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Special

DB International

Transport solutions worldwide

A message from the Federal Minister of Transport and Digital Infrastructure

The world is growing closer together. More and more goods and people are being moved throughout the world in shorter times, over longer distances and over an increasing number of borders. The railways are a safe, economical and environmentally friendly means of transport and are currently experiencing a renaissance.

The worldwide interconnection of rail services is also bringing China and Germany closer together. International arteries are emerging and becoming increasingly important, not only in the passenger sector but also, and above all, in the freight sector. This is illustrated by the example of the container trains that operate on a regular basis between Germany and the People's Republic of China. Rail transport only takes half the time required by maritime shipping – and is largely unaffected by the weather and tides. The railways from China, Mongolia, Russia, Kazakhstan, Belarus, Poland and Germany are participating in the development of the Eurasian railway links. This route for the exchange of goods between Europe and Asia is an important project for all the countries involved.

The railways are the transport mode of the future – safe, economical and environmentally friendly. We are only too happy to contribute the expertise of Deutsche Bahn AG and the German rail industry to bring China and Germany closer together.

The potential inherent in the rail mode is still a long way from being exhausted. There are still major challenges to be tackled before it will be possible to exhaust the opportunities for growth in international rail transport. Barriers to cross-border rail transport have to be dismantled, ranging from differences in technology and infrastructure to operational procedures on either side of a border. The most important thing, however, is that rail networks must be made modern and efficient. In Germany, we have ramped up investment, thereby ensuring that, over the next five years, there will be a record 28 billion euros available for the renewal and modernization of the network. We need a strong and high-performing domestic market. This is one of the keys to success in international competition.

Given the need to tackle climate change, the rail mode will, in the future, play an even more important role on the world's transport markets – and it will do so to an even greater extent when the scope for efficiency inherent in digitalization is exploited. With its wide range of services and its many years of international experience, Deutsche Bahn AG has much to offer. The German rail industry is highly productive and competitive. It provides technical solutions and a multiplicity of innovations. We look forward to partnerships that will enable us to join forces to shape a worldwide market for the railways as a mode of transport with a promising future.

Alexander Dobrindt
Member of the German Bundestag

Railway needs intelligent mobility and logistics solutions

Around the world, we are witnessing a renaissance of the railways. Large-scale social transformations such as increasing demand for transportation, rising levels of urbanization and demographic changes make an efficient rail system more important than ever.

At the same time, people's mobility needs are undergoing a fundamental change. Young people in particular want intelligent, integrated and sustainable solutions for public transport services.

The railways of today, the 21st century, are already by far the most energy-efficient, most environmentally friendly and the safest, most secure form of transport. Many countries have therefore opted to focus on trains as they increase spending on their future transport infrastructures.

This is not only good news for the environment, but it also helps Deutsche Bahn AG in our mission to become the world's leading mobility and logistics company by the year 2020.

A wholly owned DB AG subsidiary, DB International provides consultancy and engineering services to clients around the globe, working with them to develop innovative, cost-effective and long-term transport solutions at every step along their relevant processes from planning to operations. Since 1966, DB International has been involved in thousands of projects in over a hundred different countries.

DB International has been active in China, home to the world's most extensive high-speed rail network, since 2004. Having contributed to 13 high-speed projects, its experts are partners in the country's herculean undertaking to expand this network still further.

Similarly, in the Middle East, states and private sector companies are also investing huge figures in local and long-distance public transport, plus in the creation of long-term rail freight infrastructure. Here, DB International once more has a vital role to play in the transport revolution these countries are experiencing in their local, freight and high-speed transportation services.

DB International has some 40 other bases around the world, which enables the company to offer its much sought-after expertise, gathered over the course of 180 years of railway history in Germany and Europe, to clients in every corner of the globe. At the same time, the experienced professionals at DB International have full access to the specialist knowledge and support of the entire DB Group.

In interdisciplinary and cross-cultural teams, our employees work side by side with our clients on site and throughout the entire course of a project, bringing their professional knowledge to bear in fields ranging from planning to engineering and operations. It is for this reason that they are so in demand as partners for the world's largest infrastructure undertakings.

The following pages give you, the reader, a chance to find out just how extensive DB International's range of services is, and I am certain that you will find much that will interest you.

Yours sincerely,

Dr. Rüdiger Grube
Chairman and CEO of DB AG

With their professional and intercultural expertise, our DB International employees offer a range of services that is unparalleled in the world.











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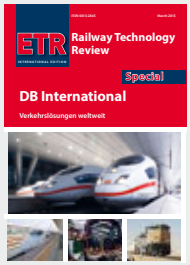
Interview

The world relies on rail

with Dieter Michell-Auli, Member of the Board of Managing Directors International Markets and Niko Warbanoff, Chairman of the Board of Managing Directors of DB International GmbH.

TO THE COVER



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Above: ICE 3 at Airport Station Frankfurt/Main, Photo: DB AG/Heiner Müller Elsner
Below right: SAR Train at North-South-Line (CTW 100) Saudia Arabia, Photo: Georg Merdes
Below middle: Namma Metro Bangalore, Photo: Churumuri
Below left: Train in Yuncheng Station, Photo: Frank Schwonke

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The world relies on rail

Niko Warbanoff and Dieter Michell-Auli discuss the global development of rail transport, DB International's target markets, the numerous projects in different countries, and Deutsche Bahn's good reputation.

***Interviewer:* DB International's activities span the globe. What major trends are currently noticeable?**
Warbanoff: Our planet's population is growing year by year, a fact which naturally has an impact on the demand for mobility, both for passenger and freight services. At the same time, environmental awareness is increasing, so there is also greater demand for sustainable transport solutions. High-capacity systems capable of providing long-term mobility for people and goods are particularly necessary in regions witnessing a rapid increasing in transport volumes.
The railway is the sole means of satisfying the demand for passenger transport: we will only bring the sheer transport chaos of megacities under control if we make intelligent use of train services. At the same time, rail freight transport is becoming increasingly important in economically prosperous regions, particularly due to its role in connecting seaports with their hinterlands.
In other words, while the reasons may vary greatly from country to country, the world as a whole is becoming increasingly reliant on rail.

***Interviewer:* Across the globe, more and more people now live in densely populated urban centers. How does this affect the market?**
Michell-Auli: Increased urbanization brings with it greater demand for rail-based transport solutions as roads simply cannot provide the capacities necessary for millions of motorists. Furthermore, scores of major cities are struggling with smog as it has a detrimental impact on the quality of life. For example, it leads to long-term higher healthcare costs. As a result, cities need local transport services in the form of trams and light rail networks, i.e. these are of major importance for the market.
Warbanoff: Another topic is, of course, connecting major cities with one another and with their surrounding regions. In Germany, we have witnessed how high-speed connections have been gaining in importance for years now. Whether you're traveling for work or for pleasure, you can relax when taking the train. Also, journey times definitely compete with other modes of transport: trains have the key advantage that they take passengers directly from once central location to another.

***Interviewer:* What target markets have you identified for your business?**
Warbanoff: I firmly believe that the greatest potential for our company over the next few years will come from the Middle East and from Asia, which is currently the planet's largest growth market. Countries in these regions are now investing tremendous sums in rail. We have been active in their markets for many years, we have made an outstanding name for ourselves, and we have created a solid foundation for our sales activities.
Michell-Auli: For example, we opened a Chinese subsidiary in Beijing at the start of 2015. This is another important step for our company, and we are confident that our services and expertise will continue to give us the edge over our competitors. Alongside our activities in these two major market regions, we are present wherever our knowledge is in demand and rail services are being established or expanded.

***Interviewer:* Your company was founded in 1966. Back then, your first project was in Brazil. What are your current projects?**
Michell-Auli: We currently have over a hundred projects in a good forty countries on five continents.
Between 2003 and 2014, we handled a large number of engineering services for China's high-speed network in the fields of construction management and supervision. Now that the phase of network construction has finished, other services are called for: the high mileage of the first generation of multiple units will generate a massive increase in heavy maintenance work as of 2017. Our expertise has been requested during work to prepare for this particular issue, and we have been contracted to provide consultancy services to support the process of developing an upkeep and maintenance plan.
Warbanoff: Our decision to open a base in India has also been rewarded: winning the contract for the Kochi Metro project was a great achievement for DB International. We serve as quality and security consultants for the Kochi Metro, an elevated line covering 26 kilometers with 21 elevated stations and a depot.

▶ VITA

Niko Warbanoff

Chairman of the Board of Managing Directors

degree in engineering management. He held a number of international positions at Daimler over a 10-year period. His move to Deutsche Bahn AG took place in 2009. Since April 2010, he has been Head of International Business Development (non-EU). In addition, he became one of the Managing Directors of DB International GmbH in April 2010 and took over as Chairman of the Board of Managing Directors in April 2011.

▶ VITA

Dieter Michell-Auli

Member of the Board of Managing Directors International Markets

degree in engineering and production technology. Following graduation, he worked for SIEMENS in Germany and China. Since June 2011, he has been the Member of DB International GmbH's Board of Managing Directors International Markets.

Niko Warbanoff (middle) and Dieter Michell-Auli (left) at the Berlin headquarters of DB International (Photo: JET-FOTO, Ralf Kranert)

In August 2014, we signed our first Australian contract for technology consultancy services for Sydney's North West Rail Link (NWRL). We're very proud to be contributing to the biggest rail project Down Under and believe this project will result in other contracts in Australia, because the country is also moving towards higher levels of rail transport.

Michell-Auli: Our expertise is also in demand in South Africa, where, since 2010, we have been working on a project to upgrade guiding and safety technology for the Passenger Rail Agency of South Africa (PRASA). Our work here comprises the technological, financial and contractual evaluation of bids and issues in project management, as well as supervision of service performance.

