCE & COST

IMPROVE RELIABILITY, SAFETY & SECURITY

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 FEASABILITY STAGE

FOR MOBILITY AUTHORITIES

- Credible CAPEX and IRR estimation
- Overall business case preparation
- KPI definition

FOR TRANSPORT INFRASTRUCTURE MANAGERS

- Migration strategy definition
- Realistic time schedule preparation

FOR TRANSPORT OPERATORS

- Migration strategy definition
- Investment strategy definition
- Preparation for arrival of competition

FOR CONTRACTORS

- Feasibility studies
- Value engineering studies
- Optimised tender design

2 DESIGN STAGE

- Technical advisory
- Procurement strategy definition
- Data management plans

- Functional and technical design
- Tender specification preparation
- Tender evaluation & contract negotiation

- Preparation for operations and maintenance
- KPI definition
- Rolling stock investment case

- Basic and detailed design
- Requirement & interface management
- Independent verifier & system assurance

3 IMPLEMENTATION STAGE

- Technical advisory
- Data modelling and analysis
- Requirements management

- Technical conformity verification
- Contractor management
- Deliverables validation

- Provision of training for operations staff
- Provision of training for maintenance staff

- Integration
- Test & commissioning
- Migration preparation

4 IN OPERATION

- Technical audits
- Performance audits
- Air quality analysis

- Technical advisory
- OPEX optimisation audits
- Security audits

- Technical advisory
- OPEX optimisation audits
- Operations & maintenance optimisation audits

- Technical advisory
- OPEX optimisation audits
- Operations & maintenance optimisation audits

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.

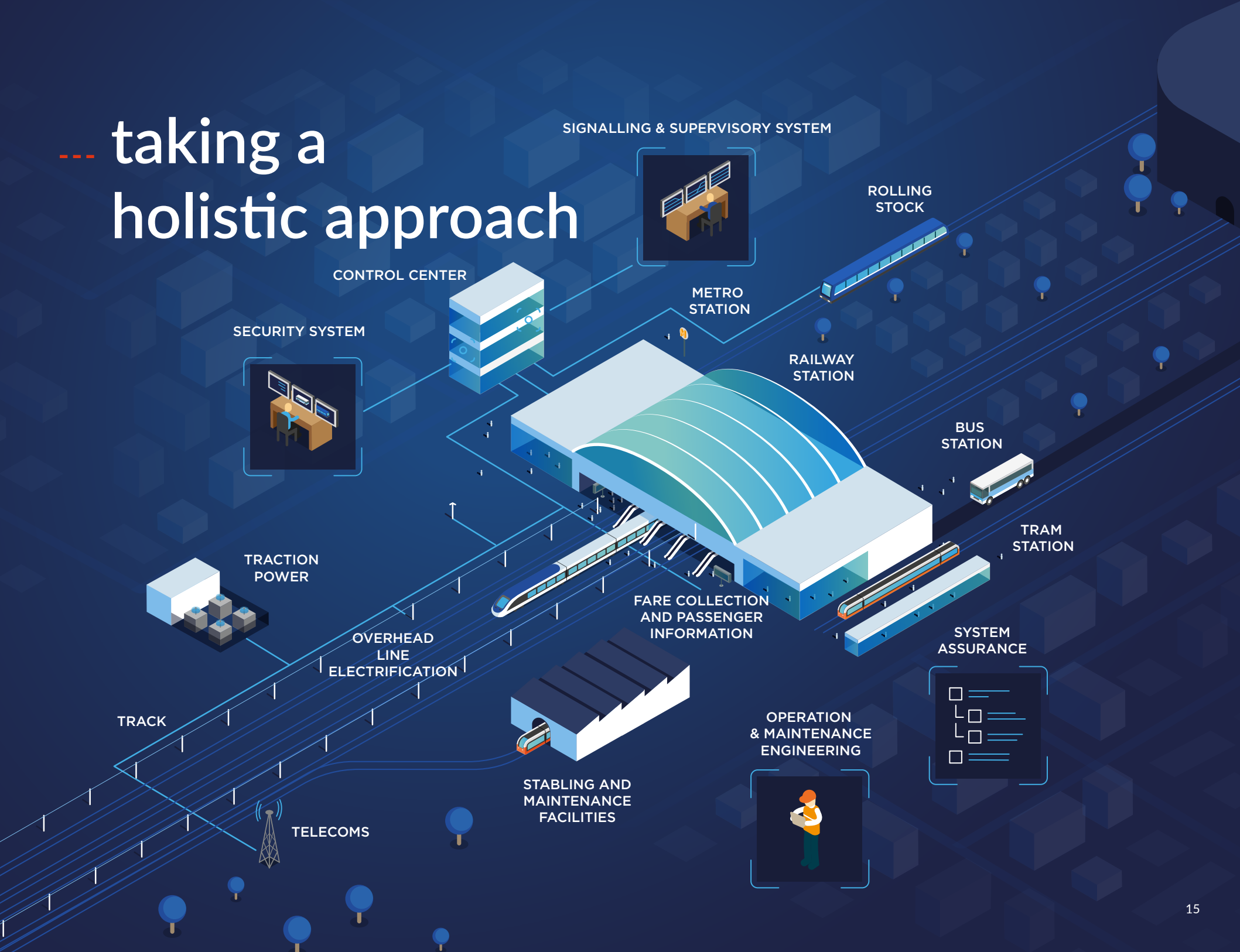
Building a new transportation system, from urban to very high speed rail requires a significant experience in delivering such complex projects with a robust system engineering approach.

