

ANNUAL REPORT

sma  **optimising railways**



2019

Technology meets nature: The world of public transport which seems so stark and technical at times can sometimes produce artistic, picturesque images. Light and perspective interplay with nature to create a wonderfully compelling harmony.

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Editorial

At a time when science and technology are under widespread social pressure, we believe more than ever that these disciplines can play a key role in meeting today's societal and environmental challenges. SMA has been proud of its *independence* since its foundation. Nevertheless, more than ever before, we are pursuing all opportunities for cooperation with strong partners and interested parties wherever this serves to promote *sustainable* mobility through rational means.

This applies in particular to cooperation with the main players in the world of public transport: the transport companies, the infrastructure operators and as the representatives of the ordering bodies, the authorities and politicians. Over many years, we have acquired the competence to support the players with a view to achieving the most fruitful interaction possible. In doing so, SMA is able to bring its experience from a European and global level as well as the internationally diverse nature of its employees to guarantee *first-class* service quality.

SMA invests considerable resources in these collaborations in the development of new methods, which are disruptive, but at the same time also application-oriented. We do this with the stated goal of reinterpreting existing processes in the planning of the railway and its operations, and re-implementing them in a digital environment.

This year, we would therefore like to present in our annual report more of the activities of sma.software in the fields of Research & Development. SMA has invested heavily this year in cooperation with the academic world. With the software.labs department, we have created an institute-like organisation with the aim of directly integrating fundamental university research into a practical system and thus into industrial application environments. Under the leadership of software.labs, a platform has been created to pool the strengths of top international researchers, and thus create added value for the railway world. The first projects in this area began during the course of 2019.

Finally, SMA cooperates with various representatives of industry whenever the research results generated in this way lead to added value for the partners and users involved. SMA is investing in various partnerships, particularly in the area of a new generation of service-oriented timetable construction systems. In addition, we also make our own software components and know-how available to experts in the field of algorithmic research.

Above all, we believe it is necessary to combine as many strengths as possible to jointly tackle the great challenges facing our and future generations. We will not be able to solve all of the problems, but we can help to provide society with mobility that is climate-friendly, socially and economically viable.

We are therefore very pleased to be able to present to you a variety of activities and projects that were undertaken in 2019. The selection of projects from our consulting division is presented for the first time as part of our new service portfolio. In addition, we offer you an overview of events and publications as well as key company figures.

We hope that you enjoy reading our 2019 Annual Report.

Eric Cosandey
CEO, Head of Consulting

Thomas Bickel
Head of Software

An Initiative for Open Collaboration

Scarce resources Global warming is one of the greatest challenges facing modern mankind. How we are to meet it is a discussion that must be held now. The central question is how to reduce the burning of fossil fuels without risking a global economic lockdown? The transport of goods and people is a crucial element of our economic system and today's prosperity. Maintaining sustainable mobility powered by renewable energy sources is therefore a basic prerequisite for achieving a transformation to an economy that is sufficiently efficient to sustain the necessary technological research. Fortunately, there is a solution to this important problem: the railways.

Rail has decisive advantages in local transport in conurbations, both in competition with motorised individual transport, as well as in high-speed long-distance transport as an alternative to aviation. Only perhaps in peripheral areas will there be mobility concepts in the future that are economically superior to the railway.

The decisive factor in solving the rail mobility problem is to make better use of existing resources and to optimise the allocation of additional infrastructure in the network-wide offer in terms of capacity utilisation. One approach to solving this problem is the consistent implementation of first-class long-term planning in network development, with the greatest possible automation of planning and operations, as well as the comprehensive optimisation of the use of the required resources.

More net from gross These two classes of problems, optimal use of personnel and rolling stock resources and automatic resolution of capacity allocation conflicts in the broadest sense have been extensively addressed by algorithmic research over the past three decades. As experience and theory have shown, solutions within these problem classes are difficult to find. So far, research has produced practically relevant solutions for only a few specific subproblems.

Researchers have often been hindered by the need to solve recurring practical difficulties. For example, the procurement and preparation of required data or the visualisation of identified solutions to analyse the quality of the solution and their practical feasibility. In addition, the algorithms require common software components, such as running time calculation, conflict detection or basic simulation methods.

The development of appropriate software systems that provide such functionalities with professional levels of quality typically exceeds the capabilities of academic research institutes in terms of time and money. In fact, such systems are very complex and extremely expensive to develop and maintain. This is particularly the case because of the high performance requirements and the range of functionality to be covered, which are necessary for the development and investigation of real timetables.

Given the importance of these challenges, SMA decided three years ago to open up Viriato to algorithmic research by implementing an algorithm platform and making it available to the interested community.

An open source The Algorithm Platform provides the research community with three basic functions:

- Viriato takes over the middleware functionalities for loading and integrating large amounts of data that are needed to solve practical problems (data acquisition).
- The algorithm platform offers a comprehensive domain-oriented data model, the Abstract Intermediate Data Model (AIDM), which provides infrastructure and timetable data in a format suitable for algorithmic research (data provision). This model, together with a number of supporting functions, serves to make Viriato's algorithm API available to the research community. This means that they no longer need to implement functions whose role is to merely support the actual algorithmic work.
- The algorithm platform provides interfaces to basic software components such as running time calculation or conflict detection and takes over the task of communicating with these components as well as with Viriato itself.

SMA undertook the initial development of the algorithm platform using its own resources and is supporting the community with close cooperation in the development of the API. This enables us to understand and acquire the knowledge required for the continuous improvement of the interfaces. The independence of SMA makes it possible to carry out such initiatives without being forced to restrict ourselves to specific use cases. This enables Viriato to be opened up to a broad spectrum of algorithmic applications. In turn, researchers are provided with a tool that allows them to analyse and evaluate the solutions to various algorithmic problems using a professional and widely used system.

For the customers of Viriato, the algorithm platform offers the possibility to benefit directly from the results of the research community, and to tackle specific problems more efficiently with their existing research partners, benefiting from the industrialisation of algorithm development. In addition, suitable automation and optimisation algorithms that are seamlessly linked to Viriato support the planning process in becoming better and faster.

All aboard! SMA has established contacts with universities and research institutes continuously over the past few years. The focus here is on internationally competitive research groups whose core competences are algorithmic research and the use of mathematical methods for the purposes of automation and optimisation. The initial collaborations took place with the École polytechnique fédérale de Lausanne (EPFL) and the University of Novi Sad. Here, the focus was on the use of the algorithm platform in teaching: SMA supported a dissertation on the topic "Automated rescheduling of trains in fault management" as the second supervisor. Currently, SMA is supporting the TU Delft in a project planning maintenance tasks for an existing vehicle roster. A thesis on line planning with the ETH Zurich is planned for later this year.

By using it in teaching, both academics and SMA can assure themselves of the accuracy of fit and usefulness of the provided functionality. During the ongoing collaborations, SMA has been continuously in close contact with the supervising university partners in order to gather knowledge such as new requirements or ideas for improvement and to incorporate them into the further development of the algorithm platform. The successful cooperation in teaching forms the basis for a subsequent cooperation in research. SMA is looking forward to supporting a first PhD at the University of Novi Sad, which will extend the algorithm developed at EPFL. With the first successful references from these collaborations, the circle of users is expected to grow continuously.



sma.software: a selection of projects from 2019

SOFTWARE.LABS – RESEARCH AND DEVELOPMENT

Works Planning The question of how stakeholders in the rail industry respond to the need for planning engineering works while maintaining an operational railway remain of vital importance. Since 2017, SMA has been developing our Works Planning module for Viriato. This module allows users to visualise restrictions on the network, and make adjustments to their train service to minimise the effect on operations.

