ANNUAL REPORT

sma optimising railways

2021

The pictures represent the six countries where we were most active last year. They show impressive images which harmonise wonderfully as a whole, despite the exciting contrasts.

Contents

Editorial

Dear readers

The year 2021 has been very similar to 2020 for many of our customers due to the pandemic. Inevitably it has created uncertainties about the future behaviour of users of transport systems, both passengers and freight. Nevertheless, given the urgency of the situation, inaction is not an option for a green transition.

The immediate threat to the planet remains climate change. In Europe transport is responsible for a quarter of all CO_2 emissions. Supporting the railways in intermodal competition is one of the keys to the challenge of decarbonising transport, given that 95% of these emissions are attributable to the road, air, and maritime sectors.

Our introductory article describes a model for the establishment of institutional tools for sustainable planning and coordination of rail capacity at the European level to address some of the challenges of the fight against global warming.

SMA aims to support all institutional stakeholders of the railway system: public authorities, infrastructure managers, and railway undertakings in establishing methods, processes and software tools which are oriented in this direction.

Once again, we are pleased to present you with various activities and projects which have been active throughout the past year from our Consulting and Software divisions.

We hope you enjoy reading our 2021 annual report.

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Pan-European Coordination and Planning

The climate crisis and European ambitions Let's start with the observation shared by almost everyone: The world is in a climate crisis. The European Commission (EC) has understood this very well by launching the "European Green Deal" with a fund of 600 billion Euros and the aim of becoming the first climate neutral continent by 2050. This crisis has perhaps faded into the background due to the pandemic and the war in Ukraine, but it is no less acute for that. In Europe, a quarter (25%) of CO_2 emissions come from the transportation of people and goods, placing transport just behind electricity production and heating (40%), but ahead of industrial production (20%). These are all facts! Another fact is that 95% of these transport emissions are attributable to road, air and sea transport, meaning that railway forms only a minor contributor to this.

One key solution to the challenge of decarbonising transport is the railways. A safe, efficient, and less environmentally damaging means of transport. All European EU member and non-member states share the view that the development, renewal, maintenance, and effective operation of a pan-European railway network will be a cornerstone of the path to carbon neutrality.

There are many and varied initiatives ongoing, such as the activities related to the "European Year of Rail 2021" which have contributed to political awareness of the topic. The stated goals were laudable: modal shift, digitalisation, automation, multimodal efficiency, with connectivity featured prominently.

A particularly ambitious project that meets the connectivity objective is the development of the Trans-European Transport Network (TEN-T). As defined by the EC, the TEN-T consists of two "layers": a core network of links between the most important European nodes – to be completed by 2030 – and an extended pan-European network to be completed by 2050. The development of the TEN-T is accompanied by an action plan for long-distance and cross-border rail transport, which sets out a roadmap of further actions to help the EC to achieve its goal of doubling high-speed (or perhaps more accurately elevated speed) rail traffic by 2030 and tripling it by 2050.

How can the planning of such a network be implemented and coordinated within the patchwork of European institutions? How can such a planning project fit into the reality of the various European railway packages, particularly in light of the liberalisation of international passenger transport?

Planned economy within the market economy At this point, it might be useful to highlight that coordinating the development of networks and capacity at European level is not incompatible with the principles of competition in liberalised framework for rail services.

The hypothesis is that a service-driven infrastructure planning methodology shall use a "path catalogue" as a mean to this end, and it should promote and facilitate liberalisation. If train paths were sold from this path catalogue in the framework of an organised and optimised marketplace for capacity, it could even enhance the attractiveness of international services. Overall it should favour competitive behaviour and bring positive consequences for the whole industry.

Firstly, it is necessary to have a clear understanding of what a path catalogue is:

- an upstream model of the network capacity
- a set of pre-constructed paths responding to market needs
- a common platform where infrastructure managers and train operating companies can communicate on the issues of capacity and paths related to the market needs

This methodology is the logical next step from manufacturing to industrialisation in the path production process. It brings the necessary information transparency in the complex planning process between train operators and infrastructure managers, which in turn could be used to set the structures and the rules of a competitive market environment.

This path catalogue can also form the first milestone towards two related processes:

- the derivation and planning of infrastructure upgrades and equipment required
- the allocation of capacity

The first process typically requires work such as: planning of service intentions (relations, stopping patterns, frequencies and connections) and concept timetabling taking technical considerations into account (e.g. rolling-stock, infrastructure and equipment performance such as signalling). This concept timetable should be considered as a translation of the service intentions that meet mobility needs and expected demand at pan-European level and determines the functional requirements for infrastructure and rolling stock and thus helps with defining a development strategy, including its phasing.

If train operators' concerns are to optimise their asset utilisation (i.e. rolling-stock and staff), those of authorities and infrastructure managers are to plan the complex combination of capacity requirements for different types of traffic (e.g. international, intercity, regional, local and freight) in a broader network. At this stage, it can also be a political choice from a body above the infrastructure manager to reserve a certain amount of capacity for future traffic that does not yet exist. The path catalogue derived from a capacity usage plan brings transparency to all stakeholders of the system: authorities, infrastructure managers and potential operators.

In view of this, the infrastructure managers should set minimal requirements for train paths, for instance regarding the minimum speeds or number of paths per day, etc. Train operators which are not able to fulfil these requirements should not be able to have access, or only have low priority access to these train paths, following the logic that their inability to do so would be detrimental to the overall capacity of the system.

While the second step, the capacity allocation itself, is not part of the considerations of this essay, the following questions will have to be answered: How to prioritise? How to set criteria? How to protect access rights? How to set prices? Again, a clear vision of a path catalogue will help in answering these questions.

Who might be in charge at pan-European level? In this context it must be a task of the infrastructure managers to set requirements for train path allocation on their own network. But who should oversee the upstream network development and capacity planning at pan-European level?

At this point it might be interesting to have a look at the institutional tools used for the development of the Swiss railway network, which could be cited as an example of good practice, for a pan-European framework (admittedly on a smaller scale but with several authorities and infrastructure managers the Swiss institutional landscape is no less fragmented than the European one):

The Network Usage Concept (NUC) lays down the planned capacity usage for a standard model hour for all sections of the rail network (this could perhaps be extended to two-hours for the pan-European level). Based on a forecast of future transport demand, this concept regulates the compulsory sharing of capacity between passenger and freight for a long-term horizon of about 15 years. It is the Federal Council's (i.e. the Government in Switzerland) responsibility to approve the NUC and to keep it up to date.

In the next step, the Network Usage Plans (NUP) implement the planning of train paths accurate to the minute for each individual timetable year in the form of path catalogues. The NUP's are drawn up by the infrastructure managers six years before the timetable year in question and are updated as required. The Federal Office of Transportation (FOT) approves the NUP's at the request of the infrastructure managers. These plans serve as a basis for the later train path allocation and are binding for both the infrastructure managers and the authorities.

Similar institutional tools are also being adopted other countries, such as the "Deutschlandtakt" in Germany and the "Plan d'Exploitation Émergent" (PEE) in France, and which were initiated by their respective Ministries and are potentially able to form the basis of a NUC. In addition, the path catalogue currently under development at DB Netz for the "mittelfristiges Konzept für eine optimierte Kapazitätsnutzung" (mKoK) project should be mentioned. In France, there are similar ambitions with shorter-term versions of the PEE called "Plans d'Exploitation de Référence" (PER).

Could such a coordination and planning body be granted sufficient competencies and resources to set up the required institutional processes and tools at the pan-European level? Are the national stakeholders (Ministries, Authorities, Infrastructure Managers) willing to accept the transfer of some of their current responsibilities to a European body in charge of real upstream network-wide capacity planning?

It is up to the European Commission to construct an institutional framework to answer these questions as it is a political decision to choose to set up the institutions that respond to the challenges of such European-wide coordination and planning questions. Nevertheless, while institutions, processes and tools help to solve a problem, they do not solve it by themselves. Instead the methodology behind them is the key factor supporting the solution of an upstream pan-European NUC (concept) coordinated by a European Authority that has been given the competence to do so, with downstream NUP's (path catalogues) developed by the respective IMs under the supervision of this authority. Having said that, the NUC and NUP's cannot be an end in themselves, but rather a means to a service-driven methodology for a sustainable development and coordination of railway networks at the pan-European level.

sma.software: A selection of projects from 2021

FACTS & FIGURES

The turnover of sma.software is made up of the three pillars of maintenance, projects and licence sales. In 2021, we sold 15 Viriato Standard licences and in the case of Viriato Enterprise and the ZLR, one corporate licence of each. In addition, we sold licences for the add-on modules conflict detection (five), vehicle rostering (four), works planning (three) and trip time analysis (two). In addition, individual licences and additional modules were leased out for shorter periods of time to some customers. Geographically, Germany, Belgium and North America each account for just under one third of our turnover. Other individual sales were made in France, Australia, and Switzerland. Our ratio of existing customers who purchase additional licences or modules to new customers is currently about 2 to 1.

