

ANNUAL REPORT

**sma**  **optimising railways**



2018

The photographs in this year's annual report focus on all aspects of being on the move. Whether alone or in company, at night or during the day, underground or in the open air, people's journeys are as individual as the people themselves are.

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# Introduction

Dear Readers,

We are pleased to present you with a lively and exciting 2018 Annual Report.

As is traditional for us, we report on various projects from the fields of our Consulting and IT teams as well as on current research and development projects that we have undertaken during the year. We also aim to give you an overview of events and publications as well as the company's key figures.

In addition, the editorial article on "Continuity and Consistency in the Management Processes of the Railway System" is intended to provide you with an overview of the various forms taken by the timetable, which as a transversal element represents the common denominator spanning the entire management responsibilities of the railway system.

We hope to arouse your interest with these exciting topics and wish you a pleasurable read of our Annual Report for 2018.

Eric Cosandey  
CEO, Head of Consulting

Thomas Bickel  
Head of IT







# Continuity and consistency in the management processes of the railway system

Railways favour a holistic approach that promotes a variety of perspectives in different dimensions due to their systemic characteristics. Several basic concepts are necessary in order to understand a system:

- Totality, i.e. a system is first and foremost a series of elements whose whole is greater than the sum of its parts
- Interactions, i.e. the elements of this system interact through processes that convert input data into output products
- Organisation, i.e. the arrangement of the whole according to the distribution of its elements in hierarchical levels
- Complexity, i.e. the variety and variability of the elements and their relationships within the system and with their environment

This article focuses on the timetable, a transversal element spanning the railway system, which forms the common denominator of the processes required to manage it. Understanding the timetable and its various forms means understanding a large part of the railway system: its totality, its interactions, its organisation and its complexity.

But what is a timetable? The answer is not immediately obvious as it depends on which part of the process we are considering. Regardless of this, the timetable is not an end in itself, instead it is a means of continuous and integrated implementation across the core processes of planning, production and operation of the railway system.

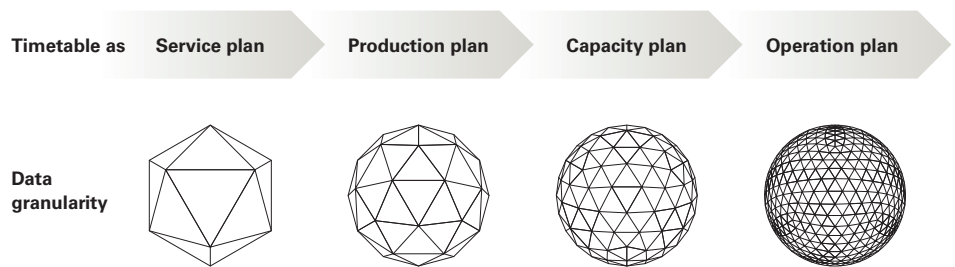
In the service offer-planning phase, the timetable is the translation of the service intention and offer that meets mobility needs and expected demand. It is expressed as the interplay of line structure, stopping patterns and timings, with the aim of improving travel times, frequencies and connections. This is achieved by a multimodal integration approach that makes it possible to offer an attractive service that forms the basis for the development of new mobility concepts. This offer also makes it possible in the long-term planning phase to elucidate the functional requirements for infrastructure and rolling stock and thus to define a development strategy including its phasing. The long-term investment plan for the network can then be developed as a natural continuation of this strategy.

In the production-planning phase for the railway operators, the timetable enables the efficient utilisation of resources, characterised by optimised rolling stock and staff schedules. It also enables the planning of rolling stock maintenance as well as the location and sizing of workshops and vehicle stabling facilities.



For the infrastructure manager during the capacity-management phase the timetable is the result of a short- and medium-term allocation of capacity between paths (trains) and construction worksites (infrastructure constraints). It must meet both the needs of the various users who consume the capacity and the rules for allocating this same capacity in compliance with the applicable technical requirements. This includes the train running time calculation, the planning of time reserves and shunting trips as well as detecting conflicts on lines and in nodes.

Finally, in the (pre-)operation phase, the timetable is translated into an operational plan and is transferred to the traffic management system for scheduling and signalling control. It is then used in all areas necessary for the operational processes, in particular for the real-time management of events and incidents, which are essential for both passenger information systems and for all the actors involved in operational processes.



The breakdown of the timetable into these different forms, a kind of staged metamorphosis, is reflected in different granularities of the data used (topology of the infrastructure, train movements, etc.). In practice, this is reflected through the refinement of the infrastructure models and train definitions to the appropriate precision for the task. The continuity in the planning and production process of the timetable ensures the temporal and spatial coherence of the system. As a result, the infrastructure and rolling stock insights derived in the preliminary stage of the offer design remain consistent throughout the planning process and meet the actual needs of production, capacity management and downstream operations.

The ability to adapt the granularity of the timetable, the sole transversal element spanning the system, is a powerful means of placing the railway system in an optimal state for each planning phase and most importantly to manage this development coherently through the various phases, despite the overall complexity.









# A selection of projects from 2018



**SBB AG: Assistance in establishing a target vision for the Basel area** As part of the 2030/35 stage of the Strategic Development Programme for Rail Infrastructure (PRODES), the Federal Office of Transport (FOT) wanted a deeper look at the Basel area in order to be able to adopt a position based on a target vision that includes all modes of transport.

SMA supported the study group from the initial definition of service objectives by producing service plans that integrated all rail services and products. Subsequently, numerous iterations were carried out in order to optimise the scenarios through ensuring travel times on the new infrastructure, integration into the national networks of the three countries concerned (Switzerland, Germany, France) and the feasibility of the infrastructure with the relevant SBB Infrastructure services. Through this integrated approach, interesting solutions on regional and main international lines traffic have been proposed.



**ÖBB-Personenverkehr AG: Assessment of operating concepts** In order to ensure the long-term economic development of transport services, ÖBB commissioned SMA to carry out an assessment of the planned operating concepts for local public transport in the eastern region. This area includes the rail services of the federal states of Vienna, Lower Austria and Burgenland. In this planning area, around 42 million train kilometres are offered annually, which were used last year by around 151 million passengers. The eastern region is the region with the highest passenger increase in Austria. In the last eight years the number of passengers has increased by one third. The aim of this project was to optimise production costs by reducing vehicle requirements, reducing empty runs and optimising the depot and workshop plans.

