ENABLING LIGHT RAIL SOLUTIONS
CONSULTANCY SERVICES FOR SUSTAINABLE CITIES
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Mobility fuels economic and social development. And with half of the world’s population now living in urban areas, efficient and sustainable transport systems are vital to ensure liveable cities.

All over the world, more and more people move to urban areas to live and work. This development puts an immense pressure on the urban infrastructure, and results in road congestion, air pollution and limited mobility. It also makes a strong case for light rail, being a high capacity, zero-emission alternative to road traffic. In recent years, a long list of densely populated cities from Stockholm to Sydney have introduced light rail transport as a means for efficient and sustainable public transport. And the fact that light rail has proven to act as a powerful enabler for urban growth and development as well, has only made the case stronger.

Ramboll has assisted numerous cities on light rail projects covering all aspects of infrastructure, systems, rolling stock as well as operations and maintenance of a light rail system. In 2014, we established the Light Rail Competence Centre in Karlsruhe, Germany, as part of the Global Rail Division. Our experts are dedicated to developing world-class light rail solutions – located in a city renowned for continuously optimising its urban and regional light rail system towards higher operational speeds and increased comfort.
WHY LIGHT RAIL
AND WHY NOW?

Cities all over the world are starting to look at light rail to relieve road congestion and improve liveability. Why? Because light rail systems meet some of the key requirements for today’s rapidly growing cities:

• It’s electric! Electrically powered light rail systems can be equipped to run exclusively on renewable energy sources, thereby lightening the city’s carbon footprint.

• Zero local emissions Unlike petrol- or diesel-powered vehicles, electrically powered light rail systems do not emit particles that pollute the air.

• High capacity and space efficiency Light rail is highly scalable to local capacity needs and generally provides a high quality as well as capacity compared to buses – thus being a real alternative to the private car.

• The rail effect Light rail is a comfortable way to travel. Experience shows that people tend to prefer light rail over buses even in cases where there is no significant difference in travel time.

• Enabler for urban growth Light rail and metro projects around the world have shown that permanent rail-based infrastructure potentially attracts long-term investments and influences patterns of settlement in a fundamental way.

Today’s rapidly growing cities call for cost-effective, reliable and sustainable public transport solutions. And as a high capacity electrically powered transport system – that has also proven to act as a powerful enabler for urban growth - light rail seems to offer a desirable solution to these requirements in a wide range of cities around the world.

While a bus line can be changed or closed down, a rail-based transport system provides a permanent infrastructure that can attract long-term investments and influence patterns of settlement in a substantial way. In fact, Nordic cities such as Malmö, Lund, Helsingborg, Tampere, Turku, Stavanger, Copenhagen, Odense and Aarhus are all developing or considering light rail as part of urban development plans.

The light rail renaissance While Germany still has one of the highest densities of tramway and light rail systems worldwide – counting 59 systems in total – light rail is becoming increasingly popular in particularly the Nordic countries. Several Norwegian and Swedish cities have already introduced light rail transportation, and cities such as Stockholm, Gothenburg, Norkoping, Helsinki, Bergen, Trondheim and Oslo are currently studying and conducting network extensions.

In France, like in many other countries in Europe, tramways had almost vanished from the streets by the late 1960s and were replaced by buses or underground metro systems. This changed with the introduction of tramways in cities such as Strasbourg, where one of the first new French light rail systems (called tramway in France) opened in 1894. Paris, Lyon, Nîmes, Rouen, Montpellier, Bordeaux and many others followed suit in developing modern tramway systems.

Since then, a veritable light rail renaissance has spread to a large number of cities in France, in the UK, Ireland, Spain and Portugal. San Diego, California pioneered the re-introduction of light rail in the United States, with the first services of the San Diego Trolley operating in July 1981 initially with LRVs similar to those used in Frankfurt, Germany.

Following this spark, the US, Canada and Australia have recently introduced light rail in numerous metropolitan areas including Portland, Seattle, Phoenix, Minneapolis, Edmonton, Calgary, Melbourne, Sydney, Adelaide and the Gold Coast.
Cities have become the engines of economic prosperity and development, and the global middle class is expected to expand further over the next two decades.