As in 2020, the trend to replace Viriato licensing via hardware dongles with a software-based online solution continued. While 85% of customers were still using hardware dongles at the end of 2019, this figure has now fallen to only 50%. With the increased use of working from home this solution provides additional flexibility.

To prepare our customers for working with Viriato, various training courses were held which were individually aligned with the requirements and working processes of the customers. As in 2020, most training was carried out online due to the travel restrictions in place.

Number of external training courses	9 training courses
Languages	German, French or English
Number of training days	20.5 days
Number of participants	approx. 60 trainees

As in previous years, our customer projects were strongly dominated by the operators in the German-speaking market. Together with internal projects, 1038 software "stories", each representing a feature or function, were implemented in 2021 as part of our agile development process. (The comparable values for previous years were 2020: 851 and 2019: 619). A total of 52 customer and product releases were delivered for 15 different versions of Viriato, which corresponds to an average of one delivery per week.

"Keeping the product alive" For a product-focused company like SMA it is crucial to maintain product development over the long term. Therefore, in addition to functional feature enhancements, it is important to constantly invest in the technological and architectural modernisation of the software. Such work prevents the software from becoming obsolete over time, minimises technical risks and ensures a positive and productive Developer Experience (DX) for the team working on the code.

A typical example is the conversion of Viriato to a 64-bit application, which we implemented during 2021. Previously, Viriato was only available as a 32-bit application and its resource consumption was limited to around two gigabytes of memory. These restrictions no longer

apply to a 64-bit application, and for example it is now possible to process several large graphic timetables simultaneously without any limitations. In the context of this changeover, we have also introduced a modern and more powerful file-based database system and made various performance improvements.

TAP-TSI A new add-on module for Viriato Enterprise provides the basis for a communication between Railway Undertakings (typically train operators) and the Infrastructure Manager based on the European TAF/TAP-TSI specification developed by ERA. The module contains the necessary data structures at the train and infrastructure level which are required for communicating over an interface between systems for ordering train paths. For a demonstration and discussion about your specific requirements for an implementation of the interface, please contact us. SMA has been working extensively with TAF/TAP-TSI for several years and will be happy to advise you.

Algorithm Platform / Research Cooperation We found new partners for future collaborations, and intensified the relationships with our existing partners. For example, we supported the master thesis of a student from the EPFL in Lausanne on the topic of disruption management. We also implemented an algorithm, previously published in the academic literature, for strategic passenger-oriented timetabling as a showcase demonstrating how easy it is to bring research into practice by integrating algorithms into our software. The source code for this case study is publicly available on GitHub at https://github.com/sma-software/openviriato.algorithm-platform.showcase.spot and can serve as practical example for potential research partners to help them to understand how to use the algorithm interface for their own work. We also supported a company from Berlin who are developing optimisation algorithms for their customers and are working closely with universities on topics of operations research in railways. They provided a path search algorithm using our Algorithm Platform for their client, a large European Infrastructure Manager.

Robustness We continued with the development of a new prototype for robustness analysis within Viriato, and during the last year this prototype was used successfully in several consultancy projects. The prototype features a mechanism for exchanging the train disposition strategy used, allowing the testing of different concepts. We have also developed a strategy that allows the changing of section and node tracks when the trains meet possessions planned in the network. This prototype tool can be used to undertake a Monte Carlo-type stochastic analysis producing detailed KPIs, allowing the users to judge the robustness of proposed timetables. Also during this year the new role of Innovation Manager at SMA was created, and they are now managing the project to develop a productive version of this tool in Viriato based on the lessons learned from the concepts developed and tested in the prototype.

Microscopy on Demand (MoD) The further development of the Microscopy on Demand Module (MoD) was dominated by its extensive use within a consulting project for an Infrastructure Manager. In the process, we implemented numerous performance improvements and invested in the stability and capability of the method. For example, it is now possible to define operational stops in the macroscopic system without any additional effort and to take these into account microscopically. Another important extension was to make the microscopic conflict detection available in the Viriato track occupancy view in addition to the graphic timetable.

The successful use of MoD for the creation of a microscopically verified nationwide timetable in a short time has shown that the promised productivity gains can be achieved with MoD.

Beyond this use case, we also see great potential for MoD in timetable-based network development. In such a case, the entire infrastructure may no longer be available microscopically. New infrastructure changes can be derived from the timetable in the macroscopic system. Existing, or potential future, bottlenecks can still be checked microscopically. This hybrid use of macroscopic and microscopic infrastructure is only possible with an architecture that combines both models: Microscopy on Demand.

VIRIATO FEATURE HIGHLIGHTS

Efficient creation of alternative timetables Railways companies are increasingly confronted with the task of producing alternative timetables. The need for short-term structural adaptation of services arises because of sudden change of demand patterns or the reduction of available resources due to operational issues. In such a context, efficient design and creation of alternative timetables help service providers realign their plans in time.

Last year we implemented in Viriato functionality that supports timetable planers to efficiently create alternative timetables. Since these timetables are rarely built from scratch, but instead borrow from existing plans, we added batch operation functions to modify the service patterns of many trains and to copy the train-path and timetable details from a reference day of a chosen timetable to the operating periods of a new one. These batch operations allow users to produce new timetables without having to manage this task for each train individually. To ensure the quality of the results of these operations, we also added the possibility to systematically compare two different timetables for changes.

These new functions offer our customers substantial help for preparation of alternative timetables, and have already proved useful during the significant changes in service levels due to rules requiring many people to work from home.

Works Planning This year we have continued to develop the Works Planning module in Viriato to increase the functionality and usability. This add-on module is an important tool for helping timetable planners, whether Infrastructure Managers or Train Operators, to understand the effects on their train service of works and to adjust their plans to deliver efficient timetables.

When working with closures and restrictions on the network, it is important to be able to not only visualise the effects but also to be sure that the consequences are modelled realistically.

An important step has been to add an additional type of restriction. Previously temporary speed restrictions were modelled only as an additional time penalty to be added to trains. Viriato can now also include speed restrictions for works which are respected by the running time calculator. This ensures that an accurate and train specific time loss due to the restriction can be calculated and the trains checked to ensure that they have sufficient reserve time to recover from the imposed delay.

In the Network View the visualisation of works has been improved, allowing the display of the location of restrictions filtered by date, or conflicts between trains and the works, and the opening of individual elements for editing or review.

Batch Operations An important part of working with timetables, especially as the plan becomes more complex and potentially involves several scenarios produced in parallel, is the ability to apply changes to multiple trains or other objects simultaneously. To improve this user workflow, we have added many new or improved batch operations to Viriato. In the Viriato trains themselves, key batch operations include the ability to update of extend train validities for a set of trains, or to change the trains within a family to a set pattern. These are complex operations, especially in Viriato Enterprise where the underlying initial validity may contain significant variations which need to be managed. Another important addition is the ability to modify the configuration information for a set of trains as it allows the planed rolling stock to be changed, for example if a new fleet is introduced and updated running time calculations are needed. When working with infrastructure, particularly with conflict detection or on algorithmic tasks, it is important to set the base number of tracks within a node, and a new batch function allows this to be done for multiple nodes allowing the user to quickly update stations to include the base information needed for modelling operations at the technical level. Within the Works Planning module we have added a batch operation which allows possessions to be grouped into related worksites, making it easier to understand the relationship between separate closures.

Robustness versus Punctuality

Punctuality and robustness, operations and planning The measured punctuality in operation is the most important and observed parameter for the railway. It is significantly influenced by the factors of operational quality, robustness of the timetable and the quality of dispatching in the operational control centres.

By operational quality we roughly mean the reciprocal value of the number of disruptions per time unit in a fixed period. Robustness is defined as the ability of the timetable to absorb the influence of disturbances and to return to the undisturbed state. The quality of the dispatching is governed by the operating rules and is measured by the ability to perform the operation as close as possible to the plan for an unperturbed state.

Robustness analysis is used here to describe a procedure that can make a prediction about the contribution of a timetable to the future punctuality of the operation on the basis of modelling the operational quality, the timetable robustness and the dispatching. Optionally, the focus may also be on the amount of the time required to return to normal operation.