SMA has developed, analysed and compared different variants of the operating concept by varying workshop locations, opening hours and vehicle rosters. The adjustments to the workshop plans were made in close coordination with ÖBB Technische Services.

Various measures for optimising the production concept were identified and specified. Thanks to an additional depot and a changed fleet allocation at the various locations, significant synergy effects could be achieved with the chosen variant. The work was carried out primarily with the Viriato vehicle rostering module supplemented by a bespoke maintenance planning model. A steering committee oversaw the work and ensured Group-wide implementation.



**Verkehrsverbund Ostregion (VOR): Target concept eastern region** The railway in Vienna and its surroundings is characterised by very high capacity utilisation due to a steady population growth. The long-term forecasts indicate further growth is to be expected, and so the rail network around Vienna will have to be expanded. Within the framework of a project of the Planning Community East (PGO) for the provinces Vienna, Lower Austria and Burgenland for the Verkehrsverbund Ostregion (VOR), two proposals have been examined more closely.

For the medium-term horizon, concepts have been developed using Viriato within the framework of a timetable study in which the regions with the most growth along the Ostbahn and the Südbahn can be managed with service extensions.

In the long term, the urban region is considering supplementing the existing S-Bahn trunk line with additional infrastructure. Initial assessments have been made as to how the infrastructure can be expanded, for example by a new through line or by supplementing the existing lines. The results have been prioritised in coordination with VOR, the City of Vienna and the federal provinces involved Lower Austria and Burgenland through an initial evaluation process, so that the preferred variants for further investigation steps in the future could be chosen.



**SNCB: Improvement of the robustness of the transport plan on the Brussels–Gent/Kortrijk axis** Since 2016, there has been a deterioration in punctuality on the Belgian rail network. Recent changes to the timetable have not improved punctuality despite the removal of some services. SNCB wanted to carry out an objective analysis of the timetable and punctuality data in order to establish an effective approach to improve their service robustness.

Many different elements can be the root cause of the problems. In order to clarify the causes of poor robustness and most importantly to find key adjustments to the timetable, SNCB Transport wanted to carry out a robustness study on the corridor and define a methodology for evaluating the robustness of its timetable to be integrated into its internal processes.

The study conducted by SMA covered the following topics:

- Evaluation of the current timetable in order to identify the vulnerable locations with regard to robustness
- Analysis of the impact of the configuration of infrastructure elements and evaluation of current planning standards
- Proposal of adjustments of the timetable and a proof of concept of them in Viriato through a comparative robustness assessment
- Dissemination of the methodology established to SNCB Transport in order to integrate it into the process of developing the timetable within SNCB

The study made it possible to assess the situation on the Brussels–Gent/Kortrijk corridor. A detailed analysis of infrastructure performance and statistical data on punctuality was carried out which made it possible to identify infrastructure constraints and to identify wider actions relating to processes. This study also highlighted the issues to be addressed to ensure that trains run as planned.

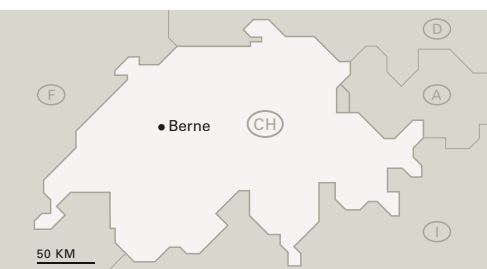


**Infrabel: Project Phoenix – Long-term network evolution** Infrabel’s investment plan for the following four years was approved in spring 2017. However, there is no clear vision of the evolution of the Belgian rail network after 2020. The Phoenix project, led by Infrabel’s Strategy & Enterprise Steering department aims to provide an answer to this question.

In this context, the aim of the study was to analyse the state of the network and to propose scenarios for the evolution of the rail network taking into account economic constraints until 2040.

In collaboration with a partner, an audit of the state of the network’s infrastructure and renewal needs up to 2040 was carried out. In addition, an objective and uniform diagnosis of the network capacity was undertaken using a tool developed on the basis of Viriato’s algorithm platform.

In order to evaluate possible solutions for the long-term operation of the network, cost reduction actions for the rail network (both CAPEX and OPEX) were identified and combined into two opposing scenarios of network evolution. A complete analysis in the form of operating concepts for 2040 was carried out and made it possible to assess the corresponding infrastructure requirements, as well as the contributions and impacts in terms of the service offer (including various quantitative performance indicators).



**SBB: Development and evaluation of new long-term operating strategies** In a context of mobility in the midst of technological and societal change, SBB has contracted SMA to participate in a study about disruptive ways of developing services and operation based on the use of new technologies in order to increase the attractiveness and efficiency of the rail system.

SMA contributed to scope development and design workshops, and then carried out an analysis of technical possibilities to establish evaluation criteria to assess the feasibility and effectiveness of different new operating strategies in a pilot corridor. Three strategies were selected, developed and then evaluated on the basis of the predefined criteria. These concepts can now be used for subsequent applications in network-wide planning.

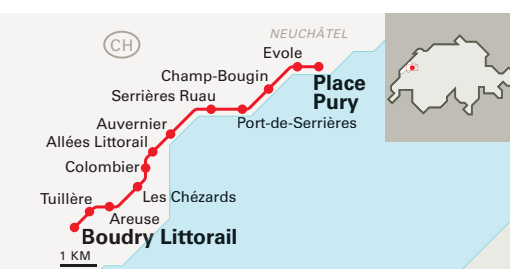


**Sihltal Zürich Uetliberg Bahn (SZU): Market analysis for the procurement of vehicles for the Sihltal Railway** The SZU operates the Zurich S-Bahn Line 4 between Zurich and the Sihltal. With the dynamic development of population and jobs in the catchment area, a renewal of the vehicle fleet is planned in addition to the expansion of the service with which the future requirements of demand and operation can be met.

For the upcoming new vehicle procurement, a market analysis was carried out prior to the procurement process in which vehicle concepts and their availability in the market were clarified.

Together with a partner company, SMA supported the SZU in defining the requirements for the new vehicle based on the future operating concept and the forecast passenger demand. As part of the study SMA determined the requirements from the timetable and the passenger changes. In order to check compliance with stopping times even with high passenger numbers, critical load cases with standing room and a high passenger exchange rate were determined from all stop situations, peak demand and distribution of passengers on the platform. Based on this the passenger change times of different vehicle concepts and door systems were calculated and compared with the information provided by the manufacturers.