As long ago as 2009, we started providing support services for the „Roadmap to Safety" project of the company Transnet Freight Rail (TFR). Here, our objective is to enhance operational safety by providing employee training plus system- and structure-related consultancy services.

Our employees are also involved in logistics consulting. For example, we recently completed an efficiency analysis of the port of Santos in Brazil. Here, DB International experts studied the port's infrastructure, its connections to its hinterland and its logistical and administrative processes, identified bottlenecks, and developed recommendations for improving performance.

Warbanoff: We have already mentioned the Middle East. This is one region where we are currently concentrating our project-related activities, be it on the high-speed Al Haramain line in Saudi Arabia, Etihad Rail in the United Arab Emirates or the construction of a transport network in Qatar.

***Interviewer:* Germany has a long rail tradition, and Deutsche Bahn is one of the largest mobility and logistics companies. These facts surely sway customers in your favor, don't they?**

Warbanoff: Yes, definitely. Deutsche Bahn enjoys a fantastic reputation around the world, and DB International's services carry the Deutsche Bahn „hallmark", so to speak. As our business model also comprises projects in Germany, DB International's employees get to work on large-scale, modern projects in our domestic market and then transfer this technical expertise to our projects abroad. In return, these foreign contacts give employees the opportunity to gather international and intercultural experience, something which then benefits our projects within Germany. To put it another way: we are an engineering practice embedded within one of the world's best service providers, something which makes us unique. ◀

Europe's open-access system as a model for rail freight transport in Brazil

In the rail sector, competition is the only thing that can generate a substantial increase in passenger numbers and freight volumes. However, one essential ingredient is required for this – open access, which in turn requires action from politicians and government legislation. DB International joined forces with a customer to analyze market conditions in Brazil and develop a strategy to effect the transition to non-discriminatory network access.

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INTRODUCTION

Mobility for people and goods is an important issue everywhere, and most certainly in the fifth-largest city in the world. Brazil's export-oriented business sectors are currently facing a major logistical challenge: how to efficiently transport goods manufactured in its interior to ports on its coast. The country's main seaports include Belem, Paranagua, Rio Grande, Rio de Janeiro and Santos, while Manaus is a major inland port on the banks of the Amazon (see 2014 CIA World Fact Book). The country also has some 4,100 airports, putting it in second place behind the USA (13,500), and its 1.5 million km of roads represent the world's fourth largest road network.

In contrast, Brazil's rail system is relatively small, with some 29,000 km of track. This puts it in tenth place in terms of track length, lower in the international table than Germany (no. 6) and France (no. 9). Looking at the modal split, rail services transport some 25 % of freight, but trains transport far more goods in other countries of a comparable size: 81 % in Russia and 43 % in the USA (see s-ge.com).

PROJECT BACKGROUND

In Germany, a range of companies operated the different regions' rail services until the early twentieth century. In rather much the same manner, Brazil's rail network was long in the hand of a number of different companies. It was not until 1957 that these firms were fused to form the Rede Ferroviária Federal S.A. (RFFSA), a listed company, with the aim of securing greater efficiency and other advantages that could not be delivered by a system made up of a myriad of small companies. RFFSA was responsible not just for operating and maintaining the national rail network, but it also provided train services for passengers and freight alike.

However, the national rail company became so inefficient and expensive that the state was eventually either unable or unwilling to foot the bill anymore, so RFFSA was broken up between 1995 and 1999. The national network was subdivided into regional networks and lines. Following tenders, these were then handed over to different concession-holders together with the system's rolling stock. Most licenses were initially granted for a period of 30 years, with the option of subsequent extension. As a result, a dominant feature of Brazil's modern rail system is the protectionist behavior of the current concession-holders, which fight to protect their exclusive usage rights. Due to the lack of rail-based alternatives, these companies' tactics have resulted in transport services being transferred from rail to road. However, road-based transport (particularly of bulk

Modal split in the Brazilian freight transport

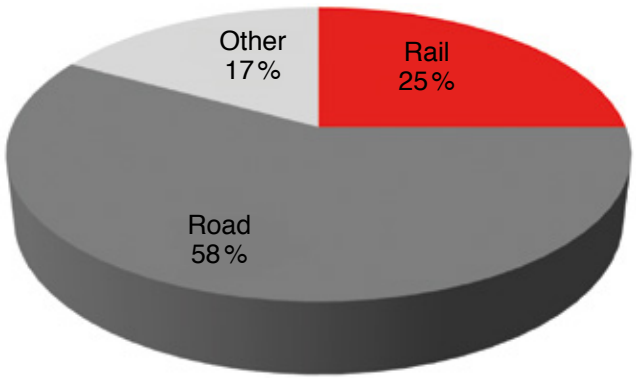
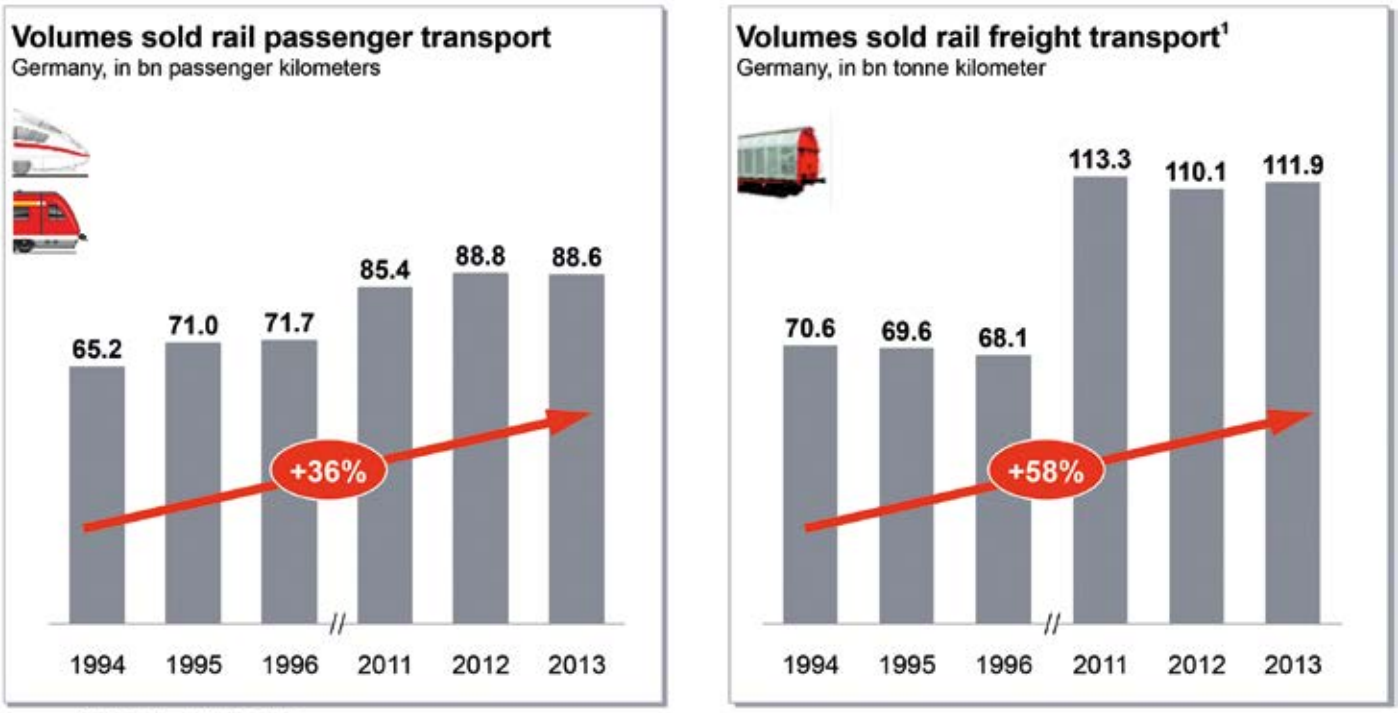


FIGURE 1:
Information from Brazil's transport ministry (2012)

(Source: Ministério dos Transportes (2012))



Sources: DB AG, Federal Statistical Office
As of March 13, 2014; 1 Figure is net volumes sold until 1998, and gross volumes sold as of 1999, i.e. shipments in loaded containers including weight of container
Deutsche Bahn AG

FIGURE 2: Changes in train-kilometer figures in Germany following the reform of the national rail system

goods) over long distances, an inevitability in a country the size of Brazil, is by and large economically unviable. This has led to complaints by industrial and agricultural groups over excessive transport costs to and from Brazil's ports. The country's central plateaus are ideal for agricultural production: one key crop is high-quality soy, which is grown in large quantities. Unfortunately, transport costs to ports make Brazilian soy so expensive that it struggles to compete with other countries' produce on the international market.

Other negative effects are an overburdened road infrastructure and environmental deterioration. Together, these problems have prompted the government to make reorganizing the Brazilian rail market one of it targets. Europe's very similar history and its creation of liberalized rail transport markets played a key role in convincing the Brazilian transport ministry that the best solution would be to establish a similar "open access" system which gives different operators the right to use the country's rail network.

THE PROJECT'S FRAMEWORK CONDITIONS AND MAIN TOPICS

Since 2012, industry publications in Brazil have run stories on the creation of an open access system modeled on the EU's rail transport market. These reports have created a sense of expectation among politicians and businesses that is, however, shaped purely by the interests of the party behind the information: the logistics and agricultural sectors are pinning their hopes on one day having high-capacity rail services as an alternative form of transport. As things stand, any company with the good fortune to possess a rail connection to one of the present operators' networks and which was classified as a rail-dependent firm by the transport ministry can expect a certain level of basic service in terms of rail transport volumes. However, the lack of competition means that market »

FIGURE 3: Intermodal terminal in Anapolis connecting to the north-south route, the pilot route for operation under the open access system (Photo: Robert Wagner)

FIGURE 4: The port of Itaqui just outside Sao Luis: unloading iron ore on a concession-holder's line (Photo: Robert Wagner)

mechanisms function more or less like those in a monopoly: services are poor in terms of price and quality. Companies in this position report that scheduling accuracy for the collection of loaded wagons varies by 24 to 48 hours, and that they have difficulties determining when empty wagons would be available. Then, once wagons do actually turn up, they must be loaded within 6 hours, or else the companies face contractual fines. The upshot of this is that employees for loading wagons have to be on call around the clock just in case a train arrives. Concession-holders are patently uninterested in providing additional transport runs, which explains why there is so much obvious interest on the part of transport-intensive industrial sectors in the introduction of open access.