Typically, operational quality is modelled in a robustness analysis by randomly drawing events from statistical distributions created from measured data, which are then applied to the timetable as primary delays.

For the determination of robustness, i.e. the extent of propagation of the primary delays over geographic space and time, either a synchronous simulation or a semi-analytical approach using stochastic simulation is usually chosen.

The quality of dispatching is usually considered ad hoc, and its modelling is often more of an art than a science due to the complexity of the real-world operational rules and the diversity of techniques used in practice.

How would we do it At the centre of our approach is the planner's need to receive timely feedback on the impact of their decisions regarding the robustness of the timetable. Here we focus on transparency and traceability of the impact, which is why we have chosen a synchronous simulation rather than an analytical procedure.

In order to implement a robustness analysis, it is essential to carry out a significant number of simulations using the Monte Carlo method based on the statistical distributions of the primary delays. Therefore, we have focused on delivering the best possible performance right from the start, for example by consistently parallelising the calculations.

For the planner, the synchronous simulation approach also has the advantage that the simulation of individual disruptions, i.e. the primary delays, can massively improve the understanding of the way in which delays propagate in specific cases.

On the architecture side, we rely on a consistent service-oriented implementation based on the Viriato conflict model for the running time calculation, conflict detection and the simulation core. The dispatching strategy is connected via the Viriato Algorithm Platform.

This allows an efficient mechanism for exchanging strategies and allows participation for interested third parties with their own independent implementations, aligned with our established process and #openviriato model for open collaboration.

The execution of many runs of the simulation provides not only statistically relevant simulated delay times, but also a rich pool of additional data on operational details that have come to light in the course of the simulation. We want to apply standardised methods for data analysis to these data to make the structural causes of insufficient timetable robustness transparent.

Anchored in the planning process In terms of processes, two different applications of robustness analysis tools can be distinguished. Firstly, a focus on the final review of a timetable as a test at the end of the process. In this case, there is a tacit assumption that the timetable is essentially robust and that feedback to the planner for the purpose of iterative adjustments is not necessary. In this case, there is no compelling need to make the mechanics of robustness transparent, as we presuppose that the timetable is already robust.

The second case, which is of interest to us here, consists of a seamless integration in the planning tool, with the aim of providing the planner with feedback as needed during the timetable construction process about changes in robustness through their planning actions. In this case, it is essential to do this transparently to enable the planner to make targeted improvements to improve the robustness.

A prerequisite for this type of integration is sufficient performance when carrying out the simulation runs. This can be achieved by scaling the hardware through suitable parallelisation.

Another requirement is the maintenance of the necessary running time calculation and conflict detection data during the timetable design process. Viriato's lightweight model comes to the planner's aid here.

In this context, the model's ability to technically handle locally incomplete data is also important, and it is in the core of Viriato's philosophy to leave this responsibility to the user. Thanks to the transparency of the robustness procedure described, the planner can decide whether the results obtained are technically meaningful.

This feature of the model makes it possible to use the robustness analysis early in the conceptual planning process. This is essential in a continuous planning process, otherwise deficiencies in the robustness of the timetable may be detected too late after it is passed on to downstream process steps.

The planner thinks, the dispatcher acts The influence of dispatching on punctuality is huge. The decisions of the dispatchers and the information available to them for this purpose are used to control the operation to adhere to the timetable and thus contribute directly to punctuality.

For this reason, we give the greatest possible flexibility to the configurability of dispatching in our model, which is why dispatching is outsourced to a separate algorithm and connected via the Viriato Algorithm Platform. This way, dispatching gets access to the central services and communicates its decisions to Viriato.

This approach enables different dispatching strategies to be studied, compared and their impact on punctuality to be predicted. Furthermore, this approach allows interested third parties, either working with SMA or independently, to develop such dispatching strategies and connect them to Viriato to study their behaviour.

A prototype has now been in operation for almost two years, and SMA has used it in various projects in Switzerland, Belgium, France and Hungary. The feedback from our users helps us to further develop this new add-on module in a manner targeted to their needs. Our customers appreciate the transparency and traceability of the results and we have been able to answer some very interesting technical questions.

In 2022, we will focus our efforts on the productive implementation to make this promising robustness analysis method available to all interested Viriato customers.


Sozialverband Deutschland

Consulting: A selection of projects from 2021

Our business segments

- Service offer
- Production
- Operations
- Capacity
- Demand
- Franchises & Tenders

AUSTRIA

Tyrol: 2030+ Tyrol offer concept The state of Tyrol already offers a very good range of rail passenger transport services. Due to the constantly growing demand, the local transport offer is to be further expanded for the 2030+ time horizon. The aim of the study was to develop various service concepts for regional passenger transport in Tyrol for the next transport service contract and after the completion of important infrastructure projects such as the Brenner Base Tunnel. In this process the service improvements and extensions desired by the province have been considered. These include the quarter-hourly service from Innsbruck to Kranebitten, the extension of the REX towards Landeck and Kufstein and the addition of new stops.

The commissioning of the Brenner Base Tunnel will also result in a significant improvement of the connection between East Tyrol and the provincial capital Innsbruck. The variants developed were evaluated considering both operational and traffic criteria, and freight services were also included in the study. In addition, an alignment exercise with the neighbouring countries was carried out.

ÖBB Infrastruktur: 2040 Target network – Freight transport, stakeholder management and challenging the systematic freight paths The nationwide expansion planning for the rail network in Austria is timetable-based, and this concept is currently being applied in the planning for the 2040 target network. Based on service concepts for passenger rail transport and system paths for freight transport, the necessary infrastructure upgrades are determined regarding shortening journey times or resolving bottlenecks. The procedure is based on the one that has been successfully applied in the long-term network design in Switzerland and for the planning of the Deutschlandtakt in Germany.

In order to challenge the procedure in Austria and planning work undertaken by an independent expert, the aim of SMA's expert services was to validate the implemented process on the basis of best-practice comparisons of the neighbouring countries Switzerland and Germany and to bring the stakeholders to a consensus-based agreement. The core of the work was the alignment of the prediction for freight transport volume so that the structure for the future time horizon is correct. In addition, the system path approach was examined in relation to the assumed model trains and the planned implementation on the three priority freight transport corridors.

The results of the study show a high degree of consistency with long-term planning in other complex networks, so that the stakeholders can gain a transparent insight into the planning of freight transport and thus recognise that their needs have been considered during the process.

The work will continue in 2022.

BELGIUM

Provincie Noord-Brabant: Improvement of the international rail services between Noord-Brabant and Belgium The international rail services between the Netherlands and Belgium are strongly concentrated on the Randstad (NL)–Brussels (B) corridor. The development of these rail services could see more regional stakeholders emerging thanks to commercial diversification on both the international corridor and feeder services towards high-speed hubs such as Brussels. The Province of Noord-Brabant wants to maintain the existing rail service between Breda and Brussels, and to evaluate future developments such as a new direct train between Eindhoven and Brussels.

To evaluate the potential of new or different international train services, the Province of Noord-Brabant asked SMA to organise informal exchanges with the main stakeholders in the rail sector on both sides of the border. Based on these exchanges and the planned long-term developments in the Netherlands and Belgium, SMA suggested several variants of potential service developments.

These variants were then evaluated qualitatively using different criteria (such as service quality, timetable integration, operational costs, operational constraints, alignment with national planning intentions) which allowed the identification of the most promising variant aiming for a direct connection between Eindhoven and Brussels.

SMA developed the most promising variant into a service concept integrated with the Dutch and Belgian rail networks which allowed a quantitative evaluation identifying specific constraints and potential demand. Finally, a roadmap of step-based development options for the international train services has been outlined. The study allowed the identification of dependencies with national developments, especially in the Netherlands and can serve as a basis for further exchanges for the province with its stakeholders.

Infrabel: Network Architecture One of the characteristics of the railway infrastructure is the long lead-time for renewal and enhancement project investments, which must often be planned 10 to 20 years in advance. Therefore, a long-term, well-thought-out, stable and timely vision is needed to better anticipate changes in timetables and any resulting investment needs.

In this context, Infrabel would like to carry out studies to define the evolution of their railway network according to the needs within the framework of a programme called "Network Architecture".

SMA has assisted Infrabel in defining and evaluating several scenarios that differ in terms of their service structure. The service objectives (in terms of volume of train paths) were defined based on the forecast evolution of the market and ambitions at the national level.