MODERNISATION

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



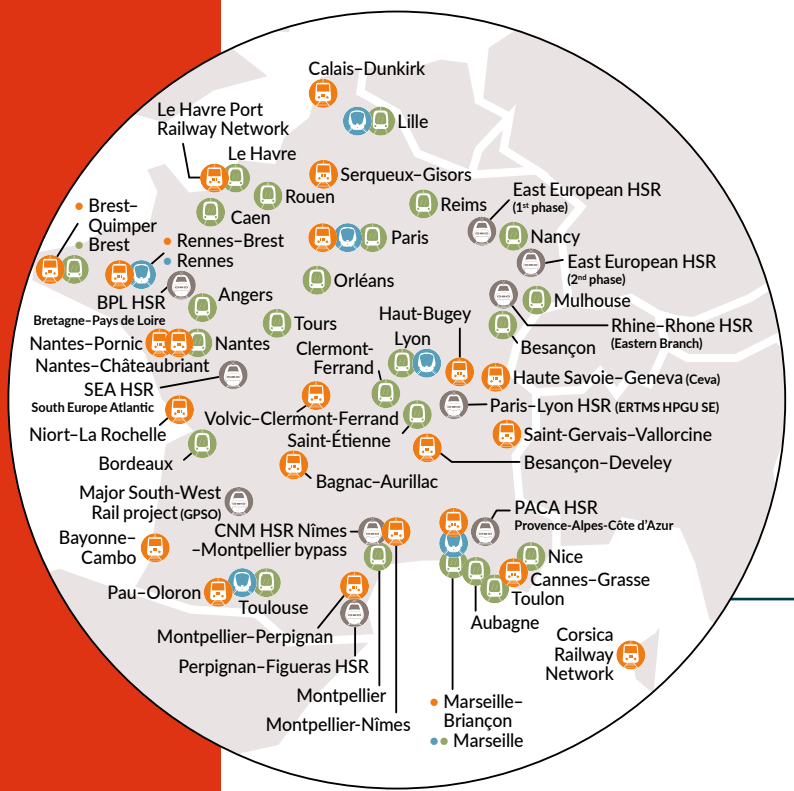
Improving mobility through new technology