Routes whose operation has been "surrendered" to mining companies such as VALE S.A. transport virtually no freight from another firm. The mining companies' thinking is this: keep the line free so we can guarantee the maximum possible flexibility for transporting our own goods. These lines have no fixed timetables – the companies dispatch trains if and when they require. Any "outsider's" train would simply be a hindrance, so many of the concession-holders are unfavorably disposed towards open access.

The expectations among Brazil's politicians are clear: they want to promote rail transport, improve the modal split in favor of trains, and so take on the role of pioneers in South America. Unfortunately, they have few financial means at their disposal, so they are forced to involve the private sector in their efforts towards achieving this goal. They are hoping for quick results: that way, they can quickly counteract the cost-related risks associated with the undertaking's early days, and so claim the open access project as a resounding success for the current government.

Brasilia's transport ministry and the concession-holders are not the only players in this game: there are a number of other stakeholders. VALEC-Engenharia, Construções e Ferrovias S.A. (VALEC) is a state-run body commissioned with the technical implementation of open access. Previously, it was

FIGURE 5: A concession-holder's marshaling yard at the port of Itaqui (Photo: Robert Wagner)

involved in planning and constructing rail lines. By government decree, it is to focus its future activities on buying and reselling all available slots (train paths). This company is the client in the joint project with DB International.

Empresa de Planejamento e Logística S.A. (EPL) is another government body that will, in the future, centrally plan transport planning, thereby taking over the functions of VALEC. It will use studies of demand patterns to assess where new lines should be built and where the open access network should be expanded.

In a rail transport market open to competition, a regulatory body is necessary to monitor safety standards and freedom from discrimination. Agência Nacional de Transportes Terrestres (ANTT) is already responsible for regulating all land-based modes of transport and will be responsible for the regulatory implementation of open access in the future. It is intended that the agency will assume duties pertaining to economic and safety regulations, similar to EBA (Eisenbahn-Bundesamt) and BNetzA (Bundesnetzagentur) in Germany.

Other stakeholders in the open access system will be independent RUs (railway undertakings) and the independent infrastructure operators, which have yet to be established. The first of these correspond to RUs in Germany. They have to meet certain requirements before they receive an RU license, which serves as the basis of their access to the rail network. Then there are the independent infrastructure operators, and these represent a special case in Brazil. Due to money shortages, the state has decided that a "build and operate" process will be deployed for constructing the core of the open-access network, a north-south route in central Brazil and an east-west route from Mato Grosso to the port of Ilhéus. The scheme functions like this: companies will bid to construct a certain length of track and, once it is complete, they will be the infrastructure operators for 30 years. The construction and maintenance costs are amortized via the sale of slots, and VALEC holds exclusive sales rights. In practice, therefore, VALEC will buy up 100 % of the slots from the infrastructure operators and then market these to the RUs. It will therefore be the state that bears demand-related risks, while the construction clients have planning stability.

The joint project between DB International and VALEC runs for 9 months and comprises two main phases. The analysis phase has already been concluded: it studied the framework conditions for introducing open access and looked at legal and organizational issues in addition to the different stakeholders with their various interests, in part conflicting. The analysis led to the development of strategy options for VALEC's future brief for ensuring the quick launch of the open access system. The second phase is currently underway: VALEC's organization is being adjusted to suit future tasks, and processes for on-the-ground implementation are being drafted.

FIGURE 6: A new-build line near Anapolis that will be used to pilot the open access scheme (Photo: Robert Wagner)

OUTLOOK AND FUTURE CHALLENGES

Due to the unfortunate consequences of how concessions were distributed in the past and the tender for the construction and operation of the new (future) sections of line, Brazil will ultimately have an infrastructure operation system like the one already in place in Europe, where a large number of infrastructure operators are obliged to ensure non-discriminatory network access. These include companies such as DB Netz AG and ADIF (Administrador de Infraestructuras Ferroviarias) in Spain. Interoperability standards will be defined to ensure that technology can be transferred from one network to another. Nevertheless, the RUs are required to know and follow the individual operation regulations.

There will be one major difference: the

FIGURE 7:
A new-build line near Anapolis that will be used to pilot the open access scheme

(Photo: Robert Wagner)

preferred strategy will see VALEC transformed into a kind of network management center. In other words, it will not only be responsible for sales in the future, but it will also handle the planning and supervision of operations. Planning will above all comprise the process of allocating lines and scheduling services so that each particular route has a consistent timetable free of conflicts and discriminatory practices. Regarding supervision of operations, a network monitoring center is under consideration. It will receive live data from each infrastructure operator's own operations center. A round-the-clock team of VALEC dispatchers will monitor the situation to ensure the timetable is followed in an efficient, discrimination-free manner. If necessary, they will actively intervene in the dispatching process.

The current team of VALEC employees tasked with implementing open access must be trained to perform these tasks. DB International employees specializing in the fields of timetable planning and track allocation processes will teach the team the necessary basics and use situations drawn from everyday work to go through these processes with the trainees. In addition, DB International's employees will communicate their experiences and expertise on non-discriminatory processes to the rail infrastructure companies.

However, it will only be possible to apply this particular version of the system to routes controlled by independent infrastructure operators. The biggest challenge will be integrating the concession-holders in the open access system. They not only manage their routes, but they also use their own trains on them, which creates ample opportunity for discriminatory practices. So far, legal regulations merely stipulate that all free slots must be reported to VALEC and offered for sale. However, in real life it has already become clear that the absence of a fixed timetable makes it difficult to prove just how many slots per day go unused and should, therefore, be reported as available. As the concession-holders' routes are the only lines giving the private RUs access to seaports during the first few years of the open access system, it is extremely important that the concession-holders be integrated in the undertaking. Trains running to and from the coast will not be able to bypass their lines until the core north-south corridor joins up with the east-west line running to the port of Ilhéus. As a result, the project organizers are currently concentrating on winning the concession-holders over as partners by explaining how they stand to benefit in economic terms if they open up their lines to external RUs for a usage fee.

CONCLUSION AND OUTLOOK

The introduction of an open access system will benefit the entire Brazilian economy. The country's political actors should therefore continue to pursue their current course of action and identify both a short- and a long-term solution. Any long-term solution should focus above all on working to develop a stable system that provides straightforward and transparent access to rail lines and then letting concessions expire. In 2015, DB International will continue to support VALEC's activities so that the foundations for non-discriminatory network access can be laid. ◀

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Further information:

http://valec.gov.br/

Ports and their hinterlands form a vital part of the transport chain, but, unfortunately, they are often the weakest link

Today, production processes encompass different steps spread around the world, resulting in a steep increase in transport volumes. Seaports play a key role in international supply networks. They serve as entry and exit points for global freight deliveries within cross-border transport chains, and they are at the same time hubs for their hinterlands.

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1. INTRODUCTION

A port's hinterland is the catchment area which serves as both the origin and destination of goods traded through the docks. A port's importance is often reduced merely to the capacity of its transshipment facilities: longer quays, new crane bridges and larger, faster container transshipment facilities are viewed as proof of excellence. This, however, is a gross oversimplification of a highly complex system. Even after substantial investments in technological upgrades, many transport chains fail to become substantially faster if infrastructural bottlenecks outside the transshipment terminal impede the distribution of goods, or of administrative and other management processes do not keep pace with today's requirements in terms of speed and reliability.

In 2012, DB International's logistics experts conducted a study of the port in Santos, Brazil, to assess its capacities. They graded its transshipment facilities, its seaward and landward infrastructural connections, and its administrative processes.

The following report details the factors identified by this assessment and describes their impact on the transport chain. Positing a theoretical transshipment terminal in the hinterland, it then outlines functions and means by which efficiency can be increased by dividing duties between the port in Santos and this transshipment terminal.

2. THE PORT OF SANTOS

"Porto de Santos" is located in the eponymous city in the Brazilian state of São Paulo, and it is some 70 km from São Paulo, the third-largest city in the world. In 2013, total transshipment volumes came to 114 million tons of freight. This represents growth of over 9 % on the previous year's figure of 104.5 million tons. The increase in containerized freight was somewhat lower, at about 8.8 %, totaling 3.45 million TEU following 3.17 million TEU in 2012 (all data sourced from http://www.portodesantos.com.br).

The port's docks are located on both sides of an estuary, cover some 780 hectares, and have a quay wall approximately 13 km long. They are mostly used for transshipping containers and a wide range of bulk commodities (fertilizers and agricultural products).

As it is immediately surrounded by built-up areas of the city of Santos, the port cannot expand its transshipment facilities. A corridor containing rail tracks and a multi-lane arterial road are all that separates residential areas from the quays (figure 1).

Over time, the terminals within the port have exhausted every possible means of »

FIGURE 1: Freight train at the port of Santos (Photo: Jan Henrik Wölbeling)

acquiring additional transshipment and storage capacities. As a result, the layout of berths and facilities for unloading containers do not meet the requirements of or have the size expected of a modern transshipment base.