The user can model line closures, both full and partial, the loss of time due to speed restrictions and track closures within stations. These can be grouped together to form planned work packages as used by the operator.

The visualisation of the time and location of works is a powerful way of understanding the relationships between restrictions and the planned train services. This year we have significantly added to the existing graphic timetable- and platform based views with a complete redevelopment of our Network Map. The Viriato Network Map is a visualisation of the infrastructure showing a geographical representation of the network. In addition to the existing possibilities of viewing and modifying the route of trains, the new version has a range of additional features. A visualisation of the topology of nodes and sections has been added to aid train planning, and the usability has been improved. An important integration with the works planning has been added, allowing the direct visualisation of sections affected by restrictions, enabling rerouting strategies to be developed quickly. The works restrictions can now be shown for any date and time within the timetable period.

An important consideration for the system of the future is how can the replanning of trains due to track closures and restrictions be made more efficient? During 2019 we have been developing prototypical implementations of methods for assisting the user with this based on the framework provided by the Viriato Algorithm Platform. The strategy to be used by any tool for making modifications to a train's path has to depend on the type of service that is being delivered. For example, the timetable modification possibilities for a long-distance passenger where the planned stops are widely spaced is very different to a commuter train which has a much higher density of stops which need to be served. In the case of long distance train, a rerouting strategy where as many planned stops as possible are respected is taken, whereas for commuter trains a part-cancellation and turnback strategy as near to the closure as possible is preferable, pairing the trains with their counterparts running in the opposite direction and operating a bus bridge between to provide a service as close as possible to normal. Of course, freight trains also need to be replanned, and the relative freedom that they have due to fewer intermediate stops along their route increases the chances of finding high quality alternative paths, although the distances travelled by freight trains can present challenges in terms of finding paths that meet the customer's trip duration requirements. As we are nearing a workable state, we are now planning pilot projects working with operators to investigate how their services can be replanned to cope with the issues caused by the necessity for engineering works on the track.

For the future, we are continuing to develop the works planning module, and intend to add more detailed restriction types and the ability to import works from a standardised European data format.

SOFTWARE.SERVICES

SBB: Running time calculations with ETCS Level 2, Baseline 3.6 SBB has been using the running time calculator (known as the ZLR from the German “Zuglauffrechner”) developed and maintained by SMA for over 10 years. Based on this ZLR, a tool known as the ZLR Toolbox was developed which is used for various infrastructure planning purposes. The comparison of running time calculations using different constraints is one of its core functions.

With the network-wide roll-out of ETCS as the train control system and the increased use of vehicles equipped with ETCS, the planning tools must also be adapted to this. On behalf of SBB, we have developed the ZLR further so that it is now also possible to calculate running times with ETCS Level 2, Baseline 3.6. A comparison of this signalling system with other signalling systems is also possible with just a few clicks.

SNCB: Offered places (PAO) During the annual and sub-yearly planning of its service offer, SNCB wants to define and manage directly in Viriato the capacity offered to passengers in terms of seats. This process requires interfacing with existing tools that determine the offered places (“Places à Offrir” or PAO in French) from the passenger data of previous years, and delivering the results to the resource planning tool (APS) in order to allow the sizing of the planned rolling stock compositions.

For this purpose, we have developed a new concept in the core of the Viriato product called “Services”, which allows for the free addition of new train attributes. This extension makes it possible to create service scenarios in which, for every individual train, each type of service can have a value that varies according to the days of operation and the sections used. The defined services can be displayed in different contexts within the software, and their plausibility checked and repaired at any time. For SNCB, these attributes have been predefined in order to be able to manage the PAO-specific upstream and downstream interfaces.

DB Fernverkehr AG and DB Regio AG: interface Viriato – IVU.rail Viriato has been used for many years by both DB Fernverkehr AG and DB Regio AG for timetable planning and train path ordering from DB Netz AG. Downstream processes such as vehicle scheduling and duty rostering are currently carried out in various systems, which are served by Viriato via various interfaces.

Many of these systems will be replaced in the future by the IVU.rail system developed by IVU Traffic Technologies. At DB Fernverkehr AG this is being done with the PP (Production Platform) and at DB Regio AG with the iPD (Integrated Planning and Dispatching) projects. In a close cooperation between SMA and IVU, an online interface between the two products has been designed and developed in recent years. This interface enables timetable planners working in Viriato to send the current status of the trains to the system at any time, without the need for additional file transfer steps. This ensures that the IVU.rail system always has

up-to-date information on the train paths ordered. It is the responsibility of the user in IVU.rail to decide when and how to react to changes to train paths in the integrated vehicle and duty roster. The interface will be introduced incrementally in 2020, and will be supplemented with additional functions on the basis of productive experience.

DB Fernverkehr AG: Viriato.FF – More than just a timetable: Getting to important data quickly The creation of the timetable is a fluid process that generates continuous changes to adjust and optimise services. These changes are reflected in resource planning and should also be available in the timetable information publications in time for the start of advance bookings. A precondition for the operation of trains is that train paths are confirmed by the infrastructure manager.

In recent years, the date for this confirmation has generally moved closer to the start of advance bookings due to delays in the submission of train path offers because of the checking process. Known modifications that had been put on hold because the train path had not yet been confirmed could only be delivered to the train path portal very late.

The resulting reduction in the time needed to prepare the data for advance booking has increased the need for software support for the publication process, which was manual until then.

During 2019 we examined the requirements for software-supported data transfer for publication together with DB Fernverkehr AG. We have reviewed which information is required, what is available in a verified form when, and have determined how to deal with uncertain or missing information on train paths.

With this knowledge, we have developed functions that automatically combine the data and thus prepare it for transfer to other systems.

Through the communication with the train path portal, all trains in Viriato are initially only created from an operational point of view. The timetable planners in long-distance traffic create segments and connections in Viriato in preparation for advance sales.

Commercial trains form the link for representing the entire train run, as required for seat reservations and timetable information. They are therefore used for the assembly of the trains in the railML interface and are therefore transferred for publication.

In 2020 the focus will continue to be on requirements for more efficient work and quality assurance of the timetable with Viriato under changing conditions.

Infrabel and DB-Netz: Microscopy on Demand (MoD) tests In the early phases of capacity and timetable planning, the creation and comparison of different utilisation concepts play a central role in order to dimension the capacity of the network optimally. Working on a macroscopic infrastructure model offers the possibility of comparing many scenarios quickly and efficiently. In more complex areas of the network (e.g. larger nodes), however, this approach reaches its limits and in these areas it is not possible to make statements about the actual operability. A local, microscopic examination of the feasibility can help the planner to decide whether a variant should be pursued further or not. For this purpose, SMA has developed the Microscopy on Demand (MoD) conceptual architecture, which allows the advantages of lightweight and efficient planning at the macroscopic level to be combined with the precision of microscopic assessment.

SMA has implemented MoD in an informal partnership with VIA-Con from Aachen. The functionality of their LUKS microscopic tool is made available via service interfaces. These interfaces are integrated into Viriato in such a way that the Viriato user can efficiently develop timetables and, if necessary, perform microscopic running time calculation or conflict detection without the need for switching systems.

In 2019, two test projects started at DB Netz AG and Infrabel, in which the practical suitability of MoD and the potential for further development was tested. The results were very positive and confirmed the viability and potential of the concept. In the next step, the knowledge gained will be incorporated into further developments so that MoD will in future cover a continuous, integrated and efficient planning process.

VIRIATO LICENSES

LOSSAN – Common Planning Server The LOSSAN Rail Corridor Agency serves the 351-mile Los Angeles–San Diego–San Luis Obispo Rail Corridor in Southern California, and is the second busiest intercity passenger rail corridor in the United States. Managing this route is a complex task requiring the coordination of a range of government agencies, railroads and train operators.