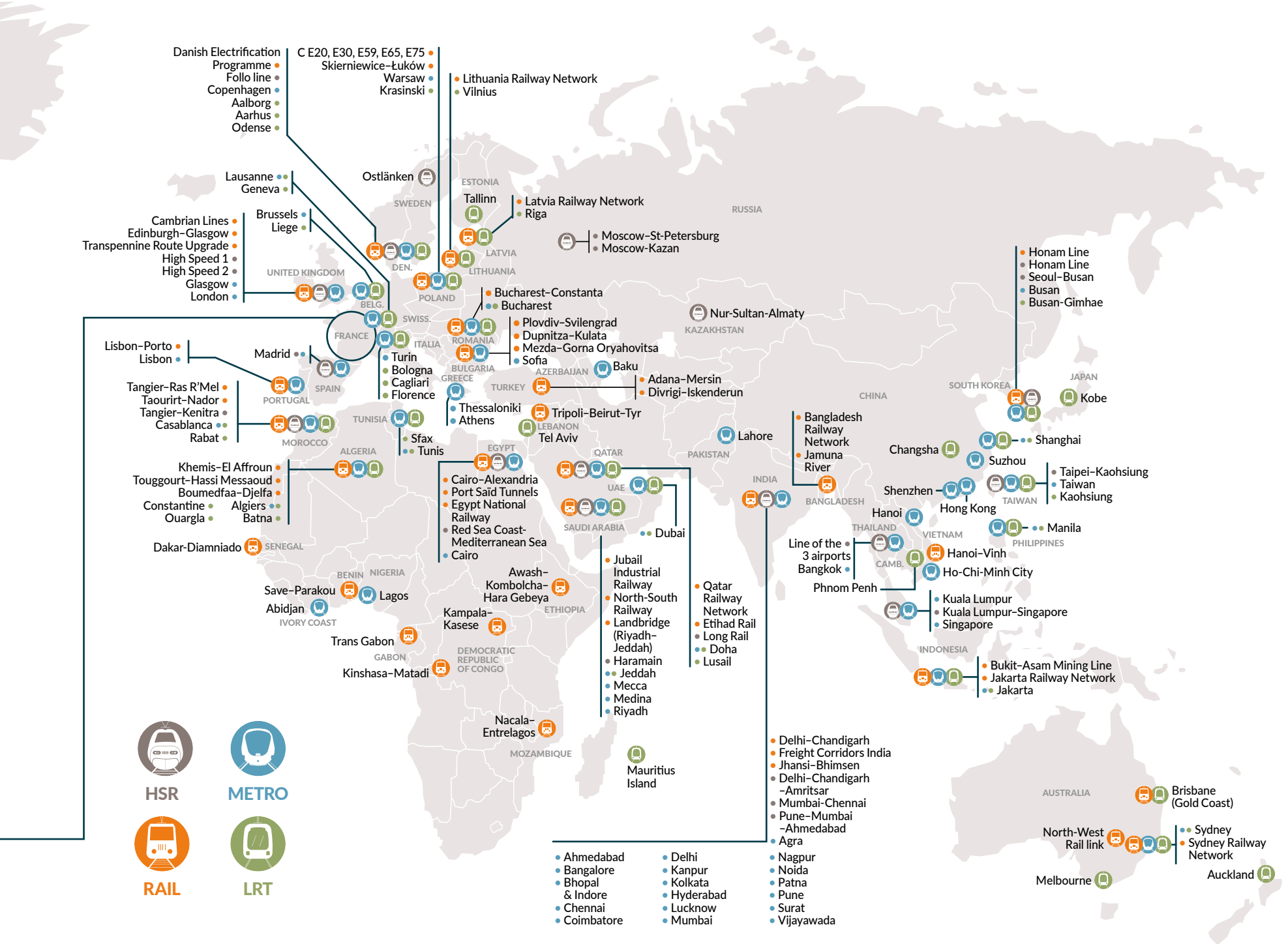
Technology is moving fast and provides opportunities to improve our transport, bringing more safety, efficiency and passenger comfort.
At SYSTRA we are connected with the innovation ecosystem through our fab lab named QETO, and continuously assess new solutions with reputed universities, innovative start 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.

Your projects are our successes!