An analysis of the vehicle types and concepts offered by manufacturers now and in the future made it possible to check the availability of suitable vehicles in the market. The SZU received a recommendation on the vehicle concept and layout, which will now serve as the basis for their specification.



**TransN: Short and medium-term planning of the Littorail Neuchâtel-Boudry line**

The Littorail metre gauge line between Boudry and Neuchâtel in the TransN network has been the subject of two studies.

The first, dealing with the short term, made it possible to design a timetable for 2020 taking into account the new constraints linked to the renewal of both rolling stock and signalling systems. The robustness of the proposed schedule was then demonstrated using a dynamic simulation. The impact of on-demand stops was calculated on the basis of passenger data.

The second study established a master plan defining the concept for the phased development of the line. This master plan defines the simultaneous development of the service offer, infrastructure and rolling stock and ensures the future compatibility of projects carried out in the short term. Passenger demand was also estimated. This was achieved through taking a strategic approach that comprehensively assessed the long-term supply and infrastructure development opportunities, and then phased these in order to identify potential intermediate steps.





**Chile State Owned Railways (EFE): Simulation of the Santiago-Alameda-Chillán**

**corridor** The Alameda-Chillán line extends over 400 kilometres. The line accommodates freight traffic, suburban and regional trains and the long-distance passenger service known as “TerraSur” linking Santiago to Chillán. Infrastructure improvements are aimed at eliminating speed restrictions in certain sections, given that today the nominal line speed is typically 140 or 160 km/h depending on the sector.

In this context, EFE commissioned SMA to build a dynamic line simulation model with the OpenTrack software and to teach their team how to use the model. SMA also tested several speed enhancement scenarios coupled with the services planned on the line and provided expertise in optimising the rail system for the client.

The simulation model is currently under construction. The modelling of the signalling systems was carried out during a workshop involving SMA and the Chilean team in our Parisian offices.



**Nahverkehrsverbund Schleswig-Holstein GmbH: Schleswig-Holstein analysis of potentials**

On behalf of Nahverkehrsverbund Schleswig-Holstein GmbH (NAH.SH), SMA previously developed two state-wide tender concepts for the future (“ITF Schleswig-Holstein 2024/2030”). The aim of these concepts was to increase further the attractiveness of rail transport in Schleswig-Holstein. Core elements of the developments were the optimisation of connection nodes, the reactivation of several lines, the commissioning of numerous new stops, additional lines for regional and S-Bahn traffic and various speed improvements. For the communication of these concepts in the state public transport plan, the effects on passenger demand needed to be examined.

NAH.SH has commissioned SMA to carry out a passenger demand potential assessment for each of the two scenarios.

In the first step SMA used the Viriato Trip Time Analysis module to quantify the quality of the offer for all origin-destination station pairs in detail, comparing them with the current journey quality and processing them into matrices (containing over 100,000 origin-destination relationships). In the second step, the development of the population structure in the future was analysed, combined with the results of the study and converted into passenger demand potentials. In the third step, the Viriato Demand Allocation module was used to assign the passenger potentials to the individual trains within the timetable concepts.

A calibration was undertaken of these results against the current demand determined the passenger demand levels for the 2024 and 2030 concepts for working days in all parts of Schleswig-Holstein. It became apparent that the planned service concepts, especially into the densely populated areas, are in some cases massively increasing demand. The results of this assessment were presented graphically with diagrams for each routes in the state and supplemented with statistics on passenger kilometres per line and annual traffic performance throughout the state.



**Competence Center Integral Timetable NRW (KC ITF NRW): Further Development of the Integrated Timetable in North Rhine-Westphalia** In 2018 SMA again supported the KC ITF NRW with the further development of the integrated interval timetable of the State of NRW. For this project SMA is operating in a joint venture with VIA Consulting & Development GmbH from Aachen.

One focal point was the development of the NRW-Takt 2025, in which the coordination of the wishes of long-distance and regional transport played a special role. For the Cologne-Berlin corridor in particular, various conceptual variants were developed, discussed in working groups with the stakeholders and developed further into an overall concept.

Emission-free local trains will play a special role in future product concepts. On behalf of the KC ITF NRW and the NRW, SMA carried out studies on electric trains (either by electrification or through battery operation) and identified possible improvements, such as new connections, travel time reductions or additional stops.

A further focus was the development of engineering works timetables for various construction stages in the course of the expansion for the Rhine-Ruhr-Express (RRX). In the case of route closures, various diversionary options for regional lines were investigated and smaller infrastructure measures were derived for the diversionary routes.

The respective results of the work in NRW were presented and discussed in robust meetings with stakeholders. The project work was completed with the annual review of the services and the updating of the current timetable netgraph.

Follow-up work will continue in the current year.



**State of Baden-Württemberg: Revision of the Stuttgart 21 offer concept** An offer concept from the Württemberg working group is available for the commissioning timeframe of Stuttgart 21. However, recent years have shown that due to various factors (e.g. availability of vehicles, infrastructure and general operational stability) this concept may not be feasible with the level of operational quality desired by the state. The state of Baden-Württemberg has commissioned SMA to develop a concept with more reserve times without introducing serious disadvantages to the offer. The long-distance traffic and the S-Bahn have to be accommodated virtually unchanged from the existing concept.

Together with the client, planning objectives were defined and based on the existing concept an analysis of each access route carried out to determine possibilities for modifications. For those that were identified as being realistically possible, several variants were then developed for each route and an optimal variant determined. Based on these individual variants, an overall concept could then be developed. For the Stuttgart area, the track occupancy as well as requests for the interconnections of different lines needed be taken into account. Due to the differences when compared to the existing concept, an extensive analysis and revision of lines which are not used by trains from/to Stuttgart main station was also necessary.





On the basis of several criteria (e.g. circulation requirements, waiting times in Stuttgart) and a comprehensive travel time analysis, it was then investigated whether this new concept is equivalent to the existing concept from the point of view of supply.

In addition, this year during the study further topics had to be examined relating to the timeframe of the commissioning horizon for the project.