The evaluation of the three scenarios in terms of service quality was carried out based on various key indicators. The analysis of the results made it possible to highlight the elements that vary significantly from one scenario to another, and to identify common elements that are independent of the service structure.

Finally, an expert evaluation was carried out to identify whether new technologies such as ETCS, ATO or new traffic management solutions would reduce the necessary infrastructure investments. This analysis gave very different results between scenarios, concluding that some service structures benefit more from these technologies than others.

Infrabel: Expertise on railway capacity for the Brussels east and west bypass lines

The development of demand for train paths through Brussels, particularly between Brussels North and South stations (via the North-South axis) calls for solutions to increase capacity and to use other routes in view of the congestion already identified today. The two bypass lines to the east (line 26) and west (line 28) could thus see more trains using them as alternatives.

The aim of the capacity study commissioned by Infrabel was to determine the current situation, identify solutions and to define a set of actions to optimise and increase capacity.

The study has made it possible through evaluating various scenarios not only to identify the infrastructure works that would allow capacity to be increased, but also to show the impact on the available capacity of the development of ETCS and ATO as well as that of an alternative service pattern.

Despite the differences in achievable capacity, the scenarios allowed the identification of common beneficial infrastructure actions independent from the final structure of the offer. These actions were then evaluated by a partner company regarding their impacts, particularly in terms of urban planning and finance.

Finally, an intermediate scenario was used to identify the conditions for increasing capacity in the short term without requiring major investment in infrastructure. These actions are mainly linked to modifications of the structure of the service offer for both freight and passenger paths.

Infrabel: Infrastructure requirements in the Port of Antwerp The Port of Antwerp has high ambitions for the development of rail transport. Through a Memorandum of Cooperation (involving the Port of Antwerp, RailPort and Infrabel), a vision has been defined with development principles identifying locations for investment in the port's rail network. This vision is based on a doubling of the rail modal share of container traffic by 2030.

Infrabel asked SMA to assess the various investments by carrying out a top-down analysis based on the objectives for the evolution of demand and identifying the main bottlenecks in the port over the long term. A strategic planning approach enabled the study to define an operating concept in line with the stated objectives, which highlighted the interdependencies between the different investment projects.

The planning of the railway system in the port environment considered the large fluctuations in demand for freight trains and their consequent need for flexibility. The planning assumptions were based on a probabilistic analysis of conflicts between services, based on train traffic data captured over several years.

The analysis of the network made it possible to identify the investments needed to resolve the bottlenecks, and to validate or amend the various rail infrastructure projects already identified by Infrabel and the Port of Antwerp.

Federal Public Service Mobility and Transport Belgium: Investigation into the conditions for the substitution of air services by rail The Federal Public Service (FPS) Mobility and Transport of the Belgian government wished to analyse the requirements for a modal shift to rail from international air services from Belgian airports. This study forms part of the national policy for the decarbonisation of transport. It highlighted the strengths and weaknesses of the current offers of both modes to a selection of European destinations, chosen according to the importance of their traffic with Belgium, and their position in a market that can realistically be captured by the rail mode. The analysis covered both day and night rail connections.

Based on traffic data and a model developed with a specialised partner, several scenarios for the development of rail services were developed. This extended the actions already undertaken, such as major infrastructure projects and the reconfiguration of the rail service announced in Germany, and quantified the effects of them on the modal split. This study made it possible to show the importance of the regulatory framework in which the various travel modes develop, but also the opportunities for better integration of international timetables to promote more attractive rail links.

SWITZERLAND

SBB Infrastructure: Configuration of the Basel hub On behalf of the Swiss Confederation, SBB has drawn up the basic principles of what rail services and infrastructure are necessary in the long term for Basel. SMA has supported this work as part of the timetable structure test-planning. In this procedure, various timetable concepts are planned for the targeted volume of services, and based on selected quality metrics (frequency, journey time) the infrastructure required is determined. The timetable structures differ regarding node configurations or the relative temporal positions of the services on different lines. This makes it possible to show which infrastructures or topologies provide a broad benefit and which are only required for specific plans.

In addition to the timetable structure test planning, SMA provided support on other topics, including fundamental work such as the compilation and harmonisation of the planning principles of the participating infrastructure operators from Switzerland, Germany and France, as well as extensive running time calculations for the various routing variants. In addition to the timetable structures, the production requirements such as strengths/weaknesses and journeys to and from the vehicle stabling and workshops were also considered. Finally, an investigation including timetable structures of possible implementation sequences for the extensive infrastructure upgrades was carried out.

The investigations showed, among other things, that an extension of Basel SBB station to include an underground station with a line to Basel St. Johann and Basel Badischer Bahnhof (the "Herzstück" project) would produce the best results in terms of coping with future services. The findings will now be examined further within the framework of the preliminary study on the capacity expansion of the Basel node, particularly in terms of construction requirements.

Canton Neuchâtel: Preliminary study of an electric bus service between Le Locle and Les Brenets The replacement of the Le Locle–Les Brenets rail line (line 224) and the road at Les Brenets (highway 385) with a combined line of battery powered electric buses was decided by the Canton of Neuchâtel and the Federal Office of Transport following a study comparing the maintenance cost of the narrow-gauge line, the connection of the line to the normal-gauge network and its replacement by an electric bus line. In this context, a study was launched with the aim of developing a service offer. Different scenarios were proposed in terms of routing and stopping policy, and these were then evaluated using a socio-economic analysis considering both investment and operating costs.

Three service schemes were proposed to test contrasting routes and timetable options in Le Locle while remaining consistent with the existing configuration of the bus and train station there. They were designed using running time calculations to propose feasible timetables with connections. The state of charge of the bus battery was modelled and considered when selecting the bus fleet. This analysis of the operation of battery-electric vehicles made it possible to specify the necessary recharging points. The operating costs of the line were then evaluated.

Canton of Jura: Assistance with medium and long-term development projects
In the medium term, the Canton of Jura (CH) and the Burgundy-Franche-Comté Region (FR) wish to implement the "Convergence 2026" project, which will modify the service on the Belfort–Delle line (reopened on 9 December 2018) by providing a full half-hourly service from Belfort-Ville to Delémont via Porrentruy. Once the framework was established, the service objectives, including connections were defined with the project sponsors. The "Convergence 2026" Belfort–Delémont scenario was then planned in several iterations with SBB Infrastructure and SNCF Réseau. Finally, this scenario was evaluated from the point of view of service quality, 24-hour standardised timetables, productivity metrics (including rolling stock and an estimate of the number of drivers required) and operational robustness.

At the same time, and to prepare the next stage of the Expansion Step 2035 plan, the Canton of Jura wished to evaluate the rail demand for different scenarios up to 2040 in order to identify the offer concepts that would maximise the use of the canton's rail network. In addition to the "Convergence 2026" project, ArcExpress (a fast direct connection between La Chaux-de-Fonds and Delémont with a good connection to the direct trains to Basel) and the plan to add extra trains between Porrentruy and Delémont were tested. These scenarios were evaluated and compared to identify which one maximises demand and best meets the main expectations for improving services both within the canton and to the outside world.

Matterhorn Gotthard Bahn: Täsch–Zermatt capacity expansion The Extension Step 2035 plan provides for an increase to a 15-minute frequency for the Täsch–Zermatt shuttle service. The existing line, which runs in exposed terrain, is to be replaced by a continuous tunnel. SMA carried out a detailed study of the practicality and operational feasibility of detailed infrastructure designs for the infrastructure including station areas. The flexibility and compatibility with a possible future expansion of train services also had to be considered in this study.

For the 2035 and "long term" horizons, the basic infrastructure requirements were identified based on service concepts and capacity analyses. Three infrastructure variants were defined for the Täsch–Zermatt line: a single-track tunnel with a crossing point, a partial double-track and a continuous double-track tunnel.

As the line, which is mainly single-track from Visp, has a significant influence on the capacity and route structure between Täsch and Zermatt, the scope in this conceptual phase included the entire valley. For the 2035 horizon, a robustness test was carried out using the Viriato robustness analysis module. In addition, coordinated development steps for services and infrastructure were outlined through to the long-term horizon.

A significant part of the study comprised microscopic operational simulations with OpenTrack for the three infrastructure variants between Täsch and Zermatt together with different frequency patterns of the shuttle trains. In addition to proving operational stability, this also resulted in the detailed requirements for the infrastructure, such as the length of

crossing points or the double track section, the design of Täsch and Zermatt stations, the signalling block lengths and pre-signalling distances. These infrastructure elements now form the basis for the detailed civil engineering design studies.