Danish Electrification Programme
Follo line
Copenhagen
Aalborg
Aarhus
Odense
C E20, E30, E59, E65, E75
Skierniewice–Łuków
Warsaw
Krasinski
Lithuania Railway Network
Vilnius
Lausanne
Geneva
Ostlänken
SWEDEN
ESTONIA
Tallinn
Latvia Railway Network
Riga
RUSSIA
Moscow–St-Petersburg
Moscow-Kazan
Cambrian Lines
Edinburgh–Glasgow
Transpennine Route Upgrade
High Speed 1
High Speed 2
Glasgow
London
Brussels
Liege
UNITED KINGDOM
DEN.
LATVIA
LITHUANIA
POLAND
BELG.
SWISS.
FRANCE
ITALIA
ROMANIA
Bucharest–Constanta
Bucharest
Plovdiv–Svilengrad
Dupnitza–Kulata
Mezda–Gorna Oryahovitsa
Sofia
Nur-Sultan-Almaty
KAZAKHSTAN
Honam Line
Honam Line
Seoul–Busan
Busan
Busan-Gimhae
Lisbon–Porto
Lisbon
Madrid
SPAIN
PORTUGAL
BULGARIA
AZERBAIJAN
Baku
Adana–Mersin
Divrigi–Iskenderun
TURKEY
GREECE
Thessaloniki
Athens
Tripoli–Beirut–Tyr
LEBANON
Tel Aviv
Turin
Bologna
Cagliari
Florence
Tangier–Ras R'Mel
Taourirt–Nador
Tangier–Kenitra
Casablanca
Rabat
MOROCCO
TUNISIA
Sfax
Tunis
ALGERIA
EGYPT
Cairo–Alexandria
Port Said Tunnels
Egypt National Railway
Red Sea Coast-Mediterranean Sea
Cairo
QATAR
UAE
SAUDI ARABIA
Dubai
Jubail Industrial Railway
North-South Railway
Landbridge (Riyadh–Jeddah)
Haramain
Jeddah
Mecca
Medina
Riyadh
Qatar Railway Network
Etihad Rail
Long Rail
Doha
Lusail
Lahore
PAKISTAN
INDIA
Bangladesh Railway Network
Jamuna River
BANGLADESH
CHINA
SOUTH KOREA
JAPAN
Kobe
Changsha
Shanghai
Suzhou
Shenzhen
Hong Kong
Taipei–Kaohsiung
Taiwan
Kaohsiung
TAIWAN
Hanoi
THAILAND
VIETNAM
Manila
PHILIPPINES
Line of the 3 airports Bangkok
CAMB.
Hanoi–Vinh
Ho-Chi-Minh City
Phnom Penh
Kuala Lumpur
Kuala Lumpur–Singapore
Singapore
INDONESIA
Bukit–Asam Mining Line
Jakarta Railway Network
Jakarta
Khemis–El Affroun
Touggourt–Hassi Messaoud
Boumedfaa–Djelfa
Constantine
Ouargla
Algiers
Batna
Dakar-Diamniado
SENEGAL
BENIN
NIGERIA
Save–Parakou
Lagos
Abidjan
IVORY COAST
Awash–Kombolcha–Hara Gebeya
ETHIOPIA
Kampala–Kasese
Trans Gabon
GABON
DEMOCRATIC REPUBLIC OF CONGO
Kinshasa–Matadi
Nacala–Entrelagos
MOZAMBIQUE
Mauritius Island
Delhi–Chandigarh
Freight Corridors India
Jhansi–Bhimsen
Delhi–Chandigarh –Amritsar
Mumbai-Chennai
Pune–Mumbai –Ahmedabad
Agra
Ahmedabad
Bangalore
Bhopal & Indore
Chennai
Coimbatore
Delhi
Kanpur
Kolkata
Hyderabad
Lucknow
Mumbai
Nagpur
Noida
Patna
Pune
Surat
Vijayawada
AUSTRALIA
Brisbane (Gold Coast)
North-West Rail link
Sydney
Sydney Railway Network
Melbourne
Auckland
HSR
METRO
RAIL
LRT

How we can help

OUR PORTFOLIO OF SERVICES

OPTIMISE SYSTEM ENGINEERING & INTEGRATION

OPTIMISE CAPACITY, PERFORMANCE & COST

REDUCE CARBON FOOTPRINT & POLLUTION

IMPROVE RELIABILITY, SAFETY & SECURITY

IMPROVE MOBILITY EXPERIENCE

DELIVER SPECIFIC EXPERTISE

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.

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 inter-connected 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...).

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 out 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).

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).

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.

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.

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 CO_2 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.

We use different tools such as ITSIM (to plan/restructure a network), MEFEM (to measure the economic and environmental impact), TESS (to adjust the charging infrastructure) and OPOSRI (to optimise the business case for charging stations).

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.

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).

Electrification

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

Electrification enables:

- enhanced performance (frequency, commercial speed etc.);
- reduced carbon footprint;
- increased availability through meshed power networks.

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 optimzed 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.

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 optimzed 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.

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.

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 approriate 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.

System assurance

#COMPLIANCE #PERFORMANCE #RELIABILITY #MAINTAINABILITY #AVAILABILITY #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.

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.

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 maintening cybersecurity.