Complex challenges call for an integrated approach. Consequently, our services bring together engineering, design and management consultancy to provide world-class expert knowledge, qualified guidance and support at every stage of the value chain. We advise from an early stage with strategy development and decision-making, provide consultancy on tendering, as well as manage and supervise the entire project to ensure that all requirements are met - at the right price, quality and time.

Our breadth of resources and depth of knowledge allows us to provide services suited best for our clients’ needs - from large client-based project teams to ad hoc advise by individual specialists or any combination of the above ideally tailored to the project.

A new point of contact for everything light rail
The Light Rail Competence Centre in Karlsruhe, Germany, was established in late 2014 to serve as a point of contact in all questions concerning infrastructure, systems, rolling stock as well as operations and maintenance of light rail systems.

Ramboll light rail experts draw on extensive experience from light rail projects all across Europe and support the entire planning process - from feasibility studies to the conception, design and tender of all operational and maintenance elements, not to mention life cycle cost evaluation for the light rail system as a whole.

Global project management framework
All of Ramboll’s 13,000 experts in 300 offices around the world share the same project management framework and system based on internationally recognised standards and best practices. The main objective is to exceed client expectations - consistently delivering optimised solutions and setting new standards.

Light rail projects draw on specific rail and complementary multidisciplinary services to develop truly sustainable solutions.
FEATURE PROJECT

COPENHAGEN RING 3

Modern and yet well-proven technical solutions that work from day one. Those are some of the key requirements for the design, procurement and implementation of what is currently the largest light rail project in the Nordics – the future Copenhagen Ring 3 Light Rail.

From 2024, the Copenhagen Ring 3 Light Rail will form a 28 km transversal link between the five S-train lines and 11 municipalities in the western part of the Greater Copenhagen area. More than 1 million passengers a month are expected to benefit from the light rail’s shorter travel times and improved comfort compared to the bus – as well as zero local emissions, since the system runs entirely on electricity.

Tested solutions and individual design
Ramboll is leading the Ramboll Arup joint venture which was responsible for developing the conceptual design and preparing the tender for the transportation system of the Copenhagen Ring 3 Light Rail. Great emphasis has been placed on creating the framework for a reliable transport system that works from day one.

“From a technical standpoint we will use proven standard components in all phases of the process. We aim for stability and predictability in the light rail service. The fact that the components are already in operation on other light rail systems is of vital importance”, says Ramboll’s Senior consultancy Director Peter Aarkrog.

While the transport system will be based on proven technology, the objective is to add a distinctive local design element to make both the rolling stock and station infrastructure recognisable and attractive. The technical concept defines the general dimensions, maximum speed, alignment, power and gauge for the 27 vehicles, and the architectural team has developed a set of design principles describing what kind of visual design Hovedstadsens Letbane is looking for. Potential suppliers will submit a specific vehicle design as part of their bid.

Dynamic simulation exposes deviations and requirements
Because of its length, various external factors will influence operations on Copenhagen’s Ring 3 Light Rail. In particular, the fact that dwell times at stations will differ depending on the number of passengers alighting from and boarding the vehicles, and that there are no less than 60 road crossings along the line, make for a high variability of runtimes. In order to determine the requirements for an attractive and robust operation, a dynamic simulation of operations was carried out, assisted by a computer model (OpenTrack). The model serves to establish the operation of each of the 27 vehicles separately and to evaluate deviations from runtime and timetable requirements, also integrating data from traffic signal planning for all road crossings.

In parallel, operational challenges at the central node and terminal stops were analysed, and by working closely with road traffic planners, the project team developed an optimised programme to enable efficient light rail operation maintaining the needed capacity of the road nodes.

A long-term perspective on control and maintenance operations
Control and maintenance of the light rail vehicles will take place at a designated Control and Maintenance Centre (CMC) complete with stabling yard, workshop for maintenance, storage for components and a control room where all operational data will be gathered and visualised.

Ramboll has supported the architectural team in drawing up the concepts for the CMC by providing all input relating to the transportation system and light rail operations. In order to simulate and prove the capacity of installations, the CMC operation was modelled and analysed, with internal runs as well as ramp-up and ramp-down operations in the morning and evening.