**Münchner Verkehrsgesellschaft (MVG): Development and simulation of construction site timetables** The maintenance of the basis of the infrastructure will increase over the next few years for the Munich underground. This will also involve an increase in the number of construction sites and their extension in terms of both more and longer closures for works. There are three fundamental questions regarding the operation of construction sites on the Munich underground network that have been identified:

- Effect of the additional sections with speed restrictions due to the construction site on the operational stability and quality of the normal timetable
- The ability to run a service and the operational stability of the closures of parts of lines during shorter construction phases during off-peak periods
- Feasibility and transport capacity of the operation of partial route closures during longer periods, including during peak traffic hours

SMA was commissioned by MVG to develop, simulate and evaluate major adjustments to timetables based on the planned work sites. This was to ensure that the corresponding timetables will function with the required operational quality during the construction phases and that any major adjustments to the route network can be coordinated at an early stage.

The first step was to develop and coordinate possible timetable concepts during the construction phase. These were assessed with regard to transport capacity and vehicle requirements and, if necessary, additional infrastructure changes were derived. In a second step, the base timetables were simulated in an unperturbed case and then with targeted individual delays. From this it was possible to derive adjustments to the construction timetables and further improvements to the infrastructure.

Experience with the implementation of the first construction timetables has shown that a process of iterative development and simulation provides valuable insights for selecting the timetable variant to be used for later operation.





**Federal Ministry of Transport and Digital Infrastructure (BMVI): Consultancy and support services for the German national integrated timetable and timetable-based infrastructure development** As part of the Future Rail Alliance, SMA presented the expert draft for the Deutschland-Takt target timetable at the Federal Ministry of Transport and Digital Infrastructure (BMVI) in Berlin on 9 October 2018.

This milestone was preceded by several interim drafts, consultations with the federal states and with the BMVI in order to combine the requirements of all participants into a nationwide overall concept for passenger and freight transport.

This work and the results will receive additional impetus from the fact that the Federal Ministry of Transport has launched the future rail alliance that bundles the interests to the voices of the industry and lends them new weight.

The “Deutschland-Takt” puts the timetable at the centre of attention and derives the necessary infrastructure measures from it in order to create more frequent and faster connections for passenger and freight transport throughout the country.

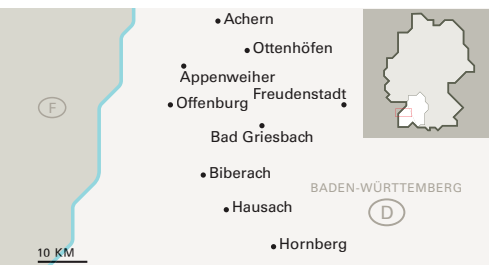
The work will be continued in 2019 with the preparation of a 2nd expert draft on the basis of the feedback to the 1<sup>st</sup> draft. The expert community consists of the companies SMA und Partner AG (management) as well as VIA Consulting & Development GmbH and Intraplan Consult GmbH.



**DB Fernverkehr AG: Half-hourly long-distance services** In 2018, SMA was commissioned by DB Fernverkehr AG to develop concepts for the coordination of long-distance and local transport as part of the expansion of its range of services in the medium term. The main focus of this work was the conceptual planning and coordination of service frequency improvements on high-demand routes as well as the detailing of lines as part of the DB Fernverkehr AG commercial growth plans.

The conflict analysis with existing public transport concepts and the development of alternative solutions were carried out with Viriato. In addition to the timetable concept, the focus was also on coordination with the participating countries, the responsible bodies and DB Netz AG.

The work will continue in 2019 in order to finalise the detailed planning with all parties involved and to initiate the implementation steps.



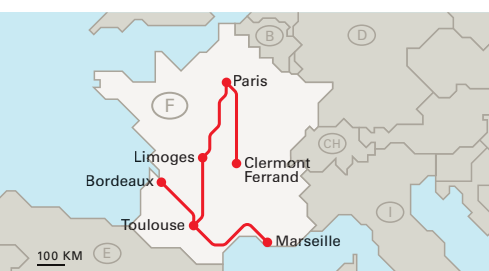
### Use of trains with innovative motive power technology in the Ortenau network

In the Ortenau network around Offenburg, there is still no overhead electricity supply for about 90 km, approximately half of the network. The Ministry of Transport of Baden-Württemberg, as the purchaser of the local services, plans to link the awarding of contracts in this network with the use of vehicles with alternative motive power technology or new and climate-neutral technologies.

SMA was commissioned by a rolling stock manufacturer to provide an expert opinion on the tender for the use of battery-powered electric multiple units.

The first step was to analyse the feasibility of implementing the given timetable concept with the planned energy-related design of the multiple units. It had to be assessed whether there were sufficient time margins for reloading the batteries on the overhead line sections, some of which had steep gradients. In an iterative process, adjustments to the timetable were proposed and the energy concept of the vehicles modified. A central question was also the vehicle planning coordinated with the concept. For energy-related reasons, turning times need to be managed closely. In addition, there were extended requirements for planned stoppages (due to the presence of overhead line or recharging stations). The depot entrance from the line and the resulting maintenance windows of the multiple unit fleet also had to be optimised.

The work on the project has shown that the use of trains with innovative motive power technology can only be achieved with a deep consideration of all aspects of the vehicle concept, timetable and rosters. This is the only way to find an energy-optimal or an emission-free, environmentally friendly alternative to the existing diesel operation.



**Ministry of Transport, DGITM: Master plan for the interregional trains** The “Trains d’équilibre du territoire” (TET) represent several interregional day and night lines in France. The three structuring lines, Paris–Clermont-Ferrand, Paris–Limoges–Toulouse and Bordeaux–Marseille, have been the subject of a master plan aimed at proposing changes to the supply in order to improve the economics of these lines and increase production efficiency. This process was carried out in the run-up to the arrival of new rolling stock on the first two lines mentioned. SMA supported the organising authority in drawing up these master plans for the transport offer, improving journey times and improving the utilisation of the rolling stock in an iterative process conducted in consultation with territorial stakeholders.





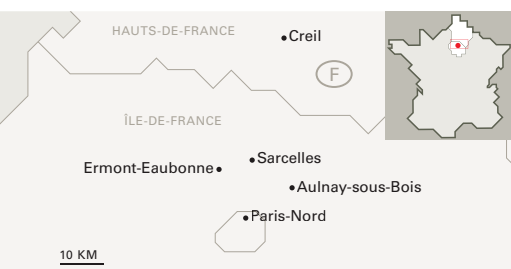
**SNCF Réseau: Evolution of the 2020 capacity structure – South-East sector** The commissioning of the new Nîmes-Manduel TGV high-speed train station on the Nîmes and Montpellier bypass (CNM) in the 2020 annual timetable makes it necessary to overhaul the systematic timetable for the south-east sector of France, primarily for high-speed services.