SYSTRA's range of services

Feasibility & design stage

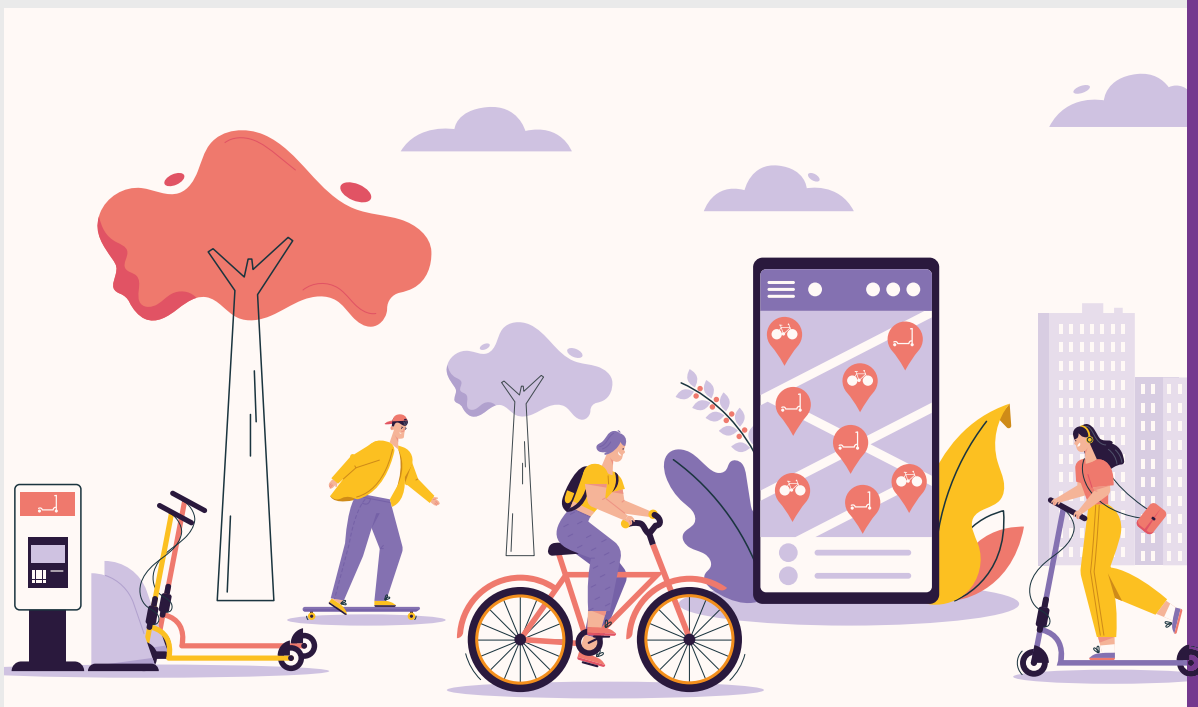
- Propose governance model.
- Define MaaS objectives & KPIs.
- Identify mobility needs & define Smart Urban Mobility Plan (mix of mobility modes).
- Define data & information system architecture (API & data format, integration platform, data exchange).
- Define tarification & cash compensation.
- Define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



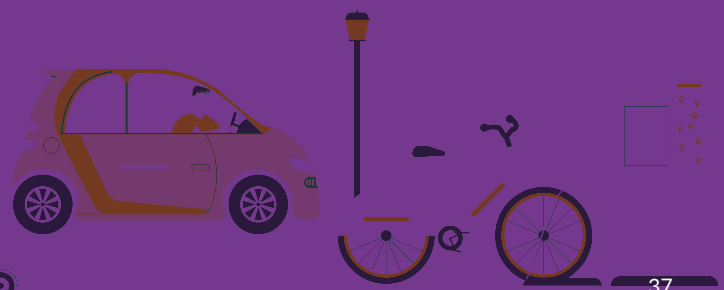
ACTIVITIES

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 air quality improvement solutions

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

Evaluate performance of solutions

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

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

- PREPARE DATA MANAGEMENT PLAN
- COLLECT DATA
- FILTER, CLEAN-UP & ANNOTATE DATA
- INTEGRATE & ASSEMBLE
- MODELISE AND ANALYSE
- INTERPRET DATA
- EXTRACT & PRODUCE REPORT

ACTIVITIES

Aggregation of data

Analysis

Recommendations

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.

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.

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.
- 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.

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.

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 amont 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.

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.

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 value analysis.
- Ensure consistency between design capacity and investment.
- 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.

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.

Credits:

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