The proposed solutions for the CMC focus on ensuring optimal utility and functionality of the maintenance site and equipment. The stabling yard could be extended to cater for up to 36 vehicles and the workshop for up to 54 vehicles by adding only a single track, as there is extra space prepared for further track or building extensions. This approach will safeguard an efficient operation of the Copenhagen Ring 3 Light Rail in the long term.

Operational data will form the basis for passenger information on board the vehicles, at the 28 stations and via web applications as well as for operational control and disposition in case of disruptions. The monitoring of technical systems also takes place in the CMC, where measures can be instigated immediately based on the incident log repair. Various systems allow data exchange and communication between the control room and the driver and personnel, both radio and trackside cable-based.

End of 2017 the project was awarded to the group Aarsleff (construction) and Siemens (systems and rolling stock). Ramboll is assisting the client now in the realisation of the project. Aarsleff and Siemens are the lead contractors for this project. The consultancy was carried out in a joint venture with Arup and sub-consultants Designit and Mott MacDonald.

ABOUT
Ramboll has been responsible for developing the conceptual design, preparing the tender and supporting the client in the procurement for the transportation system of the planned Copenhagen Ring 3 Light Rail.

The transportation system tender comprises
• Permanent way
• Rolling stock and required maintenance equipment in the workshop
• Power supply
• Passenger information, signalling, intelligent transport systems and communications
• Operations and maintenance
• Safety assessment

The entire project is based on BOSfjord and the corresponding technical rules. Our Light Rail Competence Centre in Karlsruhe, Germany, has played a key role in this project. The consultancy was carried out in a joint venture with Arup and sub-consultants Designit and Mott MacDonald.
WHAT WE DO

Ramboll provides consultancy on almost every aspect of light rail infrastructure:

- Alignment
- Permanent way
- Acoustics and noise
- Station design and accessibility
- Lighting design for stations and outdoor space
- Traction power
- Depot design
- Buildings
- Road design and engineering
- Signaling and bridge engineering
- Geotechnics
- Infrastructure asset management
- Construction and contract management
- Risk and safety management

Every city has its individual character - and so has every light rail system! Sometimes high operating speed is paramount, at other times maximising system accessibility is a crucial factor.

In many cases, a balance needs to be achieved between operational efficiency, the overall system’s whole life cost and visual amenity. At Ramboll, we draw on international experience in developing solutions that provide just the right customisation for the unique qualities and requirements of the local environment – and that balances interests and considerations in a way that allows all parties to endorse the final solution. For instance, depots can be highly efficient in terms of track layout and arrangement of the workshop but still make up an architectural landmark and minimise noise emissions to the surrounding area.

In order to provide sustainable light-rail infrastructure that leads to a better urban environment, particular attention needs to be paid to the design of various light rail infrastructure assets. This is vital to ensure that all assets are attractive, durable, safe to use, easy to maintain and economically sustainable both in investment and operation.

The interfaces between infrastructure and other systems such as rolling stock (wheel-rail contact, traction power, barrier-free stations) or operation (signal cabling, cant calculations) are also important in the alignment, station and depot design. Mismatches in these areas may lead to reduced operating speeds, undue noise, excessive wear or an unattractive appearance of the system in the public realm.

“...We have acquired a unique understanding of the different stakeholder needs and this gives us a valuable insight for finding solutions for all stakeholders in the projects we engage in.”

Director Light Rail
- Nils Jänig
WHAT WE DO
Ramboll provides consultancy on almost every aspect of rolling stock:
• Vehicle design including interior layout and appearance
• Capacity
• Accessibility
• Energy consumption
• Technical studies and investigations for individual vehicle aspects
• Electro-magnetic compatibility
• Wheel-rail interface
• Support during the entire procurement process
• Tender design
• Offer preparation
• Contract negotiations
• Approval of delivery
• Solutions for cost-effective maintenance/life cycle cost
• Service vehicles for infrastructure maintenance

Not only does the light rail vehicle have a very visual and important interface with passengers, but the vehicle serves as the workplace for a large share of the light rail operator’s workforce - the drivers.

In addition, the light rail vehicles constitute one of the most significant contributions to the system’s whole life cost, as they amount to a large proportion of both the initial investment but also the ongoing maintenance cost. All things considered, choosing a rolling stock solution is anything but straightforward.