SBB AG: Service offer and timetable expert group SBB would like to improve punctuality on its network. The "Groupe de réflexion offre-horaire" expert panel formed of both internal SBB and external members, including SMA, developed approaches for actions that could contribute to this. The committee approached the first phase of this task with an open mind and searched the entire spectrum of service offers and operations for innovative and unconventional approaches.

In a second phase, three sets of actions were combined into scenarios, one each for short-, medium- and long-term horizons, which were then tested for their effect on the robustness as well as on service quality and the rolling stock fleet. The test area comprised the Bern–Visp–Lausanne triangle, in which long-distance lines are linked at connecting nodes and in some sections are overlaid with dense urban and freight traffic. After the planning of the conflict-free timetable concepts, the modelling of the robustness parameters and the definition of initial disturbances in the form of localised train delays, the robustness simulation was carried out. The Viriato robustness tool was used, which determines the propagation of delays in the investigated network over the simulation period. The conflict detection checks for compliance with the predefined train headways and separation times on routes and in nodes and, if necessary, continuously adjusts the train trajectories. The "consumption" of reserves and compliance with the constraints such as vehicle links and connections are also taken into account.

With the simulation results, the effectiveness of the punctuality measures could be quantified, for example in the form of the resulting median train delay. As there are also differences in the quality of service and the operating costs due to the scenarios, an overall evaluation of the actions and the conclusions can only be meaningful if these effects are also quantified. For each of the three horizons, solutions were recommended for further development.

Federal Office of Transport: 2050 Rail Perspective, doubling the share of rail in passenger transport The Swiss Federal Office of Transport is developing the 2050 Rail Perspective, which is to serve as the basis for the next 2040/45 Expansion Step. Core principles were formulated as a basis for this, and which were then examined for their effect in separate studies. One of the core principles is "In passenger transport, the share of rail will double". Based on this principle, SMA investigated how high the potential shift from road to rail would be based solely on actions to improve the rail offer, which features would have to be improved and to what extent, and what effects the achievement of the core principle would have on the rail system overall.

In the first phase, the theoretical shift potential to rail was investigated. The potential was distinguished according to transport segments and according to the service characteristics that can be influenced by public transport, e.g. service density, frequency of transfer and travel time. The basis for these assessments was the data of the current national passenger transport model. Using a logit approach, the change in the modal choice of the entire transport demand (approximately 50 million origin-destination pairs were in the data set) could be calculated by changing public transport resistance factors, and thus the required improvements to the public transport offer could be quantified.

In the second phase, timetable concepts were planned in scenarios in which the service improvements necessary for the transfer were either partially or fully implemented. The extensive changes in frequency, direct connections and travel time reductions would result in major infrastructure upgrade requirements. The additional costs for regional passenger transport were then determined, and the corresponding values from the sample network were projected onto the entire Swiss rail network with the aid of a tool.

The findings of the study on the modal shift effect and the cost of service improvements will help the FOT to specify the priorities for the 2050 rail strategy.

RegionAlps SA: Assistance with the tender for the Central Valais bus routes
In Summer 2021 the Canton of Valais, in collaboration with the Federal Office of Transport (FOT), published a call for tenders for the operating concessions of three bus lines in the central Valais starting from December 2022 for a period of 10 years. SMA's task was to provide technical assistance to RegionAlps and its partner in responding to this invitation to tender.

This assistance consisted of an analysis of the current situation in terms of the operation of these three lines, and the competitive context concerning the existing local bus companies and other firms that could potentially be interested in this call for tenders.

During the tendering process, the assistance was intensively focused on providing support for the bid team and the preparation of their technical response, the development and comparison of various operating scenarios and the determination of the necessary operational management roles. SMA developed proposals for optimising the operation of the buses and the workshop location. The personnel required was determined to specify the necessary teams and to evaluate the operating costs. Finally, an analysis of the feasibility and robustness of the timetable and the establishment of scenarios in case of disruptive situations completed this support.

CHILE

Concept design and simulation of the future suburban network in Santiago The Chilian State Railway Company (EFE) wants to increase its role in public transport in Santiago by commissioning new suburban and regional services to Batuco and Melipilla, and planning new infrastructure, including the Quinta Normal–Alameda tunnel which will create the basis for a suburban through-network. To manage the increase in traffic volume, a new masterplan for the Alameda station is required.

SMA has been awarded a study to support EFE in implementing future service concepts for a pre-defined set of infrastructures for two different time horizons, both before and after the opening of the Quinta Normal–Alameda tunnel, with the aim of analysing and validating future service concepts. The proposed methodology has been structured around two study phases. A preliminary macroscopic approach has been used to investigate alternative operational models, to set a preliminary timetable for the typical 24 hour weekday, to evaluate the resulting travel time between selected station pairs, to size the pool of required vehicles, to identify the needs in stabling capacity through the network, to define the required functional layout for terminus stations and the Alameda complex and to analyse freight capacity in each corridor of the Metropolitan area (Batuco–Melipilla–Paine).
A microscopic approach was then used to validate the planning assumptions and evaluate the robustness of the proposed solutions for both time horizons through simulating the selected scenarios.

CZECH REPUBLIC

Správa železnic – Czech Rail Infrastructure Manager/Mott MacDonald CZ: Prague Railway Node feasibility study SMA in partnership with four other companies, with Mott MacDonald CZ as the lead partner, participated in the Prague Railway Node feasibility study in the Czech Republic. Prague has become a major bottleneck on the Czech railway network in recent years, and the study is investigating how to substantially increase capacity of the node and to meet the demands of all traffic types. Considering several planned and ongoing infrastructure projects, such as the new high-speed-connections entering the node or the new city-to-airport connection, a long-term target service and operational concept for the Prague metropolitan region is being developed. Based on the optimised service concept, necessary infrastructure upgrades were identified, including city-tunnels with underground stations situated partly beneath the historic city centre. With major growth in passenger services, special attention is focused on the Prague rail freight ring ensuring that the freight traffic requirements are not restricted.

While 2021 was devoted to the definition of the base scenario, in 2022 SMA will develop ten project scenarios at a macroscopic planning level to identify the most beneficial solution for the Czech capital.

The involvement in this study gave SMA the opportunity to have frequent contact with the infrastructure manager, local transport authorities, service operators and representatives of the city of Prague and Central Bohemian Region.

GERMANY

BMDV: Deutschlandtakt Consultancy services and timetable-based rail infrastructure development for federal transport infrastructure planning In the summer of 2020, the German Federal Government published the target timetable for the Deutschlandtakt. To assess the results in terms of their economic viability, the 3rd expert draft of the target timetable was evaluated according to the federal transport infrastructure planning methodology by an expert consortium consisting of Intraplan Consult GmbH, TTS TRIMODE Transport Solutions GmbH and SMA und Partner AG. For this purpose, a reference case for the evaluation of the 3rd expert draft was developed in coordination with the client. In parallel, the infrastructure costs of the upgrades required due to the plan were determined.

The evaluation result shows a benefit-cost ratio of 1.4. The realisation of the infrastructure actions relevant to the proposed plan is thus advantageous in macroeconomic terms under the assumptions and constraints used. As a result of this assessment, the infrastructure actions derived based on the timetable for the Deutschlandtakt move from potential to priority requirements in the Rail Requirements Plan.

The expert services in connection with the Deutschlandtakt and the timetable-based infrastructure development have reached their provisional conclusion with this positive evaluation. The results and findings from the design and evaluation of the Deutschlandtakt will be used as a basis for further planning. The derived infrastructure set, which has now been positively evaluated, thus forms a basis for the further development of the rail network in Germany.

Landkreis Lörrach: Kandertal traffic study The Kandertal is a region in the north-west of the district of Lörrach and is closely linked economically with the Basel metropolitan area. Transport links exist via Weil am Rhein to the Markgräflerland, via Lörrach to the Wiesental and to Basel. The municipalities in the Kandertal have developed the 2040 area concept together with regional partners including the district of Lörrach, Basel itself and the Hochrhein-Bodensee regional authority. This shows the development potential of the Kandertal, which is also intended as a regional development axis, and outlines ideas for its development.

In this context, the currently unattractive road-based public transport system is to be reorganised, with the reactivation of the Kandertal railway to play a central role in these plans.

In this study SMA developed a range of variants for the future public transport system in the Kandertal, which resulted in two variants – both with and without reactivation of the Kandertal railway. The two variants are compatible, so that the variant without reactivation can also serve as a preliminary stage for a possible later reactivation of the Kandertal railway.