The challenge faced by these stakeholders is how to develop an integrated plan for their operations, with efficient and consistent data exchange between them. An important consideration is that all schedules should be constructed based on the same infrastructure data and agreed planning rules.

In a project led by DB Engineering & Consulting USA Inc., SMA's partner in North America, we have supplied our Viriato timetabling tool to form part of an integrated railroad scheduling and analysis platform containing several tools and a common database. This system has been acquired by LOSSAN with four other bodies to coordinate their planning and for the production of operational KPIs.

By working together on this single system, it is now easier for train schedulers based in southern California to concentrate on developing coordinated longer term strategic plans providing a lasting benefit to their railroad users, as the effort required for the type of typical short term schedule modifications which are needed by all railways has been significantly reduced.

SMA is proud to have supported this coordinated scheduling initiative led by DB Engineering&Consulting, which is the first time that Viriato has been used in a single platform by multiple operators, and that this is a model that will bring benefits anywhere where there are multiple stakeholders operating on shared infrastructure.

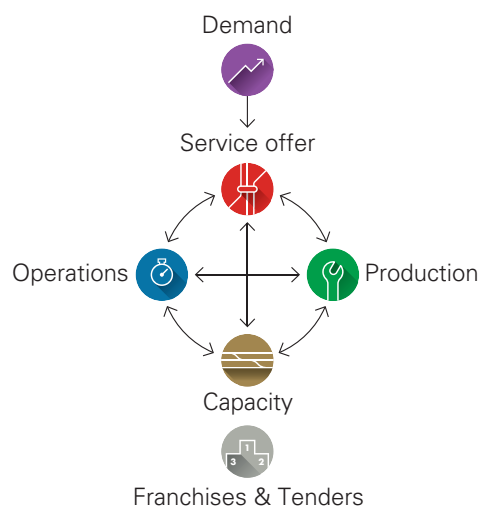
VIRIATO TRAINING

Software training

Number of external training courses	29 Training courses in German, French, Italian or English
Total number of training days	50 days
Number of participants	Approximately 175

Consulting Division: the new service portfolio

The integrated approach to the railway system makes it possible to consider it in its entirety, interdisciplinarity and complexity, and thus to understand it in relation to its environment, functioning and mechanisms. To do this, SMA Consulting has translated its services into an interdisciplinary approach in six areas of activity: Supply, Production, Operations, Capacity, Demand and Tenders.



This year we have decided to present you the selection of projects from our Consulting Division through our new portfolio of services. Our step-by-step approach of “Analyse and Audit”, “Plan and Optimise” and “Evaluate and Recommend” applies to all six of our business areas. Of course, the steps may vary depending on the objectives and tasks to be accomplished in each project.

		Analyse and Audit	Plan and Optimise	Evaluate and Recommend
	Service offer			
	Production			
	Operations			
	Capacity			
	Demand			
	Franchises & Tenders			

Offer: Meet mobility requirements – *Attractive service offers*

To build an attractive offer that meets tomorrow's mobility needs, SMA supports you with analysis of the existing service level, assessing its adequacy for future demand and with the development of new concepts to improve journey times, frequencies and connections into an integrated multimodal plan that allows you to offer an attractive service that forms the basis for the development of "mobility as a service" (MaaS) services.

Production: Optimised resource utilisation – *Guarantee an efficient production*

To achieve efficient production that optimises the use of resources, SMA supports you in the evaluation of existing productivity and then creating scenarios for optimising rolling stock and personnel deployment, including vehicle storage and maintenance, as well as with the definition of fleet strategies and the location and dimensioning of workshops and parking facilities.

Operation: Assurance of quality – *Ensure robust operations*

To enable robust operation, SMA supports you in the analysis of existing punctuality, identifying the causes leading to irregularities and the creation of robust operating concepts with the help of simulations which integrate the verification of running time calculations, conflict resolution and shunting, for the planned schedule, with small incidents or through the anticipation of incident management situations.

Capacity: Capitalise on asset investments – *Optimised capacity utilisation*

For the optimal use of railway infrastructure, SMA supports you in the evaluation of the capacity utilisation and the balance between capacity requests and the route capacity including infrastructure restrictions, the development of functional requirements and the design of the infrastructure as well as in the preparation of schedule variants for engineering works.

Demand: Maximised revenues – *Meet traffic demands*

In order to satisfy the demand and thus maximise the transport revenues, SMA supports you in the analysis of the existing demand and the evaluation of the future transportation potentials due to the implementation of a new offer, the estimation of the corresponding revenues, the allocation of this potential to services and the comparison with the transportation capacity.

Franchises & Tenders: Optimise quality-price ratio – *Successful tender submissions and processes*

In order to successfully carry out a tender for transport services and to optimise the price-performance ratio, SMA will support you as the tenderer with the definition of sub-networks, requirements and the evaluation of offers or on the RU side before and during the tender, e.g. with the concept creation working as an internal challenger within the scope of parallel and/or joint planning up to the submission of the offer.

You can find out more about our six areas of activity at: www.sma-partner.com



Consulting: a selection of projects from 2019

GERMANY



ITF NRW Competence Centre: Support 2019 In 2019, SMA again supported the KC ITF NRW with the further development of North Rhine Westphalia's integrated interval timetable.

In 2019, the design of a suburban railway system for the Münsterland region was a focal point of the service planning. In this context, S-Bahn trains were planned every 30 minutes on the star-shaped lines leading to Münster, which are supplemented by accelerated RE traffic. This will create an S-Bahn line in the city of Münster which operates every 15 minutes. The infrastructure required for implementation was derived on the basis of the timetable.

Another focus was the development of smaller infrastructure measures to increase the robustness of the network. The results of the investigations on worksite timetables for different construction stages, which were started in 2018, were integrated in the course of the extension for the Rhein-Ruhr-Express (RRX). The upgrading of diversionary routes, which can be used both during the construction phase and in the event of a disruption, plays a special role. The results have been incorporated into the "Robust Network NRW" programme, which contains 16 measures for short-term implementation.

In the course of the working group "intermodal transport" the planning on various corridors was analysed in different variants and coordinated with the participants. The results also serve as a basis for future vehicle procurement and lot design in the tendering networks for local public transport.

The development of the NRW 2040 target network was continued in order to develop the future tender concept. For this purpose, connection shortfalls were analysed and possible alternatives for solutions were developed. Zero-emission traction systems will play a special role in future tender concepts.

The results of the work in NRW have been presented and discussed in working groups and committees. The work was supplemented by the annual monitoring of the performance level and the updating of the current netgraph.

The support work will also be continued in the current year.



Verkehrsverbund Rhein-Ruhr (VRR): 2019 Consulting SMA has again supported the VRR in 2019 in the further development of the integrated interval timetable in their network area.

One focus of the offer planning was the development of a vision for the future of the Düsseldorf S-Bahn in order to be able to meet future increases in demand. SMA developed and evaluated different variants. In this process connections to non-electrified lines were also examined with the help of battery hybrid vehicles.

Based on investigations of the S-Bahn Düsseldorf and the target network of the Cologne S-Bahn, SMA has prepared a joint study for the VRR and NVR to improve the connection of the Solingen/Remscheid and Opladen regions to Düsseldorf and Cologne. In the process, different routes and service concepts were examined and compared.

Today, there is a connectivity shortfall in north-south traffic in the Ruhr area between Recklinghausen and Bochum. To remedy this, variants for a direct connection were developed and the necessary infrastructure requirements were determined. Subsequently, the construction feasibility was examined and a rough cost estimate for the infrastructure works was made.

Regular work included the examination of additional stops on various lines as well as the vehicle scheduling in the RRX and S-Bahn network. The results of this work were presented to committees and discussed as usual.