The study commissioned by SNCF Réseau had as its objective the coordinated design of the 2-hour national network (TGV and TET) of the South-East sector (Paris–Lyon–Marseille–Nice and Montpellier–Perpignan), as well as the regional networks Rhône-Alpes, Occitanie and Provence-Alpes-Côte d’Azur.

The aim was to collect the requirements of the various stakeholders, analyse them, provide preliminary guidelines for the positioning of long-distance train paths in the plan (according to criteria for responding to requirements and capacity consumption by taking into account TER and freight needs) and build objective service plans.

Using Viriato, different variants of national and regional timetables were developed, shared and iterated with the infrastructure manager, local partners, railway companies and timetable offices for the validation of systematic track occupancy charts.

The selected variant of the timetable developed by SMA is now being used as the basis for developing the applications for train paths for the 2020 annual service.

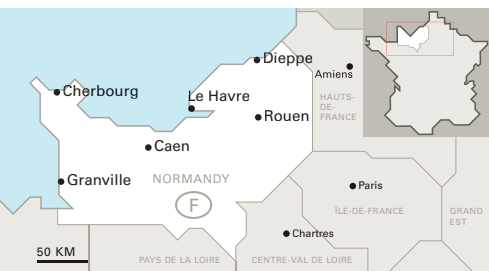


**SNCF Réseau: Risk analyses of work in the Paris-Nord sector** The purpose of the risk analysis of the Paris-Nord works carried out for SNCF Réseau is to undertake a high level study the impact of Temporary Circulations Interruptions (ITC) or Temporary Speed Limitations (LTV) linked to network development or renewal projects in the Paris-Nord sector between 2020 and 2024. The aim is to determine the critical time periods and sectors due to the impact on rail traffic and to propose solutions to mitigate these consequences.

The method used was based on targeting critical sectors and times of the day through a capacity compression analysis of perimeter traffic using Viriato’s capacity analysis module. For these critical sectors and periods, an in-depth analysis of the planned worksites was carried out and an aggregated weighted risk indicator was constructed to target the periods requiring further work.

The detailed study of high-risk calendar periods was undertaken with analyses of routes, macroscopic flows, train-by-train impact and time loss. Possible solutions were proposed for the following areas: rescheduling of work, organisation of work, organisation of traffic and management of the track occupation in Paris-Nord.

The implementation of a macroscopic study for the impacts of works is a first in Île-de-France and makes it possible to quantify as many of the possible impacts as feasible early enough to generate a warning in the event of likely major difficulties to the flow of both passenger and freight traffic. This makes it possible to use all the controls at the disposal of SNCF Réseau and the railway companies to moderate the impact of the necessary worksites on daily traffic.



**Normandy Regional Council: Design of the road transport offer** As the body responsible for non-urban rail and road transport, the Normandy Region has fundamentally revised the services offered in its territory. The rail offer must form the backbone of a global public transport service, around which the road offer taken over from the departmental networks is to be structured, while in some places a shift from rail transport to road transport is planned.

In this context, the study entrusted to SMA was to propose a new structure for regional road transport, structured and coherent with the rail offer in an hourly framework for the road services. At the request of the region, this new service was designed from a blank sheet to respond to the regional mobility needs identified by regional and SNCF studies and on the basis of a transport potential model developed by SMA.

SMA continues to support the region in its efforts to put the new road network into operation. Topics include 24-hour operation, optimisation of vehicle depots and further development of new intermodal connection hubs.



**SNCF Voyages: Analysis of production in the Rennes node** The load capacity analysis of the Atlantic TGV axis previously performed by SMA investigated the mechanisms of propagation of delays along the Atlantic axis. It was supplemented by analyses of the main nodes to investigate propagation phenomena at the local level. The aim of this study was to deepen the analysis of the mechanisms of delay and propagation in the Rennes area in order to derive an action plan.

The diagnosis was based on the cross-referencing analysis of infrastructure, planning and production data. In particular, the routes were analysed and the different types of movements quantified. In addition, the actual distances and travel times within the node could be determined. These analyses were compared with the punctuality performance of TGVs in stations to reconstruct local phenomena of delay propagation. Based on the diagnosis, measures were defined to improve production quality in the short, medium and long term.

One of the components of the action plan concerns the stabilisation of track occupancy charts (GOV) and lines, based on an industrial GOV concept that allows the risk of additional operating restrictions or off-system trains to be quickly assessed. The other measures proposed concern the production of high-speed trains and the train collection protocols and running times of high-speed trains in the Rennes area.

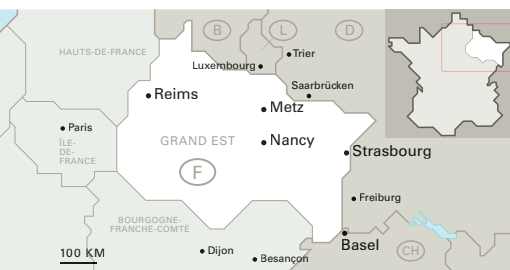


**SNCF Réseau: Long term planning on the Southern Transversal** The study was intended to give SNCF Réseau an overview of the axis between Bordeaux, Marseille and Nice. The study was based on the long-term offer on the southern transversal, taking into account several major projects planned in the region. To this end, an analysis of the roadmap was carried out according to the various phases of the following projects:

- Grand Projet Sud-Ouest (GPSO), a new route linking Bordeaux to Toulouse
- New Montpellier–Perpignan line (LNMP) extending the Nîmes–Montpellier bypass in the direction of Béziers, Narbonne and Perpignan
- New Provence-Côte d’Azur Line (LNPCA) involving the construction of an underground station in Marseille and the construction of new sections between Marseille and Nice.

The uncertainty for the southern axis concerns both the different phases and the maximum speeds foreseen for the vehicles travelling on these lines. An analysis of the nodal structure was carried out for each of the infrastructure and vehicle speed options to measure the ability to meet the transfer nodes and boundary conditions of the study area.