In 2022, the results of the Kandertal transport study will be examined in greater depth in the state-funded "Feasibility study on reactivating the Kandertal".

Competence Centre Integral Timetable NRW (KC ITF NRW) and public authorities in North Rhine-Westphalia (NRW): Further development of the integrated interval timetable of the state of NRW In 2021, SMA again supported the KC ITF NRW and the three public transport authorities in NRW (NWL, NVR and VRR) in the further development of the integrated interval timetable of the state of NRW.

The focus of the work in 2021 was the completion and communication of the NRW target networks for 2032 and 2040. Following the example of the nationwide Deutschlandtakt, the concept was conceived and developed from the supply side. The Deutschlandtakt not only serves as a model here but was also used as a starting point for the creation of the target network concept to enable not only state-wide but also cross-border operational planning. From this "ideal" timetable, the necessary new and upgraded infrastructure upgrades were derived. This concept also provides answers to the NRW transportation change strategy and considers measures for decarbonisation through the use of zero emission vehicles. The planning of an intermediate stage for the commissioning phase of the RRX infrastructure in NRW was started as the next component of the study.

Quality improvement analyses were carried out for individual corridors, and operational and infrastructural actions were derived to improve punctuality. In addition, timetable integration tests of potential new railway stations were carried out for individual routes.

On behalf of the public authorities in NRW, in 2021 SMA has prepared various studies on the operational feasibility on the reactivation of routes in regional passenger transport (e.g. on the Westfälische Landes-Eisenbahn or the Walsumbahn). These are compatible with the NRW target networks and form the basis for studies to be carried out later regarding the technical and economic feasibility of these projects.

Further work for the authorities consisted in the support of tendering procedures, where specific timetables were drawn up and vehicle planning was carried out for the tendering process.

The results of the work in NRW were presented and discussed in working groups and committees. The work was supplemented with the annual monitoring of the service volume and the updating of the published netgraph.

The work will continue in the current year.

Bavarian Ministry of Transport: S-Bahn Nuremberg expansion programme Alongside the Munich Metropolitan Region, the Nuremberg Metropolitan Region is the second largest conurbation in Bavaria with a suburban railway system. The quality of life and work in the Nuremberg area depends to a large extent on the attractiveness of the transport routes. Against the background of the political goal of significantly increasing the number of passengers using public transport and minimising traffic-related environmental pollution, rail transport in particular the S-Bahn, plays a major role as the backbone of public transport in the Nuremberg metropolitan area.

The "Nuremberg S-Bahn Expansion Programme" describes the main points for the future design of local rail passenger transport in the Nuremberg Metropolitan Region. The programme currently considers 23 actions, or groups of actions, which are in the planning or implementation stages.

With a view to clarifying the programme goals, a further 24 individual actions (as of the end of 2021) are to be assessed in a feasibility study regarding their traffic impact and their construction and operational feasibility. The study is scheduled to run for five years, and in the first year will be focused on the development of coordinated reference cases for the work already planned for implementation. In addition, the first basic studies were carried out on supplementing the core network, which includes the idea of using the freight ring for local rail passenger transport.

Hamburger Hochbahn: Operation simulation of the U3 line The growth in demand on the U3 requires an increase in capacity. In addition, renewals are planned for the infrastructure, most of which dates to the initial opening. Through operational simulations, the project aimed to show the current capacity of the U3 and how this can be increased to meet future requirements.

SMA has been commissioned by the Hochbahn to create an OpenTrack simulation model for its U3 underground line. In the first phase, SMA constructed the model with the current infrastructure, vehicles and operational rules and calibrated it. In subsequent simulation runs, the baseline performance of the system was determined. Further scenarios followed with the aim of increasing performance through targeted adjustments to the infrastructure and signalling systems. The operational simulations made it possible to determine the predicted changes in performance due to the upgrades and renewals.

In a further phase, studies on the performance of the turning facilities have been carried out with this model, and simulations on the handling of different construction stages are planned.

The project will continue in 2022.


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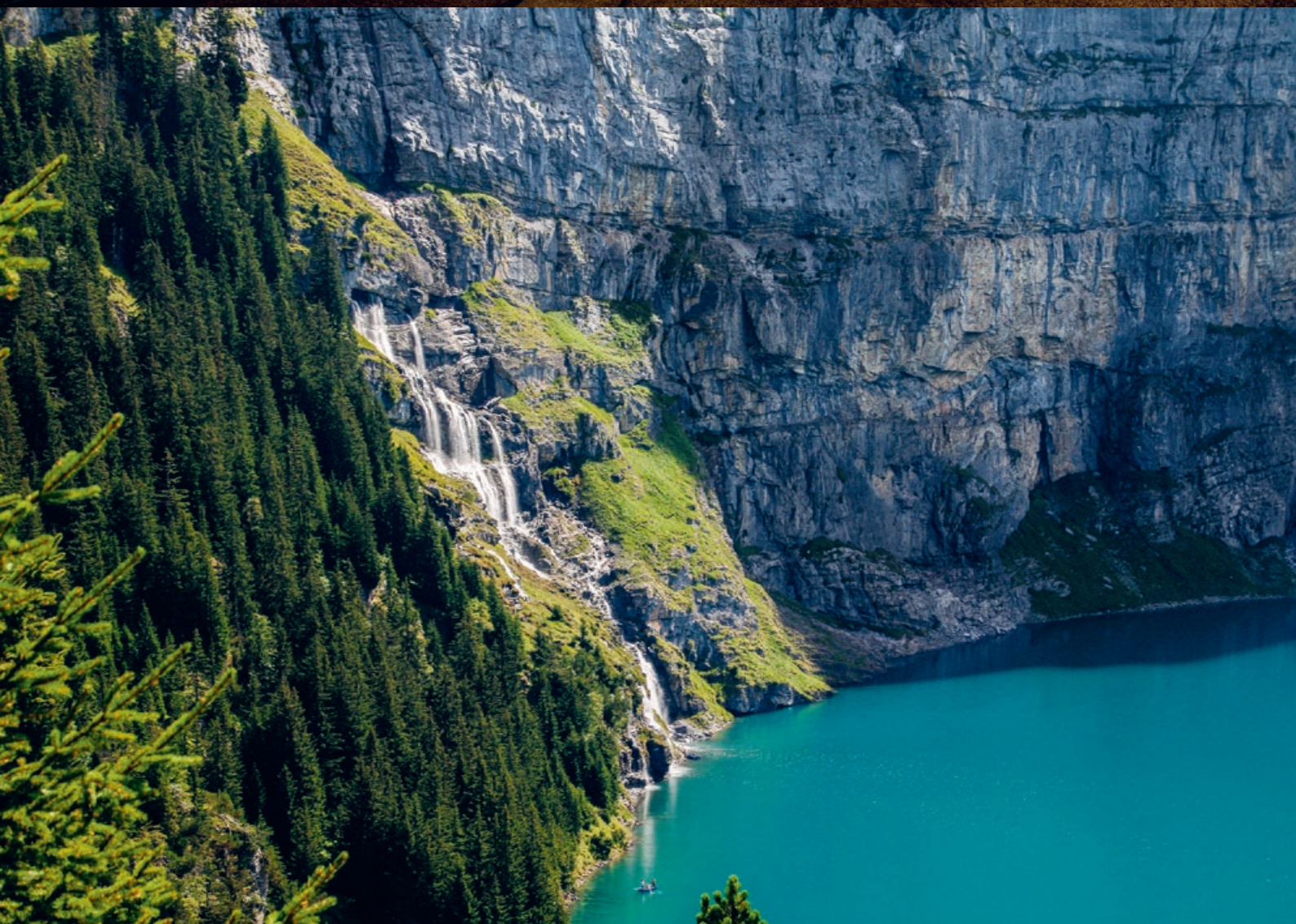

DB Netz AG: Medium-term concept for optimised capacity utilisation Capacity on DB Netz's railway lines is a scarce commodity. To be able to manage this capacity well, new approaches are required. In future, the focus will be increasingly on overall optimisation. For this reason, DB Netz AG is striving for a reorientation of capacity planning based on pre-structured timetables and service concepts.

One element of this reorientation is the creation of a medium-term concept for optimised capacity utilisation (mKoK) for the timetable year 2024. The aim of SMA's supporting work was to develop a concept together with DB Netz AG that plans the additional services desired by the market in rail freight and passenger transport into the existing offer on the infrastructure available in 2024. The aim is to balance the growth of the transport modes wherever possible, to maintain the operating quality in the long term and not to worsen the connections, traffic volume and journey times. The basis for the data to be integrated was an industry-wide customer survey of the access rights holders, which SMA analysed and filtered based on their relevance for implementation. The customer survey showed that there is a high demand for additional services, particularly in regional rail passenger transport capacity.