A regional express bus network which will connect areas far from the rails and create cross-connections to the local rail axes is to be established as a supplement to the local rail network. SMA has determined travel times, suggested potential stops and optimised connections to rail and local bus networks.

The support work will continue in the current year.



Rheinbahn: Capacity analysis of high-floor light rail network Rheinbahn AG is the transport company in and around Düsseldorf with over 225 million passengers a year. It operates an extensive transport network on 11 light rail/underground lines, 7 tram lines and 114 bus lines. Due to current situation, the Rheinbahn is faced with the strategic question of which organisational (e.g. line unbundling/reorganising) and technical actions (e.g. signal upgrades) are possible in order to decrease train headway times and optimise service capacities in the high-floor light rail tunnel and other critical points. In addition, the expansion of the vehicle fleet will result in the need to improve the performance of the Heerdt depot.

Different tools and methods were used to answer the various questions:

- A performance model was developed for a process assessment of the Heerdt depot. Based on the processes in the depot and their effects on the throughput, the capacity utilisation of the plant components, including the variations during the course of the day, could be determined. The comparison of the available and required capacities revealed the need for expansion and/or an adjustment of the processes.

- For the development of the service concepts, a Viriato model was created for the entire high-floor light rail network, including the tram lines running on common sections. This allowed fundamental questions regarding the compression of intervals and vehicle requirements to be clarified.
- To determine the performance of the high-floor trunk line and of critical intersections, an OpenTrack operational simulation model was set up and calibrated for the entire high-floor light rail network. The simulation of the possible train headway cases allowed the capacity of the high-floor trunk line and the resulting need for modifications to be determined. The model was also used for the simulation and verification of the service concepts created with Viriato.



Rhein-Main Verkehrsverbund (RMV): Consulting 2019 The Rhine-Main area is one of the largest conurbations in Europe and has particularly high levels of demand, especially in the inflow to Frankfurt am Main. SMA has been advising RMV, the authority responsible, about the further development of the integral interval timetable for many years. In 2019, there were two main areas of study.

On behalf of RMV, SMA created a Viriato database containing all trains of the 2019 annual timetable. The trains were imported from other systems via the railML interface or, in some cases, entered manually. With the help of this database, it was possible to carry out train-specific timetable examinations for the 2019 timetable year. In addition, the timetable was displayed in a netgraph in order to visualise features such as connection nodes, train distribution and line frequencies.

Many secondary lines in the Frankfurt am Main area have shown a considerable increase in demand in recent years. One of the corridors with particularly strong growth is the Niddertalbahn from Bad Vilbel to Glauburg-Stockheim. On behalf of RMV, SMA carried out running time calculations and, based on the timetable concert derived infrastructure modifications and the required vehicle requirements.



Bayerisches Staatsministerium für Wohnen, Bau und Verkehr (StMB), Münchner Verkehrs- und Tarifverbund (MVG), City of Munich: SPNV connection of the northern ring The north of Munich has shown considerable growth in population and employment for several years. New residential areas have been and are being created or planned as a result of the subsequent use of conversion areas. At the same time, work and research facilities are also being created, in some cases in considerable numbers (including the BMW Group's FIZ research and innovation centre). The demand for transport in this area is high and will continue to rise in the future. However, there are significant bottlenecks in the transport infrastructure in terms of both public and private transport. In public transport, the two U-Bahn axes are already nearing the limit of their capacity as they approach the city centre.

Due to the current and expected public transport situation in the coming years, a feasibility study was conducted to examine the possibility of establishing passenger transport services on the Nordring by 2025 and in what form. As a double-tracked main line, the Munich North Ring has been crossing the study corridor in a tangential direction for a more than 100 years, largely within the Munich urban area. With the exception of the Daglfing–Johanneskirchen section, it is today used exclusively for freight traffic.

This study shows that much of the rail infrastructure in Greater Munich is already being used at full capacity or will be by the 2025 planning horizon. The most effective operational concepts for serving the Nordring cannot be implemented with the existing infrastructure, so that the only possible solution for the short-term realisation is either a shuttle service from Karlsfeld–Nordring or Moosach–Nordring, serving the stations BMW FIZ and Euro-Industriepark as an S-Bahn line operation. Due to the higher traffic impact, the Karlsfeld variant is preferable to the Moosach variant.



Bayerisches Staatsministerium für Wohnen, Bau und Verkehr (StMB): Programme “Railway development Munich region”

The Munich Metropolitan Region and the whole of southern Bavaria are among the main growth regions in Germany. The growing mobility that goes hand in hand with this requires the availability of efficient transport routes. In addition, this growth must be ecologically sensible. In this respect, rail transport and in particular the S-Bahn (suburban railway) as the backbone of public transport between the City of Munich and the surrounding region plays a prominent role. The continued development of local rail passenger transport and the associated conclusion of transport contracts with rail transport companies requires the coordinated development of additional railway infrastructure over many years.

The “Munich Region Railway Expansion Programme” describes the key points for the future development of local rail passenger transport in the Munich Metropolitan Region and Southern Bavaria. The programme currently comprises 28 schemes that are already in the concrete planning or implementation stages, including the 2nd main line for the Munich S-Bahn with its seven supplementary network measures as the core element of the programme.

With a view to defining the programme in more concrete terms, a further 40 individual measures (as of the end of 2019) are to be assessed in a “Feasibility Study for Railway Expansion in the Munich Region” with regard to their impact on traffic and examined for their structural and operational feasibility. The study is scheduled to run for four years and in the first year focuses on the development of coordinated reference cases for the measures already being implemented and planned. In addition, fundamental clarifications concerning the extension of the core network will be made. This also includes considerations on the use of the northern (Nordring) and/or southern (Südring) lines for local rail passenger transport.



Zweckverband Ringzug: Feasibility, study on consolidation and further development of the 3er Tarifs

The coalition agreement of the state government of Baden-Württemberg defines the merger of transport authorities as a goal for this legislative period. To cushion the resulting revenue shortfall, the state also provides appropriate subsidies. In the districts of Rottweil, Tuttlingen and Schwarzwald-Baar-Kreis there are currently independent transport authorities, which have so been united in a regional tariff cooperation (known as the "3er Tarifs"). Nevertheless, the respective transport authorities (VVR, VSB and TUTicket) differ in terms of tariff zone structure, ticket prices and marketing.

Based on the development described above, the districts commissioned a feasibility study to determine if the creation of a joint network would bring advantages, and what these advantages would be. As a basis for an overall assessment, the study included the following main areas:

Fare structure: The study investigated best-practice examples to show the advantages and disadvantages of various tariff models (single and multi-zone models, long-distance tariff) and tariff elements (e.g. city zone, short-distance travel) and what combinations are conceivable. These tariff models were also defined in concrete terms for the study area and their consequences for passengers and transport companies analysed and the effects on demand estimated.

Organisational consequences and possible synergies: The study illuminates the consequences of founding a unified authority to replace the previous organisations. In addition, the study showed which synergy effects in the areas of tariff, sales, personnel, etc. can be expected from a merger and where these can be realised.

Costs: The report makes an initial calculation of the loss of revenue resulting from different, standardised tariff structures and price models for the respective network areas. In addition, an estimate of the financing framework was made taking into account the state subsidies.



Neckar-Odenwald-District: Future Madonna Railway The Madonnenlandbahn (Madonna Land Railway) connects Miltenberg in Bavaria with Seckach in Baden-Württemberg. Today, this branch line is inadequately connected to the surrounding lines and the travel time is very low due to the permitted line speed. In addition, at the state border in Walldürn, Germany, the lines from Bavaria and Baden-Württemberg meet each other but don't integrate, and lead to interrupted or long idle times in journeys. There is now the desire for attractive local rail passenger transport. On behalf of the Neckar-Odenwald district, SMA has developed and evaluated various service concepts for this branch line with the goal of a long-term improved integration into the regular SPNV services of both Bavaria and Baden-Württemberg.