A selection of scenarios was then made based on the most promising and likely combinations of infrastructure and maximum speed. These scenarios were evaluated and compared in terms of travel time, compliance with transfer locations and retention of remaining capacity for other services, in particular TER and freight.



**Grand Est Regional Council: Assistance in defining a regional rail service strategy**

The Grand Est Region includes three former regions and renewed its TER agreement with SNCF Mobilités at the beginning of 2018. Its main objectives are not only to connect better the territory internally, but also with neighbouring regions and countries by maintaining a constant financial contribution. In this context, the main objective of the study entrusted to SMA was to optimise the regional rail network and offer.

After analysing all the lines, a number of optimisation proposals were made, in particular in Champagne-Ardenne with a project planned for 2020, in the TER Vallée-de-la-Marne for cross-border services to Germany and in the TER200 between Strasbourg and Basel. SMA has also advised the region in several studies and examined several new stages. Training has been provided for the services concerned. SMA is working with partners to respond to the study programmes.











**SNCF Réseau: Capacity study of the Strasbourg node** Major challenges in terms of service are identified in the Strasbourg area, following in particular the approach of the Grenelle des Mobilités which aims to rethink mobility around Strasbourg. This is a consultation between all Alsatian elected representatives and economic stakeholders led by the Grand Est Region and the EuroMétropole de Strasbourg. In this context SNCF Réseau entrusted SMA with a capacity study of the Strasbourg node in order to achieve new service objectives compared to previous studies.

On the basis of these objectives SMA carried out a capacity analysis taking into account national and international constraints and detailed analyses of the functioning of the Strasbourg node. In case of difficulty, adjustments to the reference infrastructure were proposed. This study makes it possible to prepare the planned service with the commissioning of the fourth track between Strasbourg and Vendenheim by 2022.



**CFL Cargo: Long-term freight capacity development** Long-term development studies previously carried out by SMA for Luxembourg Railways (CFL) have shown the difficulty of ensuring sufficient capacity for freight. In this context, CFL Cargo commissioned SMA to undertake a study aimed at ensuring this capacity by stabilising the service and identifying the necessary infrastructure while guaranteeing compatibility with other traffic, within the geographical scope of Luxembourg and international connections.

The expression of long-term freight needs was determined on the basis of CFL Cargo traffic projections, the routing of trains in Luxembourg and the European corridors concerned were analysed and the compatibility of freight paths with passenger paths. Operational (the offer and timetables) and infrastructure (signalling, station configuration redesign) measures have been identified and evaluated. The results made it possible to promote exchanges with the infrastructure manager and CFL's passenger division, and led to a new project for Bettembourg station.

This study also made it possible to stabilise the freight needs for intermediate timescales, particularly during construction work periods. These are subject to a parallel risk analysis and works schedule planning for CFL Voyageurs.



**Ministerie van Infrastructuur en Milieu (IenW): Future view of the Dutch public transport system** Within the framework of the "ÖV-Toekomstbeeld" project, various measures were defined to increase capacity. The IenW has commissioned SMA to deliver the study "Use and Innovation" with the aim of evaluating the measures and identifying the most efficient ones. The study was conducted in two phases:

- Phase 1 – A deepening of the short term measures for description and assessment
- Phase 2 – Compatibility analysis to determine the conditions under which each measure is to be implemented

The measures were divided into two categories: Increasing capacity and reducing (or redistributing) demand. Different means for this are possible: adaptation of infrastructure, rolling stock, line management or planning standards. Demand can also be reduced by means of a time redistribution, influence on demand or modal shift.

In order to compare the measures with each other, various “heat maps” were created to identify the most effective and promising measures. The best measures were then categorised and evaluated in three groups:

- Price differentiation in order to be able to influence the demand of all customer groups
- Offer adjustments during peak hours
- “Comfort reduction” for more capacity onboard the trains



**Nederlandse Spoorwegen N.V. (NS): Long term planning** In the last few years, various studies have been undertaken to plan for the long term and improve public transport in the Netherlands. In this context, NS wants to ensure that rail network planning meets future objectives. Interviews and workshops with SMA made it possible to evaluate their current approach to long term planning and to identify strengths and weaknesses based on international benchmarks. SMA then developed a methodology to understand better the choices made during the process and to quantify the various planning assumptions.

Based on this methodology, SMA has developed and evaluated two variants for the development of the national rail offer. Both have the same ambitious objective but use different financial constraints (an unlimited budget vs. a constrained budget). The approach makes it possible to identify which infrastructure measures are necessary to meet the future demand in all cases. Other infrastructure developments are related to NS’s internal ambitions or from external political demands. The entire process was performed with the collaboration of experts from both NS and Prorail in order to maximise the acceptance of the proposals.

The service scenarios were developed using Viriato and then imported into NS’s internal tools to compare them with service variants previously studied by NS.



**SBB AG: Introduction of Viriato Enterprise** SBB Infrastruktur AG (SBB-I) has been using Viriato in its long-term and medium-term planning for many years. In the future, SBB-I would like to substantially increase the level of detail of the network usage plans created with Viriato in order to more precisely coordinate capacity usage earlier in the timetable production process. SBB-I also has the need to manage several infrastructure upgrades with Viriato in parallel in order to create timetables for the respective time horizons according to the planned facilities.

In order to meet these two concerns, SBB-I has decided to migrate its Viriato installation to the Enterprise version. This version supports the creation of detailed 24-hour timetables. The routes within a family of trains can be differentiated both during the day and within the calendar. Viriato Enterprise also allows the mapping of different infrastructure variants. This makes the work for the timetable planners clearer and the system can detect conflicts more precisely. SMA has automated the data migration to the new Viriato version together with the unbundling of the infrastructure elements to such an extent that the version change at SBB-I took place without interruption of work and loss of data. This paved the way for more efficient and accurate long- and medium-term planning at SBB-I.

**Infrabel SA: Calculation of network-wide capacity metrics** Optimal capacity utilisation of the network is a central concern of infrastructure managers. When designing new concepts, they have to consider the capacity utilisation throughout their network due to the high degree of interconnectedness of the train paths. Infrabel commissioned SMA to automate the calculation of network-wide capacity utilisation values in order to compare network usage plans and to include objective key figures in discussions with authorities and transport companies. As a result, three indicators are now available: the theoretically used capacity, the practically used capacity and the remaining capacity.