The work was carried out in close cooperation with the planners of DB Netz AG. The "Microscopy on Demand" (MoD) software architecture developed by SMA was used for the first time on a large scale. This allows microscopic services such as running time calculation or conflict detection to be called from Viriato to microscopically check the feasibility of the concepts.

The results were presented to the market in a transparent manner, analogous to the procedure used previously for the Deutschlandtakt. The mKoK was completed at the end of March 2022 and forms the basis for the 2024 timetable application procedure for framework agreements holders.

DB Fernverkehr AG: Simulation of layout variants for a new ICE workshop in the Nuremberg area DB Fernverkehr AG is planning a new ICE workshop close to its operations in the Nuremberg area. To ensure that this new plant meets current and future needs, SMA was commissioned to develop a workshop layout. In addition to maintenance work, all cleaning activities and parking of the vehicles were to be considered.

In a further step, the developed workshop layout was compared with the previous plans and with alternative proposals from other experts. For several of these proposals, a simulation using the performance model for parking and maintenance facilities developed by SMA was undertaken. The results of these simulations show the operational advantages and disadvantages of the different proposals and represent an important factor in the selection of a suitable site layout.

FRANCE

SNCF Réseau: Assistance in preparing the 2025-2030 strategic timetable deliverables SMA assisted SNCF Réseau with the creation of the strategic reference and projected timetables for the 2025 and 2030 horizons in Viriato. These cover the national timetables for the whole of France, and the regional one for the North-East-Normandy area. SMA consolidated the studies previously carried on these sectors into a single Viriato database, and built new strategic timetables integrating the changes in service requirements identified by the SNCF Réseau, in particular following the commissioning of new rail infrastructures and the entry into the market of new operators.

SMA produced the strategic timetable outputs intended to constitute the sole reference for future timetabling projects using Viriato. These timetables are in the form of systematic 2-hour and 24-hour schedules intended to guide the action of the service planning and infrastructure teams, as well as other SNCF Réseau entities in defining infrastructure requirements and identifying the constraints for the development of rail traffic. These studies also contributed to the definition of a strategic timetable enabling the infrastructure manager to make the necessary choices in terms of asset management. The overall consistency of the work carried out on the other territorial boundaries was ensured by SMA working in partnership with the contractors responsible for the other sectoral lots.

SNCF Réseau: Capacity study and operation of the new Mulhouse–Basel EuroAirport line SMA has been selected by SNCF Réseau to continue the capacity and operation studies for the Mulhouse–Basel EuroAirport (EAP) New Rail Line (NLF) project at the Detailed Preliminary Project level. The main objectives of this study phase are to set the work programme, bring the studies to a "pre-project" level of detail, define the work scheduling, refine the costs, ensure compatibility with connected projects in France, Switzerland and Germany and to define and integrate the future operating methods.

The study began with a review of the work carried out in the Preliminary Project Summary and by sharing of all the developments concerning the service, timetable, rolling stock and operating assumptions with the authorities, infrastructure managers and railway companies concerned. These elements were discussed in the framework of the bilingual service working group.

SMA then drew up proposals for a service and operating scheme for both the 2035 horizon and the project's commissioning date, carrying out numerous tests and iterations in relation to the questions posed by the study's partners, including the analyses carried out in parallel using the OpenTrack tool. This was used to ensure that the proposed scenarios met the partners' objectives in terms of robustness.

As a result of this work, the international rail infrastructure scheme was endorsed for further study.

French Ministry of Transport, Organising authority mission: Study of new regional balancing train lines The December 2019 Mobility Orientation Act (LOM) asked the French government to submit a report to parliament on the development of the regional balancing train services. The corresponding study identified several corridors, for both day and night services for which several complementary analyses were undertaken from an operational perspective. Having contributed to this report, SMA also assisted the Ministry on several issues relating to these lines.

For the night service, in depth operational and economic studies were carried out to support the economic model proposed for the development of a new network of lines, as well as their technical and contractual organisation.

For the daytime services, SMA assisted the Ministry in discussions with the current operator SNCF Voyageurs and with SNCF Réseau about the short-term introduction of a new line between the east and south of France. This support involved exchanges with the various regional organising authorities connected with this new line, as well as the consolidation of projects to extend the network of lines between the north and west of France, with a view to providing a coordinated service with the regional ones.

SNCF TER: Study of the operating conditions of the Toulouse Matabiau depot SNCF TER Occitanie has strengthened the service offered in the region in recent years to meet the demand of the regional organising authority and thus strengthen the attractiveness of the railways for travel in the Toulouse area. As other rail traffic has also increased in parallel, and SNCF Réseau has changed the operating rules for the Toulouse rail network, the organisation of TER Occitanie's main rolling stock maintenance site near Matabiau station has become more difficult. TER Occitanie commissioned SMA to carry out an analysis of this facility on the requirements for ensuring its operation while ensuring the smooth running of traffic in the railway complex in order to facilitate their working with SNCF Réseau.

The study developed several operating scenarios and analysed their impact on the occupation of the station's tracks and the capacity used by the necessary operational train movements. A microscopic simulation of the railway network was then used to carry out a detailed quantitative analysis of their impacts on the robustness of operations during peak hours, and to provide detailed information for discussion with the infrastructure manager SNCF Réseau.

SNCF Réseau: Benchmark of service and infrastructure planning approaches
In accordance with the recommendations of the Conseil d'Orientation des Infrastructures (Infrastructure Orientation Council), the French State and SNCF Réseau are setting up Services & Infrastructure platforms, with the aim of jointly building a vision with stakeholders of the rail network, i.e. railway companies, organising authorities and local authorities, and the service offer over a 5-to-10-year period. The aim is to define the services to be provided and the investments required to meet them so that their financing can then be contractually agreed.

As other European countries have set up similar planning processes, the aim of the study was to provide a comparative analysis of the service and infrastructure planning processes undertaken in these countries in order to draw up proposals for their operation and coordination in France.

After clarifying the framework and reviewing the French approach, the study continued with benchmarking the approach taken in four countries - Switzerland, Germany, the Netherlands and Belgium - on the basis of a standard questionnaire before producing a summary and formulating recommendations.

The study showed that the French approach was consistent with the other approaches analysed in terms of objectives, methodology and results. The Swiss and Dutch approaches are distinguished by the presence of a legal framework ensuring their sustainability and funding. The French approach is characterised by its defined 24-hour timetable for a 5-year period.

SNCF Réseau: Operating study for the REM St-Mariens–Langon line SMA carried out a study on behalf of SNCF Réseau's Nouvelle-Aquitaine region to verify the compatibility of the AFSB (Rail Development South of Bordeaux) project with the development of a Metropolitan Express Service (SEM) for the Bordeaux rail hub.

The study consisted of establishing several proposals for systematic timetables for the metropolitan component (SEM) of the Bordeaux hub for the AFSB project before the completion of the Grand Projet du Sud-Ouest high-speed line to Toulouse. This was for the two functional AFSB scenarios under consideration, as well as for additional services between St-André-de-Cubzac and Beautiran during peak hours. It enabled the feasibility of these services to be verified, as well as the identification of the infrastructure improvements required to achieve the target timetable.

The study identified risks associated with the introduction of a 15-minute service interval on the St-André-de-Cubzac–Beautiran route under certain infrastructure configurations, particularly at Bordeaux station where there is a high volume of both commercial traffic and operational train movements around the station area. The infrastructure improvements currently planned as part of the AFSB project will not be sufficient to allow all trains to run without modifying the target timetable, as further infrastructure modifications in the Bordeaux station area are necessary to operate a denser SEM.

HUNGARY

Főmterv: Budapest Danube Railway Tunnel Feasibility Study Budapest's railway system is currently under a wide development programme covering aspects of urban development, transportation, railway technology and environmental protection, with the aim of expanding the east-west railway interoperability, changing the usage of disused land around the main railway stations for urban development purposes, developing new stations, improving urban connections, establishing a comprehensive new modern timetable concept and an operational plan for the location of workshops and stabling sites. The construction of a tunnel under the Danube to connect Budapest-Nyugati station to Kelenföld (replacing the existing Budapest-Déli station) is the key component of this transformation.