As in many other areas, a balance needs to be achieved between the desire for an attractive and presentable vehicle and the need for a vehicle that is engineered to last for the duration of its entire operational life, which generally spans about 30 years, but can be up to 40 years.

This means that the choice of rolling stock needs to be a farsighted decision that takes both the vehicle’s durability and ability to adapt to future needs into consideration.

At Ramboll, we strive to find the best solutions within these potentially conflicting requirements. We draw on our experience with rolling stock technology as well as operations and maintenance to determine the unique requirements for each system and suggest the right rolling stock solution for the local environment.

As in many cases, it is of great value to consider passenger needs first, followed by requirements for the usability of the rolling stock, such as operability and maintainability.

ROLLING STOCK
A light rail vehicle makes a bold statement in the urban landscape and works as a visible and moving ‘business card’ for the light rail system as a whole. This is just one of the reasons why choosing the right rolling stock solution is crucial to ensure the success of the system.

A1 Light rail vehicles, Jerusalem, Israel
- Rolling stock procurement and tender documents
Within the Jerusalem JNET DBOM tender Ramboll was responsible for drawing up the tender material for more than 100 vehicles for the extended JNET LRT system. The objective was to ensure the procurement of vehicles that are optimally suited to the planned infrastructure. Significant challenges are the topographical and environmental conditions. Beside the rolling stock tender, Ramboll also compiled the tender for the depot equipment.

A2 Utrecht, The Netherlands
- Operational modelling, EMC, wheel-rail interface, permanent way, infrastructure advice.
Ramboll has assisted in the planning of an 8 km extension of Utrecht’s light rail system with nine stations, connecting a university campus to the new terminus De Uithof – an extension that entails a modification from the current high-floor construction to a new low-floor system. Ramboll’s consultancy covered disciplines within infrastructure, rolling stock, electromagnetic compatibility and operational modelling.
WHAT WE DO

Ramboll provides consultancy on almost every aspect of light rail systems:

- Conceptual design of communications systems
- Intermodal transport control system
- Radio and communications
- Passenger information systems
- Signalling system planning
- Control room layout
- Traction power supply
- Tender design
- Support during the entire procurement process
- Offer preparation
- Contract negotiations
- Approval of delivery

Currently Ramboll is part of the alliance (with VR Track, Sito) to compile construction design and realise the project.

SYSTEMS

A light rail system embodies a large number of interfaces with passengers and staff, not to mention car drivers, cyclists and pedestrians in the street. All interfaces need to work seamlessly and intuitively in an integrated manner to distinguish the light rail system from the hustle and bustle of traditional mass transit.

Take for instance the ticket purchase and validation process, which should be self-explanatory - and definitely not feel like a ‘process’ at all. It shouldn’t hinder or hold up boarding and alighting. And passengers should be able to find information about next stops and connections both on platforms and in vehicles, in real time, of course, and ideally taking delays into account.

In order to avoid such delays in the first place, an intermodal transport control system should ensure that the operational staff at the control and maintenance centre have complete overview of the light rail operation at all times. Traffic light pre-emption at road crossings should prioritise the progress of the light rail vehicle, making sure that the only necessary stops are at the stations, while signalling ensures safe operation at single track sections, in tunnel sections and terminal stations.

To make sure that the entire light rail system and all its parts work seamlessly and efficiently, diagnostic data from vehicles and installations should flow automatically to the control and maintenance centre to facilitate maintenance and increase the overall system availability. Power supply systems for traction and auxiliary equipment should also provide self-monitoring capabilities.

At Ramboll, we can help to determine the right balance between desired functionalities, economic investment and operation. In relation to existing systems, we can help to investigate the possibilities of increasing system reliability, user acceptance and efficiency of the light rail operation and maintenance.

In the end, technical equipment should only be used where it provides significant benefits for safety, passenger convenience or efficiency gains in operations and maintenance. The overall approach should be to implement a light rail system which is as simple as possible and as technically complex as necessary.

01 Jokeri Line, Helsinki, Finland
- Traffic engineering, transport planning and safety, light rail design, operational modelling, depot design.