- → Sufficiently deep water (16.5 m) for the largest container ships
- → Adequate and rectilinear arrangement of space with enough backreach (over 450 m, or better 600 m) for efficient processes, with possibility of expansion
- → High-capacity connections to various modes of transport for access to hinterland (road, rail, inland waterways)

On the right bank of the Baia de Santos are the two long-established Tecondi and Rodrimar terminals. The Brasil terminal, operated by APM, opened immediately adjacent to them in 2013. Following an extensive, expensive soil restoration program, the Brasil Terminal Portuário (BTP) terminal was built on a former APM dumping site. The Embraport terminal recently opened opposite these facilities, on the left bank of the port's channel. In contrast to the two old terminals, no rail connection is envisioned for the two newest terminals at Santos, the facilities which are the most modern in terms of logistical capacities (Figure 2).

When it comes to transportation, the topography of the region renders the port rather difficult to access. The São Paulo plateau rises immediately outside of Santos, with the land climbing from sea level to about 800 m in just a few kilometers. Heavy freight trains cannot manage such a pronounced change in elevation without assistance, and there are two options for doing so. No. 1: a 45 km rail line with a gentle incline climbs up to the plateau. No. 2: trains are broken up into smaller groups of wagons, and a funicular hauls them up to the plateau over a distance of 10 km. Both options take some 4 hours to complete for a block train of 1,050 m.

The road infrastructure poses similar complications. There are two main freeways: the Rodovia dos Imigrantes (figure 3) and the Rodovia Anchieta. Both routes have to cope with a change in elevation of some 800 meters over their final, winding stretch of 10 km to the coast. The motorways have three lanes in each direction and are largely built on pylons or run through tunnels. This difficult topography makes it virtually impossible to increase their capacities and, moreover, trucks bound for the port of Santos are prohibited from using the steep sections of the Rodovia dos Imigrantes.

Only by making greater use of rail facilities, with their capacity to transport large quantities of freight, will be possible to even attempt to increase the port's transshipment levels while at the same time reducing road traffic congestion and improving the quality of life for the citizens of Santos. Which of the rail options is used is unimportant in this regard.

The issues relating to these infrastructure connections were just two of the total of 25 different factors that were analyzed when assessing the capacity levels of the port of Santos. They are, however, at the same time the largest stumbling block for transportation to and from Santos. Every increase in the port's freight capacity adds more traffic to routes that are already extremely busy and which require vehicles to move freely so they can function well. The following table (no. 1) provides an overview of the factors covered by the survey.

One important variable in container transportation is dwell time – the average period of time a container remains in a port. Dwell times at the terminals in Santos are noticeably high, averaging between 10 and 17 days. This contrasts with 6.4 days at CTA Hamburg. There are two reasons for these long periods: a) the slow completion of customs processes, and b) the container-based calculation of demurrage fees. At Santos, customs officers takes an average of no less than 7 days to inspect and release imported goods if all documents are correct and signed.

Demurrage at Santos is a major source of revenue, so the terminal operators benefit greatly if containers with high-value freight have long dwell times within the port's terminals. This contrasts with the European system, which bases demurrage on a con-

FIGURE 2: Map of Santos indicating terminals' positions (Source: Jan Henrik Wölbeling)

Terminals	Seaside access	Road Access	Rail access	Processe and IT
Quay factors Berth Area Layout Area Back Reach Expansion Area Crane Equipment	Channel dimensions Vessel Maneuvering Tracking System VMTS	Close acces to roads of national importance Traffic management to regulate freight flows	Direct terminal access Separation of freight and passenger transport Hinterland infrastructure Hinterland terminals with direct rail access Appropriate hinterland terminal network	Operation Scheduled berthing Pilot performance Dwell time Port Authority Customs clearance procedures Administration Customs declaration process steps Transit procedures Legal Framework Paperless procedures /electronic signature Communication and information platform

TABLE 1: Investigated factors influencing performance enhancement at the port of Santos

tainer's size (20 or 40 foot), giving rise to a situation in which operators are concerned with cutting containers' dwell times to the absolute minimum so that container turnover is high. In response to this fact, the work entailed in cargo handling is frequently divided between the seaport and a hinterland terminal. Longer dwell times would encourage the terminal operators to fill up the limited space for containers with "long-timers", thereby increasing the number of lifting operations (e.g. sorting activities). Such practices would also reduce the availability of storage space for other activities, i.e. reducing a ship's idle time by loading freight into export containers before the ship docks. In Europe, trucks, trains and barges transport freight to hinterland terminals, which is where customs activities are performed and freight then released to the end customer. For the most part, customs officers actually inspect goods only if conducting spot checks. However, certain types of freight require mandatory inspections.

While the customs officers are doing their work, they are also preparing the necessary documents in electronic form in real time. Brazil intends to follow suit and is in the process of planning a similar system. Before the project, up to 18 approval forms had to be obtained before a container could be imported to the country.

3. HINTERLAND IN BRAZIL

As things currently stand, hinterland regions in Brazil have poor rail connections, and trucks are often the first choice for transporting freight. Any rail lines that do exist are single-track routes. However, hinterland terminals require high-capacity rail connections. Today, container terminals and inland ports do more than merely serve as transshipment points. Hinterland terminals with around-the-clock hours complement seaports in the following ways:

- → A gathering point for local transport services heading towards seaports via motorways and main rail lines; low waiting and idle periods when collecting and delivering freight
- → Spreading transport services throughout the region surrounding the seaport's hinterland terminal
- → Regional hub for logistics services and customers
- → Providing empty containers plus other services such as repairs, cleaning, stuffing (loading) and stripping (unloading/reloading), refilling
- → Taking on administrative processes to reduce workload at seaport
- → Storage space for equipment
- → Transshipment tracks of full train length

Cooperation between seaports and hinterland terminals is growing in importance. Seaports have a direct influence on the hinterland terminals, thereby generating additional space and streamlining their processes. In return, the operators of hinterland terminals profit as their facilities enjoy higher and more stable levels of utilization. Here again, it is necessary to expand communication and ensure the holistic integration of ports into existing plans as discussed above. This is the only way to generate synergy effects and ensure that both sides profit from their cooperation.

With regard to the port of Santos in particular, an additional transshipment terminal on the plateau could help ameliorate conditions. Unsorted shuttle deliveries from the port could use designated high-capacity corridors prioritized for them on uphill routes. The transshipment terminal would then sort the freight according to destination and handle reloading onto the necessary modes of transport. This would help reduce truck numbers and traffic jams in the city as there would be fewer vehicles looking for parking and being forced to wait before completing their deliveries. Instead, this would all be relocated to a large terminal on the plateau. Deliveries to and from the port's terminals, i.e. through the city, would only be permitted in slots in line with traffic management procedures which use the ships' calls for orientation. Specialized drivers would know precisely when and where they are to deliver their loads.

4. RESULTS

While intermodal transport connecting seaports, inland ports and their respective hinterlands benefits from the wide-ranging effects of globalization, this process also poses considerable challenges for ports. In today's world, using traditional forms of transport on rail routes and inland waterways no longer seems productive. Transport chains must be concentrated along suitable corridors and use the form of transport best suited to their specific conditions. Emphasis must be placed on the fact that competing companies and systems must actually work together, not against one another, to develop broadly acceptable solutions. All involved parties must understand that they have an integral role to play – this will enable them to deploy their strengths in a way that maximizes benefits.

Even without investments in transshipment technology, the infrastructure of the port of Santos can achieve some growth in freight handling volumes. The seaport terminals' link to the city's hinterland represents the main challenge, as pressure on them can »

FIGURE 3: Caravans of trucks on the uphill section of the Rodovia dos Imigrantes (Photo: Femke Grabbert)

be eased by connecting them with hinterland terminals. Simpler customs procedures and the use of electronic documents would improve the terminals' storage capacities as they would substantially reduce containers' average dwell times.

The BTP and Embraport terminals have increased transshipment capacities still further and have boosted the port's throughput capacities considerably. Less positive is the way road transport is favored as the means of connecting the port with its hinterland: the road infrastructure to and from Santos had already reached its maximum capacity in 2011, but additional deliveries to and from BTP and Embraport have further exacerbated the situation.

Overall, the case of the port of Santos makes it clear that adding to capacities does not necessarily improve the performance of the supply chain. Within this context, the logistics experts from DB International emphasize that whenever infrastructural improvements are undertaken, then the entire transport chain and its accompanying processes must be taken into consideration. The interaction between different factors at the port and the hinterland should be supported by establishing partnerships and encouraging cooperation. This will secure the port's long-term performance capacities and safeguard supply processes in its hinterland.

5. OUTLOOK

Centro Nave, the client, was very pleased with the analysis. A number of national media outlets in Brazil discussed the final report, and the recommended measures received great attention.

At present, the greatest progress has been made in relation to the issue of IT/networking, and some initial steps towards simplifying and standardizing documents were taken even while the project was still underway. Organizational changes to administrative processes are currently under discussion. However, further measures, above all infrastructural measures, require higher levels of investment, and their implementation will therefore be a gradual process over the coming years. ◀

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- DB International GmbH (2011): Performance analysis of the Port of Santos. Unpublished final report for a project.
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Operational simulation: at first simulation, then implementation

It is in the interests of both the operating company and the orderer to transport more passengers and freight by rail. The fundamental aim is efficient transportation, which is supported by the key factors of increasing revenue by increasing capacity and reducing expenses by designing facilities that meet demands. These two factors can be evaluated, combined and optimized by means of operational simulations.

1. WHY RUN AN OPERATIONAL SIMULATION AT ALL?

The point of an operational simulation is to analyze the correlation between the timetable and infrastructure during a normal day's operation. In addition, an operational simulation allows the operating systems, operating procedures, operational safety and rolling stock technology to be analyzed, designed and optimized. Typical scenarios where an operational simulation is used include:

- Timetable creation
- Capacity planning
- Infrastructure design
- Construction operations planning
- Analysis of operational quality
- Development of scheduling strategies
- Development of incident management strategies

By creating timetables, the basis of any operational simulation, train paths can be determined along their entire length. Travel times, occupation of blocks and conflicts with other trains can be calculated regionally as well as throughout the network. Hold-ups and delays occur repeatedly during a normal day of operation in any network. Both minor and major disruptions cause delays. Every day is different. By testing the operational quality, we examine whether the theoretical timetable created works well in everyday operations. Days affected by faults can be simulated and analyzed with regard to how delays develop and the resulting effect on punctuality and passengers making their connections. The simulation takes into account all of the interactions between the timetable, the infrastructure and the vehicles. Train operations are analyzed in a real-time simulation in order to be able to examine the network-wide consequences of delays. The operational simulation also shows whether the timetable is capable of reducing these delays with the help of travel time additions. If that is not possible, a change to the timetable or infrastructure is a possible solution.