After defining the constraints on the adjacent lines, an extensive range of variants for possible long-term service and infrastructure concepts for the Madonna Land Railway and the regional bus service with a time frame of 2030 was developed. Within this horizon, the electrification of the adjacent Miltenberg–Aschaffenburg line will result in decisive

changes in the services offered. In order to achieve a faster, continuous connection from Miltenberg–Seckach with good connections at both ends of the line, increasing the speed in all variants is an absolute necessity, especially of the northern part of the line. After the selection of variants to be considered further, the offer-dependent development of the passenger demand was shown by means of a potential estimation. Finally, the variants were evaluated by means of a cost-effectiveness analysis for numerous criteria.

From the results, recommendations for the phased and upward-compatible expansion of the offer and infrastructure for the Madonna Land Railway in the next 10 years were derived. Only a line expansion will prevent a decline in the number of passengers.



Bayerische Eisenbahngesellschaft (BEG): Analysis, improvement and expansion of existing Bayerische Oberlandbahn (BOB) incident plans

Due to extreme weather conditions with heavy snowfalls at the beginning of 2019, massive operating restrictions were imposed on the BOB network. The main reasons for this were insufficient snow clearance and the operational reliability of the infrastructure. This also revealed weaknesses in incident management with regard to operational control, emergency bus services and customer information. The Bayerische Eisenbahngesellschaft is pursuing a standardisation and expansion of the existing BOB incident plans, so that the communication processes between the individual players run more efficiently in the event of an incident. In addition, all parties involved should be in possession of the incident management plans in order to reduce the coordination effort.

The SMA analysis of existing incident plans revealed a particular need for improvement in the communication processes and in the establishment and operation of emergency bus services. Due to a lack of standardisation, valuable time was lost in the communication processes between the players. In addition to the fact that there are generally too few buses available for the emergency bus services, especially during peak hours, the travel times specified were also too short for reliable operation.

The incident concepts developed for the 2020 timetable provide the dispatcher with the most important information clearly presented in the form of a bulletin. The replacement concept is described in text form and also presented as a route network plan. In the event of an emergency bus service, the required number of vehicles is listed depending on the day and time of the incident. The texts for the customer notifications are ready-made so that they can be easily transferred in digital form to the customer information systems. The timetable of the replacement concept is displayed in tabular form and also as a netgraph. For the return to regular operation, there is a priority list of the trains that will be the first to run according to the timetable. The incident concepts will be further developed and optimised annually on the basis of experience and any changes that are found to be necessary.





Federal Ministry of Transport and Digital Infrastructure (BMVI): Consulting and support services for the German timetable and timetable-based infrastructure development

Within the framework of the Zukunftsbündnisses Schiene (Future Rail Alliance), SMA presented the second expert draft for the Germany-Takt target timetable at the Federal Ministry of Transport and Digital Infrastructure (BMVI) in Berlin on May 7, 2019. It focused on the timetable and derives from it the necessary infrastructure measures to create more frequent and faster connections for passenger and freight traffic throughout the country.

This milestone was preceded by several interim drafts, coordination with the federal states and with the BMVI in order to bring together the requirements of all parties involved in a nationwide overall concept for passenger and freight transport.

The work and the results were closely monitored by the Future Rail Alliance, so that the interests of the industry were incorporated in the best possible way into the second expert draft.

The work will be continued in 2020 with the preparation of the third expert draft on the basis of the feedback on the second draft.



DB Fernverkehr AG: Stabling and preparation concept for the ICE depot in Hamburg

On behalf of DB Fernverkehr AG, SMA has developed a vehicle stabling and preparation concept for the ICE depot in Hamburg. Efficient and effective maintenance of the vehicle fleet is an essential foundation of successful rail operations, the basis of which is the management and stabling of trains.

Various scenarios have been developed and modelled by SMA for the stabling and processing facilities. The feasibility of the favoured solution was then tested using an operational simulation. Some of the infrastructure and operational solutions developed during the process will enable the further development of the depots in Langenfelde and Eidelstedt with a focus on future needs.



DB Regio AG: Optimisation of MDSB I transport contract DB Regio AG, South East Region operates the Central German S-Bahn network (MDSB) in the Halle/Leipzig area. DB Regio Südost faces particular challenges, especially in view of the limited fleet due to the tendering process, the enormous number of worksites, operational and transport regulations.

The aim of the project was the development of innovative approaches for the optimised provision of the S-Bahn Mitteldeutschland (using a “green field approach”). The focus here was on the planning of multiple variants in vehicle rostering (including modified route connections) and the optimisation of personnel requirements, carried out by a partner company.

From a large number of variants a preferred option was selected, which is characterised by the line exchange of the southern branches of the S3 and S4. This results in a demand-optimised use of the 3 and 4-carriage vehicles, reinforced trains on the S4 improving the supply and a 4-car reserve vehicle freed up by the changed operation which improves the scope for scheduling.

In addition, additional trains between Leipzig Hbf and Schkeuditz expand the range of services, and the use of 4-car units exclusively on the S1 and S3 lines simplifies dispatching in the event of a disruption.

The project has shown how useful it can be to revise a tender network after the first few years of operation. As the preferred variant of the construction plans in the years 2020 and 2021 brings additional positive effects, it was possible to implement this in coordination with the responsible authorities as early as the timetable change in December 2019.

NETHERLANDS



Nederlandse Spoorwegen (NS): Long term reference model In order to get more transparency in the long term planning process and show the possible developments and constraints of the railway network, NS has launched a long-term reference model. The model allows the development and evaluation of creative solutions for a defined strategy, without delving into the details of production planning. The approach used is a two-step method: First the chosen strategy (service pattern, use of innovation such as ATO) is translated into the service offer and planning specifications which define a scenario. Then the planning of long term service concepts allows the evaluation of several variants of the strategy.

This study has considered and evaluated two variants of a defined strategy. In the “Ambition” variant the service pattern is given and the study aims to evaluate the needed infrastructure to ensure this “optimal” service pattern. The “Network NL” variant has a constraint on infrastructure and thus on the financial side in order to find a balance between service pattern objectives and financial reality.

The study has revealed many insights into the possible evolution of the network. Interestingly, even the “ambition” variant shows that the combination of apparently optimal service patterns on each corridor is not always feasible and compromises are needed. On some corridors, a small modification of the service pattern allowed a considerable reduction of costs in the second variant.

Overall, this project demonstrated that the interpretation of the results was difficult. For nationwide studies, it appears to be better (and maybe faster) to develop several simple scenarios that are easy to compare and interpret, rather than develop just one scenario that combines too many objectives which are subject to numerous trade-offs.

SWITZERLAND



SBB Infrastructure: Swiss network plan SBB Infrastructure plans the long-term development of the rail network in an integrated approach using tools such as the “network plan” and “regional master plans”. The network plan is an SBB-internal planning tool for the network-wide planning of infrastructure expansion, which indicates further long-term considerations. Among other things, these form a basis for the regional master plans and for checking the forward compatibility of expansion steps and specific infrastructure measures.