The Raide-Jokeri line is a planned 25 km light rail line with 31 stations forming an orbital link between the outskirts of Helsinki. In a joint venture with WSP Finland, Ramboll developed the conceptual design for the line, including horizontal and vertical alignment design, urban integration, a cost-benefit analysis to underpin the project’s business case and a dynamic simulation of the intended operational programme as well as involvement of the public. Ramboll was also responsible for the conceptual design of the control and maintenance centre and stabling area.
WHAT WE DO

Ramboll provides consultancy on almost every aspect of light rail operations and maintenance:

• Operational modelling
• Runtime estimation
• Timetable planning and design
• Operational control centre
• Staffing and duty rosters
• Vehicle rosters including phasing in of service vehicle runs
• Maintenance of rolling stock, infrastructure and systems
• Key Performance Indicators (KPI)
• Performance monitoring and payment regimes

High operational performance and reliability are key to ensure that light rail poses an attractive alternative to private car use and hence becomes a driving factor for sustainable mobility and city development.

Operations bring together all elements of the light rail system – from infrastructure to rolling stock, power supply, intelligent transport systems etc. – and put them into motion and use within the urban environment.

Maintenance, on the other hand, is crucial to keep the light rail system in adequate condition to ensure safe and reliable operation and keep it in a presentable state. And together, operation and maintenance represent the light rail system’s ongoing cost (opex) that is to be balanced against the initial investment cost (capex).

At Ramboll, we consider operation and maintenance right from the initial planning stages of a light rail project. This includes integrating regular operating conditions as well as possible fail backs during disturbances. In the end, it is the way the light rail operation can effectively deal with any such disturbances that to a significant extent will drive the public perception of the system.

From our experience in designing operational and maintenance concepts as well as infrastructure and rolling stock design, we identify the main issues and risks of the project and propose a tailored solution, considering the delicate balance between capex and opex especially when these are funded by different sources.

01 The Hague, Netherlands
- Operational modelling
  In order to find efficient ways to improve the capacity of The Hague’s light rail system, Ramboll developed an operational model. Different signalling concepts were tested virtually on the track section commonly used by The Hague light rail and Rotterdam Metro. The results helped the client to develop strategies towards the future operating concept for the RandstadRail network.

02 Darmstadt, Germany
- Feasibility study, cost-benefit analysis, operational advice, infrastructural advice track
  Ramboll carried out the feasibility study, cost-benefit analysis and demand analysis for the extension of Darmstadt’s light rail network across a converted military site. Ramboll was also responsible for the dynamic operational simulation and for developing the adjustments to the bus network complementary to the proposed light rail line.
WORLD-CLASS LIGHT RAIL EXPERTISE

Internationally recognised, world leading consultancy

Combining local presence on five continents with global knowledge

Specialists from Ramboll’s Light Rail Competence Centre collaborate closely with local Ramboll engineers

Ramboll offices all over the world provide a local point of contact for our clients

KEY PROJECTS

01 Light rail extension Potsdam, Germany
Project management, master planning, rail engineering, light rail planning, traffic planning.

02 LRT Sinsen, Oslo, Norway
Preliminary design and feasibility study, land-use planning, impact study.

03 Ring 3, Copenhagen, Denmark
Concept design, tender documents, operational advice, depot design.

04 City and regional train link Erlangen - Nuremberg - Herznachau, Germany
Rolling stock concept, alignment study and preliminary design.

05 Bergen, Norway
Detailed planning and procurement documents for depot, civil structures and technical equipment.

06 Light rail vehicles and depot, Jerusalem, Israel
Rolling stock and depot equipment tender documents and procurement support.

07 Utrecht, The Netherlands
Operational modelling, EMC, wheel-rail interface, permanent way, infrastructure advice.

08 Jokini line, Helsinki, Finland
Detailed design within alliance, traffic engineering, transport planning and safety, light rail design, operational modelling, depot design.

09 The Hague, Netherlands
Operational modelling.

10 Darmstadt, Germany
Feasibility study, cost-benefit analysis, operational advice, infrastructural advice track.

11 Light rail vehicles, Lund, Sweden
Rolling stock procurement and tender documents.

12 Traun railway vehicles, Kassel, Germany
Rolling stock refurbishment concept.

13 Light rail, Stockholm, Sweden
Alignment study and tender documents for the Solna grenen branch.

14 Light rail, Birmingham, UK
Operational and power simulation.

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