For this purpose SMA has developed a specific add-on module for Viriato. Given a timetable, the new module determines a corresponding division of the network into related track sections, calculates the three key metrics for each section and then exports the results in a form that allows their further use in GIS tools. The theoretical and practical capacity are calculated using a route compression method. The remaining capacity is determined using an external saturation algorithm that is connected to Viriato via SMA's algorithm platform, and which attempts to add additional trains until the network is full. The algorithm platform is a new development by SMA to connect automation components to Viriato via a dedicated interface (API).

The additional module for the calculation of capacity key figures has a very high performance, and it can determine all three key metrics for the entire Belgian network within a few hours, and saturates the given timetable using adaptive train paths. These key figures help Infrabel to plan capacity and to coordinate with its business partners.

**SBB AG: Connecting Viriato to the UNO infrastructure database** SBB Infrastructure (SBB-I) uses Viriato in network design and in long- and medium-term timetable planning. Downstream the capacity and traffic management are carried out with other systems connected to the UNO infrastructure database. However, Viriato has its own infrastructure data, which allows more flexibility, especially in long-term planning where some infrastructure elements are only known rudimentarily. However, data that is not linked to UNO requires a great deal of maintenance. It also entails the risk of diverging infrastructure data and train path characteristics derived from them, such as the calculated travel times. These deviations will then have a negative effect on the exchange of timetable data with the downstream systems.

Viriato Enterprise, which has been in use at SBB-I since 2018, allows parallel infrastructure statuses to be maintained, would allow in principle the connection of Viriato to UNO without losing flexibility in their long-term planning. SBB-I asked SMA to analyse this interface and to implement a prototype in order to carry out a cost-benefit analysis. In this study SMA has shown how the microscopic infrastructure model of UNO can be mapped to the macroscopic model of Viriato. SMA also investigated the possibility of outsourcing the route search, journey time calculation and conflict detection functions so that these calculations could be performed directly on the UNO microscopic infrastructure model. This externalisation in the form of shared services was developed by SMA as part of the “Microscopy on Demand” architectural concept, which can be implemented in the form outlined above.

**DB Netz AG: Improved import of journey times from RuT-K** Viriato has been used by DB Netz AG’s “Strategic Timetable Planning and Infrastructure Development” department since 2010 for the strategic and conceptual development of service concepts and for assessing the capacity of the rail network in Germany. The variable detail level and scenario-capable Viriato tool makes it possible to cover medium- and long-term travel planning without interruptions between systems. Viriato is therefore ideally suited for the process step of timetable-based network development and is frequently used outside Germany for this application area.

Due to the existing interfaces, the Viriato software at DB Netz AG includes a custom “DB Netz Module”, which in particular supports the import of trains from various software systems. To develop Viriato further, improvements have been made to the import of data from the RuT-K timetable system (computer-aided route management construction). The correct construction and travel time allowances can now be imported in addition to the running time.

In the future it is planned to further reduce the number of system changes and breaks in the course of the process from conception to design. The “Microscopy on Demand” software architecture concept developed by SMA will be used here. With the help of calls to a service (e.g. a routing and travel time calculation call), it is now possible to make direct requests to existing systems with a microscopic infrastructure which are connected without having to store the necessary data in Viriato itself. This allows essential parts of the timetable design process to be carried out directly in Viriato. This makes it possible to





find qualitatively better, more effective and faster solutions to the problems of DB Netz AG's customers. This further development will make a significant contribution to the digitalisation of the timetable process.

**DB Fernverkehr: Viriato.FF – Faster to important data** With Viriato.FF going live in 2015, a system for efficient planning work and communication with related systems, integrated centrally in the DB Fernverkehr production chain was handed over to users. The interface to the train path order system Trassenportal Netz (TPN) plays a very important role. The timetable planners use it directly from Viriato to handle the entire train path application process, from initial application through to importing offers and concluding train path contracts. The increasing number of construction sites to be considered increases the complexity of the process. In 2018, the focus was therefore placed on two topics – the usability of Viriato data in subsequent processes and simplifications in the execution of the train path application process.

Many customers have the requirement to collect promptly new or detailed key figures that are not yet available in Viriato's existing reports. Last year, SMA developed a new data export with a low degree of complexity in a stable generic export format (xml). The analysis of the data generated can now be done with commercially available Business Intelligence tools, and the output has been optimised for analysis with QlikView.

Automation in the processing of train path offers was used productively for the first time for the 2018 timetable year. The identified optimisation possibilities can now be implemented within the scope of further development and made available to the users. In particular, they support the handling of construction site-related adjustments to the annual timetable.

In 2019, support for data preparation for systems downstream of Viriato will play an important role, for example for timetable communication. Despite the growing number of changes during the year, the time available for informing customers must remain the same while maintaining the current data quality.



**Algorithm Platform** Through the provision of the Algorithm Platform in Viriato, researchers and other interested parties are free to concentrate on their areas of specialisation without the need to manage the support functions such as data acquisition, filtering, and the creation of user interfaces.

One of the main design goals of the Algorithm Platform therefore is to offer algorithmic researchers and developers quick access to data taken from multiple heterogeneous real-world data sources via a well-documented and stable interface. This stability is important as it means the developer of these new methods can rely on them to continue to work over a long period of time as the core program itself is developed further. It is also important that once the results of the algorithm have been generated, they can be written back to the production system so that the wide range of available visualisation, analysis and publication functions can be made use of. This use of existing functions leads to a dramatic increase in the pace of development of new algorithmic concepts and methods.

As an industrial production system, Viriato forms a scalable base from which the Algorithm Platform can be used for solving problems. We describe elsewhere in this Annual Report a case where it was used in the calculation of the capacity of a customer's national railway network in two different ways by decomposing the network into sections and then either adding trains until their network was saturated, or through the process of timetable compression.

Another practical example where the Algorithm Platform has already been used is to provide a connection between algorithmic requirements and a production timetabling system in the development of a rescheduling heuristic for trains around engineering works. It has been possible to develop quickly a proof-of-concept tool that can make decisions regarding whether trains should be diverted, part- or full-cancelled. No changes were required in the existing Viriato timetabling system and the algorithm simply had to request the planned trains and the time and location of engineering closures which were then collected and processed by Viriato before being sent across the Algorithm Platform. The results of rerouted, rescheduled or cancelled trains could then be sent back via the Algorithm Platform and inserted into the timetable database.