Operational infrastructure design with the help of the operational simulation makes it possible in advance of a construction measure to assess the design of track systems, identify their benefits and compare different alternatives in order to find the best construction solution.

The operational simulation is useful when searching for spare capacity and bottlenecks in the infrastructure and operations, examining alternatives and defining solutions. Some practical examples explain how the DB International specialists approach an operational simulation.

2. OPTIMIZATION OF S-BAHN URBAN RAIL SYSTEMS BY MEANS OF OPERATIONAL SIMULATION: EXAMINATION OF RAIL OPERATIONS ON THE CENTRAL SECTION OF LINE IN THE MUNICH S-BAHN NETWORK

2.1. INITIAL SITUATION AND OBJECTIVES

The Munich S-Bahn urban rail network is one of the busiest S-Bahn networks in Germany. It has seven branches in the west and five in the east. The eastern and western branches are connected to each other by the central section of line. With up to 30 trains per hour and direction, this central section of the Munich S-Bahn system between Pasing and Ostbahnhof is one of the busiest sections of line in Europe in terms of the frequency of the trains using it.

Even slight delays of individual trains on the outer branches of the network result in secondary delays on this central section. When individual trains are delayed, delays of subsequent trains often cannot be avoided due to the high frequency at which the trains run. In order to be able to ensure that the transportation network copes with the requirements of today's high frequencies and that the required quality is provided, continuous monitoring and analysis of operations is required together with rapid implementation of the necessary optimization measures in order to ensure lasting operational stability.

Within the framework of a joint project of DB Netz and DB Regio, DB International analyzed operations in the Munich S-Bahn urban rail network. The objective was to model and simulate the operations of the Munich S-Bahn in order to achieve a better understanding of the system in terms of the responses and cause-and-effect relationships. To this end, various planned measures to improve punctuality and the scheduling measures used in operations management to handle different disruption situations were to be examined to ascertain their effectiveness and identify any potential for improvement. »

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FIGURE 1: Munich S-Bahn urban rail system: The S3 (ET423) to Deisenhofen leaves the tunnel of the central section of line heading for Ostbahnhof (Photo: DB AG/Uwe Miethe)

2.2. METHODOLOGY

Based on the detailed (microscopic) modeling of the rail infrastructure of the Munich S-Bahn network, the timetable for an average working day in the year 2013 was represented in the RailSys simulation model [1]. In the next step, current delay data (stopping times exceeded and delays in entering the part of the network under examination) from the Munich control center was implemented in the model in order represent the "background noise" of "normal" minor delays that occur on an everyday basis. The resulting calibrated timetable served as the basic version and as the basis for comparison for the subsequent investigations and scenarios.

On the basis of the system model, various operational statuses and disruption scenarios were simulated. A total of over 4,000 days of operation and around 60 different variants were simulated.

2.3. INVESTIGATION VARIANTS

Effect of extended stopping times as a result of interventions by emergency doctors

Although emergency doctors have to be called to the platform or the trains quite often, this happens at irregular intervals. Their distribution over time cannot be planned. Emergency doctors' interventions last for an average of around 15 minutes. During this period, rail operations in the relevant direction largely come to a complete halt, which has significant consequences – including on the branches of the network leading to the location of the intervention. If the duration of the emergency doctor's intervention can be reduced, the time required before resumption of normal operations and the number of delayed trains can also be reduced. Without systematic modeling and simulation, however, it is difficult to assess the positive impact on punctuality in the system.

Impact of optimizing the procedure prior to the train setting off

During peak periods, train operations are extremely vulnerable to delays due to the high frequency of the trains. Delays often occur when stopping times are exceeded on the central section of line. This generally occurs as a result of passengers' behavior. The Munich S-Bahn München therefore wants to reduce the time between the doors closing and the train setting off, which is one of the components of the stopping time, by using optimized technologies and procedures. Furthermore, the door-opening time – and thus the (minimum) stopping time – at the stations in the central section of line is to be reduced by opening the doors centrally. In the operational simulation it was investigated whether the time thus gained could be used to reduce delays.

Impact of measures to handle disruptions

The Munich S-Bahn has developed incident management strategies for dealing appropriately with disruptions and the peculiarities of metropolitan traffic in which all lines converge on a central section of line.

By means of standardized incident management strategies, the disruption management decision-making process is accelerated. In order to minimize the consequences of failures (e.g. extended stopping time due to an emergency doctor's intervention) and, in the case of a diffuse disruption situation, to relieve the network and stabilize the system, the Munich S-Bahn has developed special programs that complement the incident management strategies.

Up to now it has only been possible to assess the impact of these operational measures on the basis of experience. For typical disruption scenarios, the simulation is intended to make a robust contribution to the evaluation of the effectiveness of scheduling measures and their effect on punctuality in the system and total delay time.

Impact of train reinforcements

In order to adjust the amount of space available to suit demand depending on the time of day, the length of trains can be changed by means of reinforcement processes (short/full/long train). This reinforcement is done at the beginning of the day's two peak periods at Pasing and Ostbahnhof (and also elsewhere) on trains heading into the center of the city. Since these stations are also key points at which traffic enters the central section of line, train reinforcements not carried out in accordance with the planned schedule result in secondary delays throughout the Munich S-Bahn network. In the operational simulation, it was investigated what the impact on punctuality and total delay time would be if these train reinforcement processes were dispensed with.

Impact of reducing the delays of trains entering from the outer branches of the network

Delays on the outer branches of individual lines generally result in secondary delays when the lines converge into the central section of the network. The impact of these delays on the operational stability of the central section, particularly as a result of the combination of different lines with different delays, is currently almost impossible to estimate. The idea was to use the operational simulation to examine whether and how punctuality could be improved in the entire system by reducing the delays of trains entering the area on selected lines.

2.4. RESULTS

Based on the results of the simulation, the findings were essentially as follows:

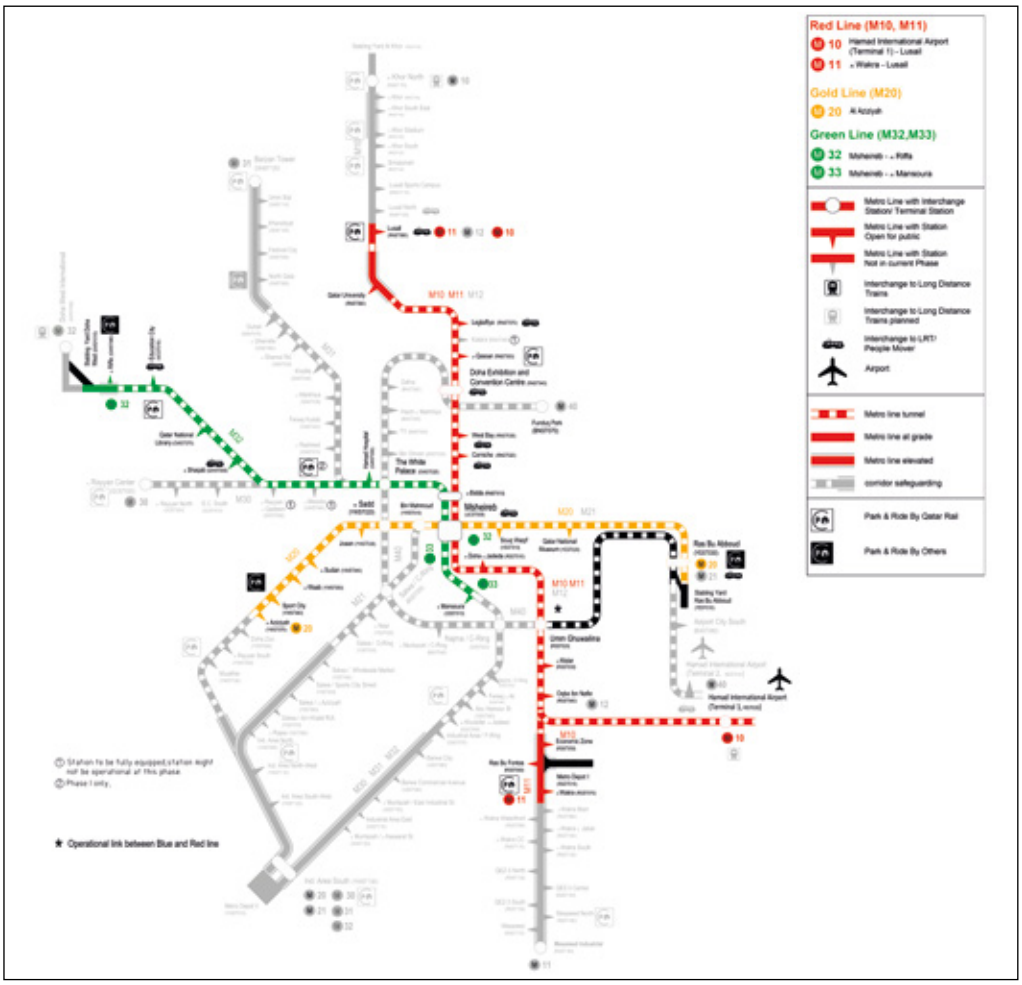

FIGURE 2:
Planned network for the Doha Metro
(Source: www.qr.com.qa, 13.11.14)

- → The relief measure selected should be made dependent on the time when the disruption occurs.
- → The more trains that are released from the central section after a disruption, the better the punctuality and the lower the total delay time.
- → The earlier relief measures are taken after the start of the disruption, the better the punctuality and the lower the total delay time.
- → Each effective measure increases punctuality and reduces the total delay time.
- → A quick resolution of the bottleneck to avoid congestion reduces the increase in delays.
- → The longer the blocking time, the more effective the relief measures are.
- → The measure selected depends on the location of the disruption.
- → Every measure that reduces the delays of trains entering the central section results in a reduction in delays in the central section.