SMA supports SBB in the development of the network plan and the regional master plans with the development of additional variants as well as with specific in-depth analyses. In this alternative variant to the network plan for the “day after tomorrow” horizon, which was drawn up by SMA, numerous alternative service and infrastructure approaches, e.g. in terms of the node system and journey times or in terms of network utilisation, were examined for their suitability in terms of capacity, demand and key infrastructure. Based on the submitted quantities, creative approaches had to be developed for the design of the infrastructure upgrades. In the continuous elaboration and evaluation of these approaches, a variant was developed which was planned with passenger and freight traffic in its entirety and whose infrastructure requirements were identified. The variants developed by SBB and SMA were subsequently evaluated, partly with the assistance of a Viriato offer analysis. The knowledge gained will be incorporated into the further iteration of the network plan. The network plan will be updated once the revised long-term federal perspective is available.



Appenzell Railways: Adjustments to STEP AS 2035 The St. Gallen–Gais–Appenzell and St. Gallen–Trogn lines of the Appenzeller railway have recently experienced a modernisation push: Since the 2019 timetable year, they have been connected to a through line thanks to extensive infrastructure expansions and are served throughout by modern vehicles. They are linked to the Swiss standard gauge network in St. Gallen. For the latter, service adjustments are planned as part of the national expansion phase in 2035.

The aim of this contract was to find an optimal service concept on the Appenzeller railway network for this expansion phase (AS), which would guarantee stable and efficient operations and good connections in St. Gallen.

The first step was to investigate possible new or alternative stop locations based on the density of settlement along the route and the corresponding accessibility. Secondly, the connection situation planned with AS 2035 at the St. Gallen node was analysed and the optimum connection times for the Appenzeller railway were determined.

The service offer variants subsequently prepared take into account the experience with the new vehicles, the infrastructure expansions already planned and the optimum connection times. The determination of the best variant was based on an analysis of strengths and

weaknesses, considering amongst other things the estimated effect on demand and vehicle requirements based on the national passenger transport model and the travel times and connection situation of the Appenzeller railway (based on a travel time analysis).

To check the stability and further define the infrastructure measures in more detail, an operational simulation was carried out for the best variant.

The principal result is a proposed service concept compatible with the AS 2035 and a description of the necessary infrastructure measures.



Canton of Basel-Stadt, Port of Switzerland: Railway Operation Concept for the Basel Port Railway As part of the overall Port and Urban Development Kleinhüningen-Klybeck project, the Canton of Basel-Stadt and the Port of Switzerland intend to modify the port railway to meet the new constraints and challenges of the port and urban development. As a basis for the preliminary project, SMA developed the Railway Operation Concept, in which the operational suitability and feasibility of two variants were examined and evaluated.

For this purpose, the traffic and technical fundamentals as well as the proposed solutions from SMA had to be closely coordinated with the Canton of Basel-Stadt, the Port of Switzerland, the companies operating within the port, SBB and DB. This involved the development of the overall concept, which includes the feeder services via the planned rail infrastructure in the Basel area as well as the pre-sorting of the freight wagons.

On the basis of the performance model developed by SMA and applied successfully on a number of previous occasions, it was possible to model the operational processes from the trains entering and leaving the port terminal to the operation of the loading points. This allowed the determination of the performance of the individual elements of the port railway and to derive the functional requirements for the infrastructure necessary for stable operation as well as the accompanying operational activities.



Transports de la Région Morges Bière Cossonay (MBC): Optimisation and phasing of works and planning for the increase in freight traffic The MBC metre gauge railway runs near the main quarries for gravel production in the canton of Vaud, Switzerland. Permits to operate these quarries are issued on the condition that a significant portion of the production is transported by rail. As this production is set to increase, MBC has requested SMA's assistance in planning the growth of freight traffic, which must occur in parallel with an increase in passenger demand. This assistance concerns not only the metre gauge but also the standard gauge network (origin/destination of consignments) and the transfer at Morges station between these two networks, a station which is likely to be significantly transformed in the coming years.

SMA carried out the running time calculation of the various timetabled movements and calibrated them based on measurements, the review of the current transfer processes



between metre gauge and normal gauge lines and the definition of the times required for the various operations. With the help of these elements, the timetables were reconstructed and optimised for the different planning timeframes. The modifications to the topology of the freight area at Morges station within the available space there were designed and represented in a functional manner. Processes that can be implemented on this topology with the timetable and the associated vehicle rosters were established. Iterations were then carried out to optimise the configuration of the network, particularly at Morges station.



Jura Railways (CJ): Assistance with the tendering for bus lines From 2018, SMA assisted the CJ in preparing for the tendering of bus routes in the Canton of Jura and the Bernese Jura. The invitation to tender was published by the Canton of Jura in collaboration with the Canton of Bern and the FOT.

The assistance provided consisted of a preparatory phase prior to the call for tenders with an analysis of the current situation and the competitive context as well as support in defining a strategy, in particular the choice of a partner. In addition, in preparation for the tendering phase, a trial run was carried out for the entire area in order to gather good ideas which could then be submitted to the client.

The intensive assistance stage took place during the call for proposals. During this phase, SMA was involved in steering the preparation of the consortium's bid and made numerous proposals for optimising services, timetables and production. At the same time, a detailed analysis of the evolution of the offer and the demographic context made it possible to evaluate the changes in ridership and their impact on revenues. SMA also contributed actively to the drafting of the response to the call for tenders.

FRANCE



French Ministry of Transport: Development of line master plans In France, regional balance trains constitute several day- and night-time inter-regional services. Following on from the three main lines in 2018, the Bordeaux–Nantes and Lyon–Nantes lines have this year been the subject of a master plan approach aimed at proposing changes to the offer with a view to improving the performance of these lines and increasing production efficiency. SMA assisted the organising authority in drawing up these master plans with regard to the transport offer, improving journey times and improving the utilisation of rolling stock, in an iterative process carried out in consultation with local stakeholders to increase their interaction with regional services.



SNCF: Study of timetable design rules for autonomous trains After the steps of electrification and high speeds, automation and its ultimate goal, the fully autonomous train, can be seen as the third railway technological revolution. In order to ensure that the benefits inherent in automation are taken into account early in the railway system's production cycle, the planning process will have to be adapted to automation. SMA assisted the autonomous train program team in defining new standards and rules for timetable construction.

An assessment of timetable construction standards and practices was carried out, revealing the current lack of planning rules for ETCS train movements. After defining the parameters that could be influenced by automation, their changes were quantified. SMA made recommendations for the integration of these developments in timetable planning and also highlighted the areas to be monitored. The gains calculated in this way were then applied to timetable development on an existing route. This analysis showed that automation will bring improvements in journey times in many cases, as well as possible reductions in headways. The available capacity could therefore be increased, as well as the operational robustness.

Finally, scenarios have been developed to rethink operating strategies given the removal of certain constraints and the change in the cost allocation permitted by autonomous trains. This allows for more attractive and optimised operating patterns, as well as simpler and more reliable operation and infrastructure.



Normandy Region: Support for the tendering of regional passenger services

As the operating agreement for regional rail services with SNCF is coming to an end, the Normandy Region wanted support for the renegotiation of the agreement, for the evaluation of the current services and to prepare for the future competitive tendering of rail services which will become the norm after 2023. For this last point, SMA studied several possible scenarios for the tendering of transport services, making it possible to optimise the allocation of resources between the various lots envisaged, while proposing potentially attractive lots for future candidates. These lots were analysed in terms of volume of activity, geography, type of services and equipment. This approach was carried out in the context of changes in the offer planned for 2025, with specific modifications to the offer being proposed periodically in order to facilitate allocation.