SMA is participating in the Budapest railway network development project as a sub-contractor, with the project led by the Hungarian engineering company Főmterv supported by the Agency for Budapest development (BFK). SMA has assisted the feasibility study with a strategic planning approach, identifying alternatives for service concepts, implementing systematic timetables, identifying the infrastructure requirements both in terms of layout and required performance levels, evaluating the resulting travel time between selected station pairs, analysing the robustness of the proposed solution and identifying the capacity for freight services. The selected solution has been developed for a 24-hour typical weekday, with the aim of identifying the production KPIs, sizing the pool of required vehicles, and identifying the needs for stabling and maintenance facilities.

LUXEMBOURG

Luxembourg Ministry of Transport: International railway links development studies The Luxembourg Ministry of Mobility and Public Works (MMTP) is developing the 2035 National Mobility Plan (PNM2035), which aims to establish a vision of mobility in the Grand Duchy of Luxembourg over a period of approximately 15 years. This PNM2035 also concerns international day and night connections.

The Ministry has commissioned a study from SMA to provide a vision of the development possibilities for international day and night rail links serving Luxembourg, taking into account the changing context in various European countries.

The study began with an analysis of the quality of the day and night services in the current 2021 reference situation and incorporated the various plans of the surrounding countries for 2025, 2030 or beyond, and the competition from other modes, mainly air and private cars. Improvements were then proposed with modifications to the reference offer in the current plan or new connections to Germany and France. Finally, on the selected lines the process and implementation stages of the proposed services were established, including specifying the operating conditions for the rolling stock.

NETHERLANDS

Provincie Overijssel: Development of the rail services between Zwolle–Münster

The Dutch-German region Twente-Münsterland (represented by the Province of Overijssel, Zweckverband Nahverkehr Westfalen-Lippe (NWL) and the Euregio) aims to achieve one single borderless territory with seamless public transport connections. Since the reopening of the rail link between Enschede and Gronau, the international demand has grown significantly. To further improve the rail connectivity in the region, the goal was to assess different improvements, such as a direct service between the two regional capitals Zwolle and Münster, and to integrate them in the national long-term planning processes, e.g. the Deutschlandtakt in Germany and Toekomstbeeld OV in the Netherlands. The goal was to develop the international connectivity in parallel to those at the national level in both countries to eliminate the political border in the public transport system.

Working together with partners, different wishes have been evaluated. The study first generated multiple levels of ambition, which led to the definition of possible service concepts. A timetable-based study then identified the required investments in rail-infrastructure and the associated operational costs, which were then assessed against the potential increase in demand level. The technical feasibility of the engineering works was also assessed, as well as an evaluation of possible cross-border ticketing solutions.

The study allowed the identification of dependencies between regional, national, and international service developments. As not all potential developments are compatible, choices have to be made. Some "quick-wins" allow a significant increase of the cross-border capacity without large investments, while other combinations are only possible in the longer-term. This allowed the creation of an international rail development roadmap identifying short-term actions as well as middle- and long-term development goals which now must be challenged against possible developments at the national level.

PORTUGAL

Infraestruturas de Portugal (IP): Master Plan for the Operation of the National Railway Network After a preliminary study (titled "Strategy for the evolution of the National Railway Network"), The Strategic Planning Department of Infraestruturas de Portugal (IP) wished to launch an integrated planning process for railway operation and the corresponding infrastructures. This study explored future service goals and identified nationwide scenarios to be developed, with particular focus on the metropolitan areas of Lisbon and Porto, as well as the North/South Atlantic Axis. The next decade will see the construction of the high-speed corridor between the northern Spanish border, Porto and Lisbon, as well as the upgrade of several lines. SMA was commissioned for the "Masterplan for the Operation of the National Railway Network" study which aims to outline the strategy to develop the integrated and timetable driven planning of railway operations and corresponding infrastructures to meet the needs and challenges of the coming decade, based on the set of interventions recommended in the National Investment Program 2030. The already foreseen investments have been included in a unique comprehensive vision and additional infrastructures have been identified to achieve the service goals. The timetable planning approach has been applied to the long-term vision (target of the Masterplan) and to intermediate phases, thus delivering the path to the future.


7
Days Inn

Communications

In 2021 we again lived without major public events due to the Corona pandemic. Nevertheless, many lectures and talks were still held. Some of them were delivered in person, but most of them were held online.

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Publications and lectures

ETR – Eisenbahntechnische Rundschau May 2021	**Machbarkeitsstudie Bahnausbau Region München** Georges Rey
Schweizer Eisenbahn-Revue Eisenbahn-Revue International December 2021	**Leistungsfähigkeitsuntersuchungen von Bahnhof-, Abstell- und Instandhaltungsanlagen** Lukas Regli
École des Ponts ParisTech Paris, France February - May 2021	**Exploitation des transports ferroviaires et guidés** Henri Saïsset, Clément Haller, Pascal Joris
NJS Forum for Nordic Railway Association Copenhagen, Denmark April 2021	**Deutschlandtakt and TEE 2.0 (online)** Frederik Ropelius
École Polytechnique Fédérale de Lausanne Switzerland April 2021	**Timetable Saturation in Practice with OR Methods, Lecture in Decision-aid methodologies in transportation at Transport and Mobility Laboratory (transp-or) (online)** Matthias Hellwig
Transport Statistics Users Group United Kingdom September 2021	**Deutschlandtakt – also a model for the UK? (online)** Frederik Ropelius
Budapest Fejlesztési Központ (BFK) Railway under the Danube conference Budapest, Hungary October 2021	**Detailed Feasibility Study (DFS), Danube Tunnel Railway Investment: Timetable planning approach** Diego D'Elia
INNORAIL 2021 Budapest, Hungary November 2021	**Danube Tunnel – Timetable-driven capacity and infrastructure planning** Diego D'Elia

Key figures

Even though the year 2021 was affected by the operational constraints of the pandemic much as 2020 was, SMA Group's gross sales in 2021 once again show excellent growth compared to the previous year.

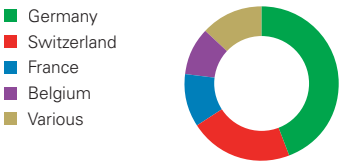
Our Consulting Division was able to confirm a healthy and sustainable consolidation of its growth in our traditional markets and business areas. A substantial geographical diversification underlines the trend of interest in our service portfolio by institutional players in the railway system at the international level.

For our Software division, the investments made in R&D over the last few years have been reflected by a significant growth in our Viriato licence sales, both in the Standard and Enterprise versions. Our service activities (maintenance and projects) continued to be carried out primarily with our larger customers.

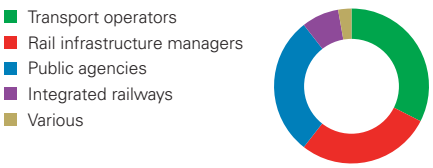
Key Figures*	**2021**	2020
Gross turnover (million CHF)	**16.1**	14.2
Full-time employees	**70**	67

*incl. subsidiaries

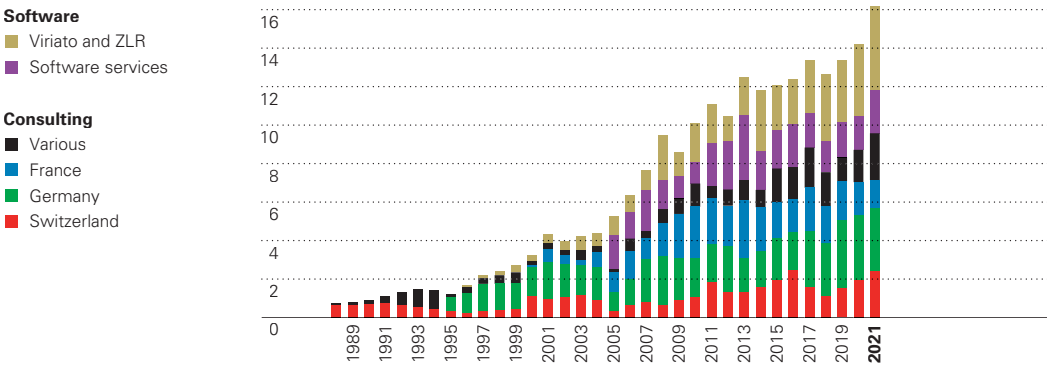
Turnover by country



Turnover by client category



Development of turnover 1988 – 2021 (million CHF)



Editorial services
SMA and Partners Ltd., Zurich
Visual concept
Eggmann-Design, Grüningen
Printing
Linkgroup, Zurich

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