On the basis of these findings, the following statement of principle can be made:

What is critical to the stabilization of an S-Bahn system is not so much the type of relief measure as how quickly it is initiated to relieve the network in the initial stage of the disruption.

3. OPERATIONAL SIMULATION FOR THE SIZING OF THE POWER SUPPLY: DOHA METRO, QATAR

An integrated rail system is to be constructed for the public transportation system in Doha. An 85-kilometer metro network is to be constructed in the first phase of development. The line layout and the configuration and standard of the network have been developed in different design phases. Worthy of particular mention are the detailed investigations carried out to determine the most suitable form of power supply for the new metro system. Thus, in addition to the DC voltage of 750 V that is usual for metro systems, an alternative of 25 kV 50 Hz AC voltage was also considered. The traction current network must have enough capacity to supply the huge amount of energy required to operate the trains. This is calculated based on energy consumption, which depends on the timetable, level of vehicle occupation, track infrastructure and times of day. To this end, a model was created based on the imported infrastructure data.

A period with the highest traffic density was simulated. This necessitated the creation of conflict-free timetables throughout the network for a period of around four hours. The result was that the travel times were verified for further calculations and the vehicle requirements were determined by calculating the vehicle runs.

In order to make enough space for the power supply systems at the metro stations, the required construction volume and the layout of the direct-current substations had to be determined. To answer these questions, a simulation model was created in OpenTrack. OpenTrack is a research project carried out at the Institute for Transport Planning and Systems (IVT) at ETH Zurich on the subject of the interactive operational simulation of rail networks.

The required traction current consumption was calculated with the help of a computer simulation taking all trains in the network into account. The OpenPowerNet program was used for this, which builds on the operations program created by OpenTrack.

A timetable and the vehicles deployed were obtained for each metro line in the Qatar Integrated Railways Project Network (phase 3). Together with the model for the infrastructure and the vehicle dynamics, the »

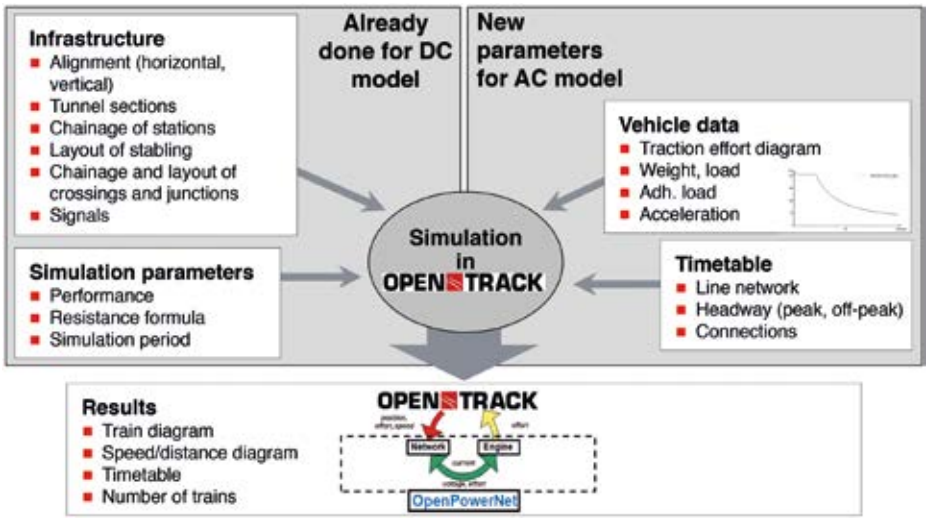

FIGURE 3: Overview of the model with input and output parameters

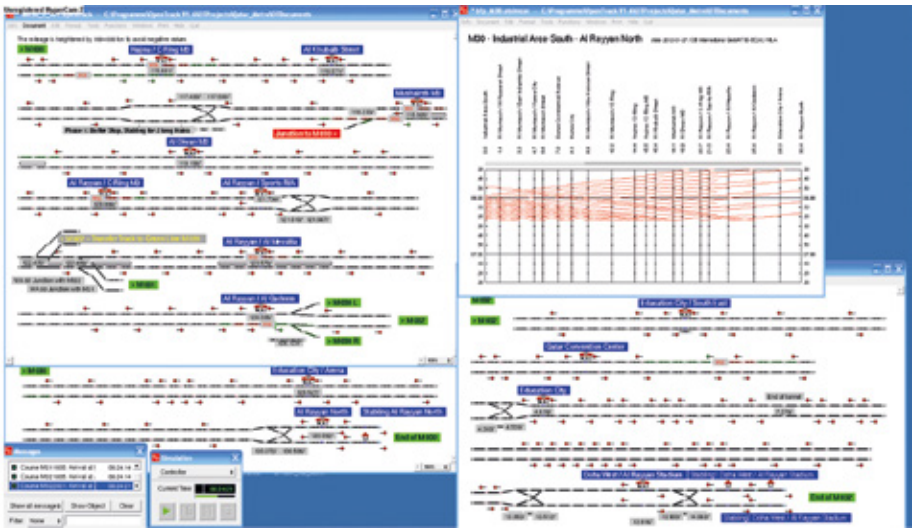

FIGURE 4: Excerpts from the processed simulation results

train movements were simulated. A traction current simulation followed on the basis of this for the peak period under normal conditions for traction current supply.

FIGURE 5: Visualization of a future underground station (Source: KASIG)

4. OPERATIONAL SIMULATION TO DETERMINE THE CAPACITY OF A COMPLEX LIGHT-RAIL TUNNEL IN KARLSRUHE, GERMANY

The city of Karlsruhe is a pioneer in light rail and the shared use of lines in the center of the city by both tram-trains and streetcars. As more and more light-rail lines have been added and the frequency of the trains has increased, the transportation facilities have begun to reach the limits of their capacity. In the Karlsruhe "combination solution", part of the streetcar network in the center of the city is being laid in a tunnel in order to relieve traffic congestion. The tunnel runs from east to west for around 2.2 kilometers with four underground stations and also has a north-south branch of around one kilometer with three further stations. Under the Marktplatz square in the city center there will be a level junction at level -2, around 17 meters below the surface. At the busiest point, with trains from four or five lines running every 10 minutes, intervals between tram-trains/streetcars will be as short as 90 seconds.

In accordance with the German BOStrab regulations on the construction and operation of streetcar systems, a train control system is required in the tunnel. DB International carried out an operational study that demonstrated the fundamental capability of the tunnel to meet requirements and gave consideration to the signaling concept required in the tunnel.

With an operational simulation of daily operations taking into account a large number of disruptive influences, the following central questions were to be answered:

- → Is the envisaged concept for the lines also viable when operations are disrupted?
- → What happens when there are delays and resulting changes to the sequences of the vehicles from the different lines at the underground junction under Marktplatz?
- → Will delays just continue to build up in the system, or can delays be reduced again as time goes on?

OpenTrack, a software application that was developed to answer questions like this, was used for the operational simulation.

The area under study extended beyond the tunnel section to include the adjacent streetcar sections of line up to the nearest node. The influence of trains or streetcars turning off at the track crossings was thus taken into account in the operational simulation. The locations of the stations, switches, signals and track vacancy detection equipment were shown accurately in the simulation model.

A further basis for the operational simulation was the timetable, based on the officially approved concept for the lines. The departure times were continuously updated based on the findings from the study examining the capability of the tunnel to meet requirements. The simulation period lasted six hours, the first two of which were for the simulation of peak-time operations. The ratio of peak to off-peak periods of 1:2 reflected the interactions in the study very well.

The light-rail vehicle GT8 100C/2S was used as the reference vehicle for the simulation. This older dual-system vehicle type was used intentionally because it represents an unfavorable case. Shorter travel times are possible with more modern low-floor vehicles with better acceleration. This would in effect increase the capacity of the tunnel. The exact dynamic characteristics of the se-

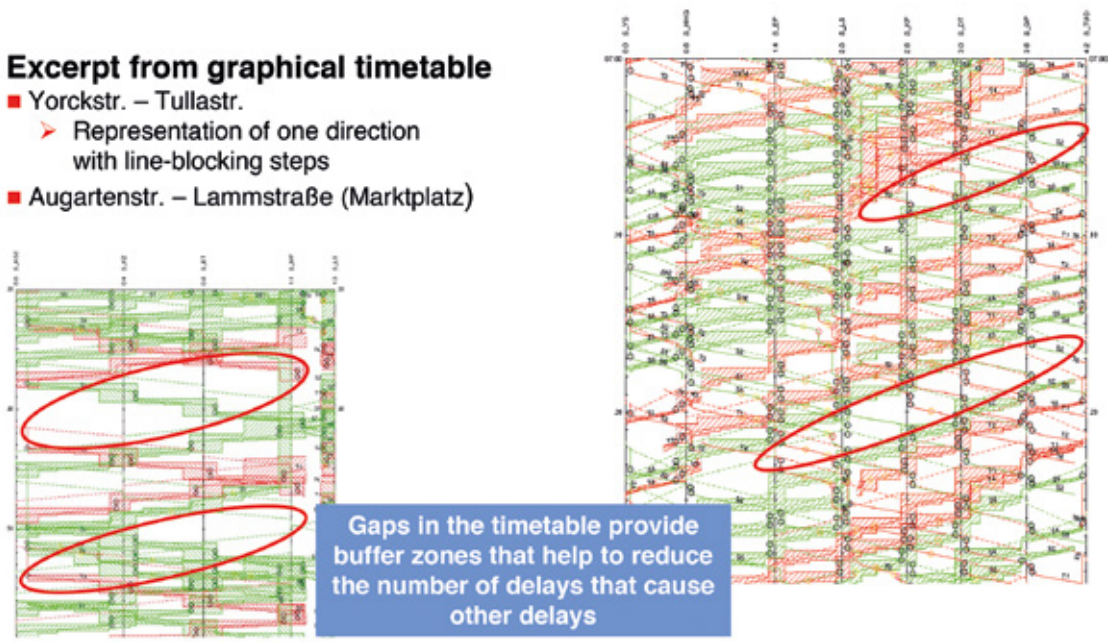

FIGURE 6: Excerpt from the graphical timetable with the gaps in the timetable indicated