SNCF Réseau Nouvelle Aquitaine: Master plans for lines and nodes As part of a national initiative aimed at building a strategic vision of its network, SNCF Réseau, as infrastructure manager, has undertaken the process of drawing up master plans for its main lines and nodes. In the New Aquitaine region, the Nantes–Bordeaux and Tours–Hendaye lines, as well as the Bordeaux and Hendaye nodes have been the subject of transport demand analyses to assess the needs for infrastructure development, capacity sharing and the organisation of production and maintenance. In a partnership approach, SNCF Réseau commissioned a group to which SMA provided capacity analysis and a coordinated approach to planning rail services, as well as a functional definition of infra-

structure needs over several time horizons, including major national projects, which integrate the prospects for metropolitan rail services around Bordeaux. Using dynamic modelling of the operation, focus was placed to the southern exit of Bordeaux towards Hendaye, with a view to reopening the Talence-Médoquine stop located in an urban area.



SNCF Voyages: Robustness analysis of the operation of the Nantes hub

The robustness analysis of the TGV Atlantic Axis carried out in the first half of 2018 by SMA studied the delay propagation mechanisms along the Atlantic corridor. It was then supplemented by analyses around the main nodes to study delay propagation effects on a more local scale. After Bordeaux and Rennes, this study made it possible to deepen the analysis of the delay origination and propagation mechanisms in the Nantes railway hub in order to develop an action plan.

The diagnosis was based on the cross-analysis of infrastructure, planning and production data. In particular, the routes were analysed and the different types of movements were quantified. In addition, it was possible to determine the actual spacing between trains and the journey times within the node. These analyses were compared with the punctuality performance of the TGVs in stations in order to reconstruct the local phenomena affecting delay propagation. On the basis of the diagnosis, short-, medium- and long-term actions to improve the quality of production were defined.



SNCF Réseau Centre-Val-de-Loire: Development of a regional timetable model

The Centre-Val-de-Loire Region and the State have placed major orders for the renewal of their passenger rolling stock, particularly for services to and from Paris. In addition numerous infrastructure upgrade projects are planned over the next 10 years, especially to accompany the arrival of this new rolling stock. In this context, SNCF Réseau's Centre-Val-de-Loire regional department wanted to develop a regional timetable model to build a forecast of the impact of these changes on its train path offer and their possible benefits for passengers.

SMA developed timetables and their variations over 24 hours for several time horizons, linked to national developments, and provided the input in this model for an assessment of their effects on demand. This work was built in the form of a modelling tool that can then be further developed by SNCF Réseau to test other offer development options.

A special focus was placed on the Orléans and Aubrais areas, where the impacts of the new rolling stock will be the greatest, particularly with the creation of a new technical centre and the renewal of the main signal boxes in the Orléans railway site.



SNCF Réseau: Hourly timetable and economic study Roissy–Picardie

The Roissy–Picardie project consists of the creation of direct links between Amiens, Creil, Compiègne and Roissy-Charles-de-Gaulle airport thanks to the creation of a new line between the High Speed Interconnection LGV to the east of Île-de-France and the conventional Paris–Creil line. The modifications to the timetable as the project was being developed, as well as changes in the timetable context for the commissioning of the line, prompted SNCF Réseau to launch a study to update and optimise the timetable.

SMA built the reference systematic and project timetables, and the 24-hour implementation of these timetables, while respecting the constraints of the national timetable on the timeframe known as “15 paths”. Together with a partner, optimised scenarios were then constructed, evaluated and compared on the basis of service and cost criteria. Finally, the timetable robustness and suitability of the infrastructure measures planned in the second phase of expansion were assessed on the basis of the selected project scenario. This made it possible to assess the decisions of the partners regarding the project components.



SNCF Réseau: Assistance in developing works timetables As part of the study of the consequences of the works on the SA 2020, SMA carried out four studies for SNCF Réseau to establish timetables during the work periods.

The complete closure of a tunnel on the North-East corridor for several weeks will lead to the diversion of long-distance freight train paths through very busy sectors, particularly in the Île-de-France region. SMA, in conjunction with the RUs, assessed the needs and possibilities for adapting transport plans and then drew up recommendations in SNCF Réseau’s THOR tool.

Work planned on the Valenciennes–Hirson axis in the Hauts-de-France region will have a major impact on the rail transport offer. In order to assess the constraints objectively, SMA has drawn up an overview of the work phases, defined the state of capacity and proposed a service plan that will allow all train paths to be used.

A major project had also been planned for the southern exit from Strasbourg, with consequent impacts on this major route. Over representative time periods, an analysis of possible diversions was carried out for passenger and freight traffic. The 24-hour timetables on lines and in stations were drawn up with an estimate of the impact on TER trains.

During the total closure of access to Paris East from the LGV for a weekend, the possible diversions of TGVs were studied. SMA analysed the residual capacity on the alternative routes in Viriato. Several diversion scenarios were proposed and the residual capacity in the Paris-North and Paris–Gare de Lyon stations was assessed.



SNCF Réseau: 2030 Timetable SNCF Réseau would like to have a reference passenger and freight timetable for 2030, taking into account international, national and regional developments. With the help of Viriato, SMA contributed to the establishment of such a coordinated timetable in Auvergne-Rhône-Alpes, Bourgogne-Franche-Comté, Grand-Est and Hauts-de-France.

In Auvergne-Rhône-Alpes, the challenge was to ensure consistency between the national passenger network with a “15 train path” horizon, the current operating plan and the plans to increase the density of services, while taking account of the reactivation of the St-Jean-de-Maurienne–Susa international base tunnel. Several iterations made it possible to define the corresponding changes in both offer and infrastructure. A special focus was placed on the Lyons and Haute-Savoie railway nodes, following the commissioning of the Léman Express, in order to define the master plans for railway developments in these two sectors.

In Burgundy-Franche-Comté, the first part of the study consisted in defining the objectives for passenger and freight services. Then a detailed analysis of the volume and routes was carried out for the current and future situation. The 2030 timetable study was able to determine the developments required in the nodes of Dijon, Besançon, Belfort and Châlons-sur-Saône station in order to meet the service and connection objectives.

In the East of France, various capacity studies carried out previously were put together in order to propose the first long-term timetable by discussing the desired changes with the Region. Extensive international coordination work with the developments in Switzerland, Germany, Luxembourg and Belgium was carried out, for both passenger and freight traffic.

In the Hauts-de-France, the study made it possible to review the structure of freight train paths in line with the estimated traffic trends in 2030. The sharing of capacity between freight and passengers then made it possible to highlight local operating constraints and to define the timetable structure in line with changes to planning standards.

BELGIUM



SNCB Transport: Alternative timetable structures 2030+ SNCB's timetable structure is revised every 3 years. Whereas the planned structure 12/2017–2020 and 12/2020–2023 provide for increases in the volume of services offered but do not change the basic structure of the timetable, SNCB envisages a more thorough overhaul of the timetable structure for the 12/2023–2027 and subsequent plans. This new structure is intended to be consistent with the commissioning of infrastructure on Infrabel's rail network while continuing to increase frequencies as SNCB has been doing now for more than five years. SMA has worked closely with SNCB for the development of this new timetable structure. While SNCB developed a "business as usual" timetable structure within the philosophy of their current operating philosophy, SMA developed two new timetable structures, improving the robustness by minimising crossing itineraries and the journey times through optimising the connection nodes.

This work was carried out using Viriato Enterprise at both the SNCB and SMA, which made it possible to exchange and compare the different ideas for the timetable structure in a single tool, and to highlight the advantages and disadvantages of each option. In addition, the project allowed a transparent exchange with the SNCB teams on the different solutions considered.

The evaluation of SMA's timetable structures then made it possible to develop recommendations in terms of the evolution of the long-term plan in line with SNCB's internal strategy.