The development of the Algorithm Platform is a bold step towards the separation of the provision of timetabling functionality from the data structures and functions needed for implementing the types of algorithms supporting automation and optimisation as the railway is transformed by Industry 4.0.

**Viriato Developments** During 2018 we continued to develop new features and improvements that will benefit all users of Viriato.

*Export for reporting.* Increasingly the onus on stakeholders in the railways industry is not only to plan the service timetables, but also to be able to generate figures and metrics for use in the calculation of Key Performance Indicators. While Viriato has included the functionality for generating graphical and tabular outputs for many years, we have now added the ability to export almost all of the data contained in a timetable in a clearly defined format. This allows the user to use third party reporting and Business Intelligence systems to create queries and reports that generate the statistics needed for managing their railways.

*Platform stopping points.* The planning philosophy underlying Viriato has always been based on the concept of “step appropriate precision”. This is a model where the data needed is constrained to the minimum required in order to achieve the goals that are needed in the planning process. We have refined the model for the definition of platforms at stations to allow trains to be planned to not only use the whole platform, but also to add stopping points which use only portions of the platform.

*Update trains import.* For users who work with other tools as part of their planning and analysis processes, it is often the case that timetables created in Viriato are tested in a simulation tool to confirm their operational practicality. In the past it was possible to re-import these tested trains into Viriato as new trains, potentially losing the relationships with existing information in Viriato due to the differences between the two tools. Viriato now has the ability to update existing trains with the results from a simulation in another tool, allowing the user the benefit of efficient planning in Viriato, coupled with the seamless testing of the timetable in operation.

*Improved usability.* To ensure that the user of Viriato can work as efficiently as possible, we have implemented several new features this year. Firstly, the batch operations functionality has been extended by allowing the user to select sets of trains that they wish to work with in a more flexible way. This makes it quicker and easier to undertake operations such as copying, moving or updating trains. When working in the netgraph, the layouting of trains has been improved allowing the user to more quickly generate clear and consistent views of the timetable offer.

*Works planning.* The development of the works planning module has continued in 2018 allowing the user to plan track closures and speed restrictions for engineering works, and to detect conflicts between trains and works so that the timetable planner can take action to modify their schedule to allow trains to run in an efficient manner.

*Demand assignment curves.* The demand assignment allows Viriato users to predict the number of passengers travelling on each train based on a model of the travel demand between each station in the demand and the time of day. This module has been improved to incorporate functionality to assist the user in generating station pair and time specific curves of passengers who wish to travel between them. This means that the model now reflects more accurately the different numbers of passengers wishing to travel during the day, and therefore shows more clearly the loading on individual trains.



### **New Viriato Licenses**

- BNSF Railway Company, USA
- DB Engineering & Consulting Inc., USA
- Ferrovie dello Stato Italiano, Italy
- Infrabel SA, Belgium
- Mahidol University, Thailand
- SPF Mobilité et Transports, Belgium
- Transports Publics Lausannois, Switzerland
- TÜV Rheinland, Germany
- Verband Region Stuttgart, Germany





# Events, publications and presentations

**InnoTrans 2018** The twelfth InnoTrans running from September 18 to 21 made Berlin the international hub of the rail world. With over 3000 exhibitors from 60 countries, the Berlin exhibition grounds were fully occupied. For SMA it was the eighth participation in Berlin. Numerous visitors found their way to SMA at the main stand of Swissrail and many exciting discussions were held.



## Publications

Schweizer Eisenbahn-Revue,  
Eisenbahn-Revue International and  
Eisenbahn Österreich  
April 2018

**Neues Fahrplankonzept im Allgäu nach  
Elektrifizierung der Strecke Geltendorf – Lindau**  
Cyrill Baertsch (SMA), Thomas Kunze and Andreas Schulz

Eisenbahntechnische Rundschau  
September 2018

**Kommunikation zukünftiger Angebotskonzepte**  
Gösta Niedderer, Georges Rey and Stephan Sigg

## Presentations

Braunschweiger Verkehrskolloquium,  
Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR),  
Braunschweig  
April 2018

**Stufengerechte Planungstiefe in der  
Fahrplankonzeption**  
Frederik Ropelius

EPFL, TRANSP-OR, Lausanne  
October 2018

**Le cadencement dans l'exploitation ferroviaire**  
Luigi Stähli



# Key figures

The SMA Group's gross sales in CHF in 2018 maintained the general upward trend of recent years, but have slightly decreased when compared to 2017.

In the Consulting division, this was primarily due to the reduction of our activities in the USA, but also to the deferment and challenging conditions of certain projects in our core markets. Nevertheless, we were able to consolidate our sales in Germany at a high level and even recorded an increase in sales in some smaller European markets.

Our IT division is showing a healthy and solid growth. This was primarily due to SBB Infrastructure's investment in Viriato Enterprise. Also contributing to these good figures were the increase in revenue from our maintenance and support activities for our main customers and the sale of several Viriato Standard individual licenses and add-on modules in various markets.

## Key Figures\*

	2018	2017
Gross turnover (Mio. CHF)	<b>12,6</b>	13,4
Full-time employees	<b>61</b>	65

\*incl. subsidiaries

### Turnover by country

- Germany
- Switzerland
- France
- Belgium
- Various



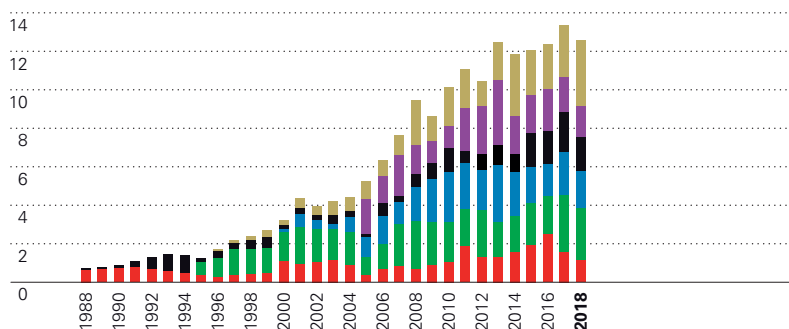
### Turnover by client category

- Transport operators
- Rail infrastructure managers
- Public agencies
- Integrated railways
- Various



### Development of turnover 1988–2018 (Mio. CHF)

- IT**
  - Viriato and ZLR
  - IT services
- Consulting**
  - Various
  - France
  - Germany
  - Switzerland





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