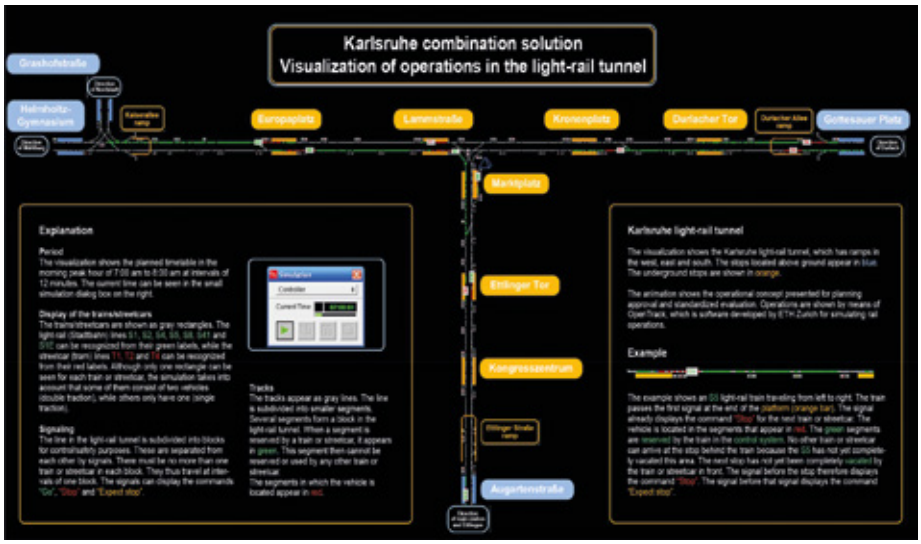

FIGURE 7: Screenshot of the video from the simulation

lected vehicle were included in the model so that the train journeys could be simulated with precision on the basis of the infrastructure data.

In order to investigate "disrupted operations", the delays on entry into the section under study, and thus the influence of operational disruptions originating outside that section, were taken into account in the operational simulation.

The delay on entry was determined randomly in each simulation run for each train on the basis of a distribution specified in advance. These delay distributions were represented for each entry station on the basis of current operational data. The stopping times were assumed to be constant in this scenario. After consultation with the local transportation operators, 30 seconds was assumed for the underground stations in the city center and 18 seconds for the stations or stops above ground outside the city center.

The operational simulation included 30 different delay scenarios with random distribution of the delays. The results showed that operations can continue and remain stable in the light-rail tunnel under the specified circumstances.

4.1. RESULTS OF THE OPERATIONAL SIMULATION

In order to demonstrate clearly to local politicians and citizens that the operational concept meets requirements, DB International presented operations graphically. It was possible to run this simulation in OpenTrack and thus create a video of the movements of the trains along their routes. The video created shows operations for an hour during the peak period at intervals of 12 minutes and has been exhibited for the Karlsruhe combination solution at the information pavilion of Karlsruher Schieneninfrastruktur-Gesellschaft (KASIG) since August 2010. On the large screen you can see the light-rail trains as they go into the tunnel under Kaiserstraße and into the southern branch of the tunnel under Ettlinger Straße, stop at the stations and then leave the tunnel again. What's unusual about this is that it represents a real timetable created using scientific methods rather than some ideal situation.

During the creation of the simulation, many suggestions for improvements were made, for example regarding the positioning of the signals or the quality requirements in terms of operations management, in order to permit conflict-free train operations.

5. SUMMARY

The operational simulation ensures the infrastructure is configured to optimum effect and also shows that the infrastructure can be expected to cope over the long term.

In the selected projects, DB International was involved at key points during the operational planning for the public transportation network. The company's experts can draw on their experience of timetable creation, the design of transportation facilities and control and command technology that they have gathered in projects carried out in a variety of locations. Moreover, the use of OpenTrack in addition to RailSys for operational simulation allows operations to be presented to the public in a digestible form. ◀

High quality of construction ensures the planned period of use is achieved

Transportation facilities are made fit for the requirements of the future. The quality of construction determines both the subsequently required maintenance effort and the service life. It goes without saying that sustainable construction principles are adhered to. Construction supervision makes a decisive contribution to all that.

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THE PORTFOLIO OF CONSTRUCTION SUPERVISION SERVICES AT DB INTERNATIONAL

Historically, traditional local construction supervision teams covered the great majority of the far-reaching range of services involved in this connection in the construction of all buildings and equipment for all modes of transport.

The construction supervision team initiates the measures required for correct and proper execution or provides the contractually agreed technical supervision services and rail operations services, including safety supervision for civil engineering structures, transportation facilities and technical equipment. The planning of construction operations also comes under construction supervision. The management of subsequent work, documentation of the course of construction, acceptance of services provided and construction invoicing complete the picture in terms of the services offered.

In a second field of activities, namely accompanying construction supervision, the services range, for example, from welding supervision, construction surveying and waste management to geotechnical and hydrogeological checks in environmental construction supervision.

Interdisciplinary construction supervision is becoming increasingly important. Both IT-based design review in an electronic design flow management system and reporting as well as the documentation of commissioning on the basis of the administrative regulation for the commissioning of structural subsystems or the grouping of the documents for certification on the basis of the technical specifications for interoperability (TSIs) or the Trans-European Interoperability Regulation are included in this.

CONSTRUCTION SUPERVISION IN GERMANY

The foundation of the successful international business of DB International remains the continuous and varied project work for all modes of passenger and freight transportation in Germany. This is how our employees maintain the high engineering and technology standards for which Deutsche Bahn and German transportation systems are known throughout the world. Thanks to their experience in international projects, our specialists develop into valued parters of their domestic and international clients for both their professional and intercultural skills.

DB International provides construction supervision services for almost any kind of project in the transportation sector, regardless of the order volume or mode of transport. The construction supervisors have been involved in virtually all of Deutsche Bahn's expansion and new construction projects and have supervised construction work in the S-Bahn urban rail networks and light-rail projects in Karlsruhe, Heilbronn and Kassel, the modernization of depots and maintenance facilities and the construction of parts of the logistics infrastructure. The requirements of these projects do, of course, vary greatly. The major projects with their long durations and high levels of complexity almost always demand coordination across different disciplines as well as interdisciplinary support processes. DB International provides not just the specialist construction supervisors and further experts but often also takes on the management of construction supervision

FIGURE 1: The TEN and an overview of the VDE 8 route (Source: designhaus berlin)

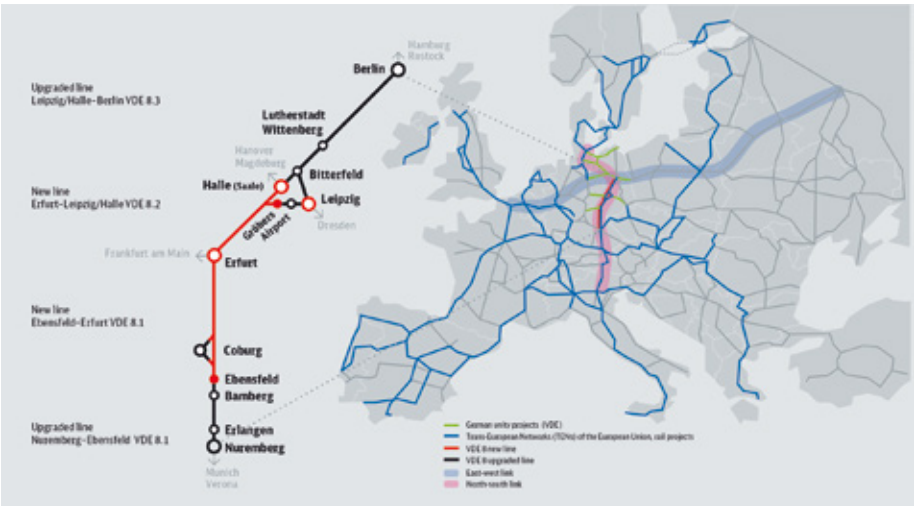

FIGURE 2: Western end of Landsberg station (looking toward Bitterfeld) (Photo: Jürgen Dietzsch)

FIGURE 3: Erfurt Main Station (Photo: Frank Kniestedt)

due to the particular challenges involved and the expertise at its disposal.

One such major project is Germany Unity Project No. 8: Nuremberg–Erfurt–Leipzig/Halle–Berlin (VDE 8). As part of the Trans-European Network (TEN), the route will handle the increasing flows of passengers and freight between Scandinavia and southern Europe. The international importance of the eastern north-south axis in Germany brings with it associated requirements in terms of the technical interoperability of the route. The European Train Control System (ETCS) Level 2 is used for train control, and the Global System for Mobile Communication – Rail (GSM-R) is used for telecommunications.