LUXEMBURG



CFL Voyageurs: 2018 Feedback and timetabling guide SMA continued the support to CFL first begun in 2016, focusing on timetable planning and improving the quality of the offer. The first visible result was the introduction of the 2018 timetable, which introduced a revised service with the aim of improving punctuality. Several developments in the rail network took place simultaneously, which explains why their objectives were not achieved. In order to examine these points in greater depth and to correct them, SMA was commissioned to complete the analysis of the 2018 feedback and to establish a corrective action plan as well as a timetabling guide. This work, carried out in close interaction with CFL, made it possible to consider all elements of the rail system and to lay a sound foundation for the construction of future timetables. This process has highlighted the impact of planning parameters on the quality, operability and robustness of the timetables. It resulted in a 2021 timetable task force to apply the planning standards established for the establishment of timetables over a period affected by numerous projects.



Events, publications and lectures

NextRail2019: International Rail and Mobility Conference in Zürich Last year's international rail and mobility conference nextRail19 was held at the Swiss Federal Institute of Technology (ETH Campus) in Zurich. Organised by ETH in cooperation with SMA and OpenTrack, the event took place from 12-14 September 2019 and was entitled *"Agile models for railway system planners and managers"*.

Over 150 participants from more than 20 countries travelled to Zurich.

As with previous events, the conference began on Thursday with a symposium entitled *"Agile models for planners and managers of railway systems"*. The subject was more topical than ever, as for a few years now it has been observed that traditional mobility actors are confronted with an environment that they seem to accept rather than dominate. In contrast, new players are approaching the market in a disruptive manner, taking advantage of the benefits of increasingly individualised mobility behaviour. Thus, the situation is not easy for traditional mobility actors. The railways must therefore pursue a proactive strategy: Changes in the environment must be anticipated, and influenced where possible in favour of its own advantages. This approach requires modelling work aimed at rationalising and reducing the complexity of the system in order to better understand it and to predict its behaviour. Speakers from politics and the railway world discussed the different ways of approaching this immense challenge of the future.

Friday was dedicated to *"Practice and Innovation"*. Here the subject of the first day was looked at in depth from a broad perspective. The speakers from SMA were internationally representative and came from Germany, Switzerland, France, Belgium and Serbia.

As at the previous conferences, the excursion on Saturday marked the end of the event. The participants were able to discover *various mobility players in the agglomeration of Zurich*: The Zurich Transport Authority (VBZ) presented their way to the future, among other things on the subject of innovative propulsion systems. The tour of the workshop afterwards was more traditional. Following this, SBB gave an insight into the topic of passenger guidance, known as crowd management.

Publications and lectures

Publications

International Railway Symposium Aachen (IRSA) – Conference paper Aachen November 2019	Microscopy on Demand – Die Fahrplanung der Zukunft ist durchgängig Björn Glaus (SMA) and Trutz von Olnhausen
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Lectures

EPFL Lausanne April 2019	Lecture: Timetable Saturation in Practice with Methods from Operations Research Matthias Hellwig
RMV-Mobilitätsworkshop Zürich April and August 2019	Entwicklung der Zürcher S-Bahn Georges Rey
Symposium 150 Jahre Seelinie und Trajekt Constance May 2019	Jetzt die Zukunft gestalten: Mobilität und öffentlicher Verkehr in der internationalen Bodenseeregion 2030 Georges Rey
Forum ÖV-Planung zum Thema "Zukunft des Taktfahrplans" Berne August 2019	Wo ist ein (Takt-)Fahrplan heute und morgen sinnvoll Luigi Stähli
RAILcph Conference Kopenhagen Mai 2019	The "Deutschland-Takt" target timetable Frederik Ropelius
DWVG-Jahresverkehrskongress Cologne June 2019	Die Bedeutung von komplexen Knoten in hochbelasteten Eisenbahnnetzen Frederik Ropelius
International Railway Symposium Aachen (IRSA) Aachen November 2019	Microscopy on Demand – Die Fahrplanung der Zukunft ist durchgängig Björn Glaus
18 th Florence Rail Forum – How to Revitalise Rail Freight with Digitalisation? Florence November 2019	Digitalisation of the (international freight) capacity planning/production process: challenges and solutions Eric Cosandey

ISO 9001 Certification

ISO 9001:2015 Certification Quality management is a key priority at SMA. The activities and processes around the two core areas of consulting and software have always shown a high degree of maturity for documented information, and which remains the basis of our daily work. At the end of 2018, the management decided to put the finishing touches to the professionalisation of our quality management: SMA und Partner AG together with all branches and subsidiaries started the certification to ISO 9001:2015 project.

The declared goal of the project was, of course, to obtain the certificate, which will send a signal to customers and other interest groups. In addition, SMA also focused in particular on:

- establishment of cross-company, consistent standards, including management and support processes
- establishment of continuous improvement processes across functions and divisions
- pragmatic and goal-oriented integration of the existing pool of documented information into an easily accessible and online quality management system
- appropriate communication of the contents to all employees

The process-oriented approach of the QMS focuses on the relevant processes of daily business and not on organisational structures or hierarchies. In this sense, all process descriptions and procedures are aligned with an SMA-specific value chain with the following core processes:

- Sales & Acquisition
- Project implementation
- Software Production
- Support & Maintenance
- Research & Development

Since December 2019, and after eleven months of project work and the support of a large number of employees, SMA is entitled to call itself ISO 9001 certified. The certification of the quality management system (QMS) and its application comprises the headquarters in Zurich, the branch in Lausanne and the two subsidiaries SMA (Deutschland) GmbH in Frankfurt am Main and SMA (France) SAS in Paris.

Key figures

The SMA Group's 2019 gross sales in CHF show a good growth compared to the previous year.

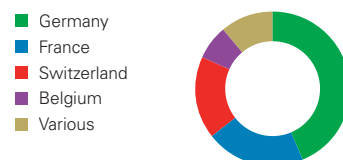
In the Consulting business, despite the decline in our US activities, our sales revenue increased by more than CHF 0.5 million. This is equivalent to a growth of more than CHF 1 million in our European markets. The lion's share of this growth is attributable to the German market, but the Swiss, French and Dutch markets also saw an increase in sales compared to 2018.

Our Software Division shows a healthy and solid consolidation of its turnover. The increase in turnover from our development, maintenance and support activities with our major customers is notable and more than compensates for the slight decline in the volatile market for the sale of Viriato Standard and/or Enterprise licenses.

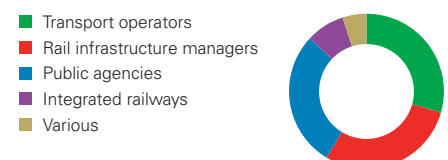
Key Figures*	2019	2018
Gross turnover (million CHF)	13.4	12.6
Full-time employees	64	61

*incl. subsidiaries

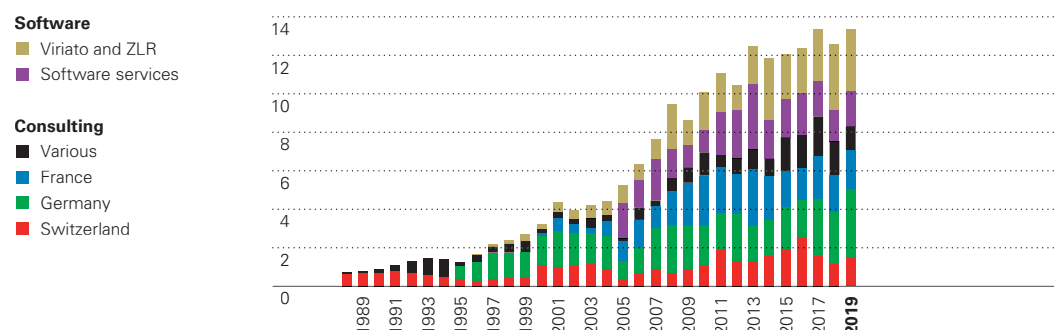
Turnover by country



Turnover by client category



Development of turnover 1988 – 2019 (million CHF)



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