The line between Nuremberg and Berlin is subdivided as follows:

- → The upgraded section 8.1 Nuremberg–Ebensfeld (82 km long)
- → The new section 8.1 Ebensfeld–Erfurt (107 km long)
- → The new section 8.2 Erfurt–Leipzig/Halle (123 km long)
- → The upgraded section 8.3 Leipzig/Halle–Berlin (187 km long)

The upgraded section Leipzig/Halle–Berlin (VDE 8.3) went into operation in May 2006 when Berlin Main Station was opened. In order to raise the speed on the line to 200 km/h, the 15-kilometer section between Halle and Bitterfeld was upgraded with effect from 1 August 2012 using a new construction of slab track (type Bögl); the 18 switches are now of the type Rheda 2000. DB International was responsible for construction supervision 24 hours a day, seven days a week while the line was completely closed for the construction work. The line was opened again on schedule on 29 June 2013.

FIGURE 4: Construction phases in the upgrading of the Halle rail node

(Source: designhaus berlin)

The Erfurt node is an important link between the new sections 8.1 and 8.2. From 2008 until 2017, DB International is providing construction supervision services and is responsible for the fulfillment of 20 construction and equipment contracts on budget, on schedule and in accordance with quality requirements. The construction measures to integrate the new sections of line from Leipzig/Halle and Nuremberg cover around 12 kilometers in the surrounding area of and through Erfurt. On the integrating line from the direction of Leipzig/Halle alone, 25 kilometers of new track are being laid with 76 switches. The overhead line system and control and command technology are also included in this. The line into the Erfurt node from the west has been upgraded from three tracks to five for the integration of the Nuremberg–Erfurt line..

The Halle node is connected to the new section 8.2 Erfurt–Leipzig/Halle. The upgrading and development of the node involves a corridor through the city with a total length of 9 kilometers. The work on the four separate sections is being carried out between 2013 to 2022 while rail operations continue. In addition to adhering to the schedule and meeting the operational requirements, the challenges for the construction supervision team consist of connecting the freight station, on which construction started in 2012, and the modernized train composition facility in accordance with the quality requirements. For the planned increase of the entry, exit and through speeds to up to 160 km/h, the station will be completely transformed on the basis of the optimized track plan. Here too, the construction supervision service package includes construction management and, in addition to conventional construction supervision of all aspects, the review of all designs/plans, compilation of TSI documents, construction site logistics, geotechnical engineering and surveying, health and safety coordination, invoicing and, finally, the creation of the commissioning dossier.

A variety of interfaces have to be taken into account given that there is construction work involved on around 50 bridges and intersections in the course of the entire project. In coordinating construction operations, the experts have to ensure that not just rail traffic but also road traffic can continue largely without restrictions during the construction »

FIGURE 5: Slide-in bridge over the motorway by Erlangen, April 10, 2014 (Photo: Toralf Bohn)

FIGURE 6: Datong–Xi'ang high-speed line, training of Chinese construction supervisors while aligning a segment of slab track of the type CRTRS 1 (Rheda 2000 China) (Photo: Bernd Fischer)

FIGURE 7: Datong–Xi'ang high-speed line, batch 4, bridge-building with steel continuous girder using the incremental launch method, May 2, 2013 (Photo: Sven Hertwig)

FIGURE 8: The Zhanyi bridge (total length 1768 m; span 128 m) is rotated into place on September 10, 2014. The cantilevers reach their final position at 25.3° (Photo: JV Huatie/DB International)

work, which will go on for years. This is demonstrated, for example, by the photographs of the first slide-in bridge over the A3 motorway by Erlangen for the upgrading of the line to a four-track line between Nuremberg and Ebensfeld in the spring of 2014.

Further current major projects in Germany are the new Stuttgart-Ulm construction project, which involves converting Stuttgart Main Station to an underground station (Stuttgart 21 project), and the upgrading of the Hanau–Nantenbach–Würzburg section, which is one of the busiest routes in the DB network with around 240 trains a day.

SUSTAINABLE CONSTRUCTION

Construction these days is about more than just constructing buildings and transportation facilities in accordance with the plans. In all DB International projects, environmental considerations play a highly important role both during design and planning and, in particular, in construction supervision during the construction phase. Two fundamental rules here are that the construction measures should take up as little space as possible and that the impact on the surrounding flora and fauna should be minimized as far as possible. Specially trained employees take on the aspects of construction supervision affected by the waste legislation, which includes ensuring compliance with Germany's strict regulations on the obligations of the producer of waste. The electronic consignment-note procedure required for this in the soil and recycling concept to categorize the building materials, depending on whether they are to be reused or disposed of, is clear to all involved.

The services involved in environmental construction supervision are subdivided as in the environmental guidelines of the Federal Railway Authority (EBA) into nature and species protection, soil protection, emissions control and water protection. Consequently, experts have been drawn together in DB International from a wide variety of different specialisms in the fields of environmental protection, geoengineering and geodesy, who also take on the specific tasks involved in construction supervision, together with others where applicable.

CONSTRUCTION SUPERVISION AROUND THE WORLD

Construction supervisors involved in international projects confirm that environmental considerations are being given increasingly more weight in projects around the world. Sustainable construction and its supervision and monitoring are becoming an increasingly important criterion when contracts are awarded. The environmental experts of DB International take this into account and pass on their knowledge and experience to clients and contractors during the project.

Globalization and the associated requirements of the markets mean that intelligent new solutions are needed for both passengers and freight. The importance of rail as a mode of transport is continuously increasing internationally. The amount of construction taking place all over the world is increasing, and DB International is facing up to the associated challenges with its experienced construction supervisors and specialists in many different projects. Hundreds of projects have been implemented since 1966, starting with construction supervision for the metro project in São Paulo, Brazil in the 1970s and going right up to the present day with projects in China, Saudi Arabia or Mongolia.

Development of the high-speed rail network in China

Our experts have been helping develop the high-speed rail network in China, offering consulting and training services since 2003. The company's construction supervisors have been on-site locally since construction activities started on the first routes. Together with their Chinese colleagues, they have so far supervised the construction of hundreds of kilometers of track in 11 construction phases of eight high-speed lines as well as civil engineering works and rail installations (figure 6). Methods that were previously unusual in railway construction in China are being used, such as the incremental launch method of bridge-building using steel continuous girder (figure 7).

Our construction supervisors will be involved in batch 1 (Yunnan section) of the Shanghai–Kunming line until 2016. Speeds of up to 350 km/h will then be possible on the 95-kilometer two-track line. Construction will be supervised by the Huatie/DB International joint venture and will include the four bridges to be built on this section of the line. In order to avoid impairing rail traffic on the main routes, parts of which are four-track lines, the bridges are constructed parallel to the line and then rotated into position while rail operations continue on the relevant lines, which is an unusual construction method (figure 8).

Freight transportation route in Mongolia

DB International has been providing construction supervision services in Mongolia since September 2013. The railway company Mongolyn Tömör Zam is building a single-track, 225-kilometer long non-electrified coal transportation line from the coal mines by Ukhaa Khudag to Gashuun Sukhait on

FIGURE 9: Bridge on the line in Mongolia
(Photo: Thomas Rath)

FIGURE 10: Construction supervisor Abdelmoula Benabida measures the track gauge with the Chinese construction contractor
(Photo: Dr.-Ing. Ali Akbar Elahwiesy)

the Chinese border. Up to now, hundreds of trucks have transported the coal on a dirt road across the desert for further processing. The schedule is ambitious: the first coal trains are expected to be running after a construction period of only two years.

The members of the construction supervision team are working on the construction site in the southern Gobi Desert. At first glance, constructing the line appears to be a relatively simple task, but there are peculiarities involved. In the middle of the desert, a railway embankment is being created, interspersed with elevated sections of line. It is hard to imagine, but in the dry season in the desert, large bridge structures like this have to be built to let flash floods drain away after heavy rain (figure 9). However, these structures also allow wild animals and Mongolian farmers' herds of camels to pass through.

Construction supervision in Saudi Arabia

DB International has been actively involved in the development of passenger and freight transportation rail links in the Middle East for many years. When the Mecca Metro went into operation for the Hajj in November 2010, it was the first mass transit rail system on the Arabian peninsula. The raised track except for the area around the depot and the operations control center and the climatic conditions placed particular demands on the construction team. The construction supervisors also made a not insignificant contribution to making sure that test operations could begin on schedule in the summer (figures 10+11).

A second, very extensive project is the Haramain High Speed Rail Project, the first high-speed line on the Arabian peninsula. With a top speed of up to 320 km/h, the trains will bring pilgrims and visitors to the two holy cities of Mecca and Medina quickly and comfortably and also connect the international airport and the city of Jeddah on the Red Sea, which is Saudi Arabia's most important port city. It benefits both business travelers and tourism. The construction supervision experts check all supplies and services and supervise the construction of the tracks and the installation of all rail systems along the electrified, two-track, high-speed line, which has a total length of 450 kilometers (figure 12). Slab track is used along most of the line. As part of the process, the local rail staff are being given training so that they can subsequently maintain the line. The client, the Saudi Railways Organization, has commissioned DB International to handle project management and review the designs/plans.

CONCLUSION

The company's construction supervisors have contributed to the success of many projects in all five of the world's continents since 1996, working on everything from tram and LRT systems to magnetic levitation lines, from industrial railways to an ultra-modern logistics center that serves as an intermodal hub. They have been responsible for the construction of tracks, civil engineering and superstructure works, for the implementation of technical rail and building systems and for the best possible level of nature conservation, completing their projects on schedule and in accordance with the required quality. ◀

FIGURE 11: Raised track of the Mecca Metro
(Photo: Dr.-Ing. Ali Akbar Elahwiesy)

FIGURE 12: Rail-laying on the slab track, October 22, 2014
(Photo: Ralf Hoffmeister)

Integration of air and long-distance rail travel and inclusion of airports in cities' transportation systems

As a result of the successful development of the Chinese economy in recent years, China has been able to – and has had to – invest in a modern, effective, high-capacity transportation infrastructure. However, an improvement of effectiveness cannot be achieved just by upgrading or building new infrastructure and systems for each mode of transport; they also have to be well interlinked.

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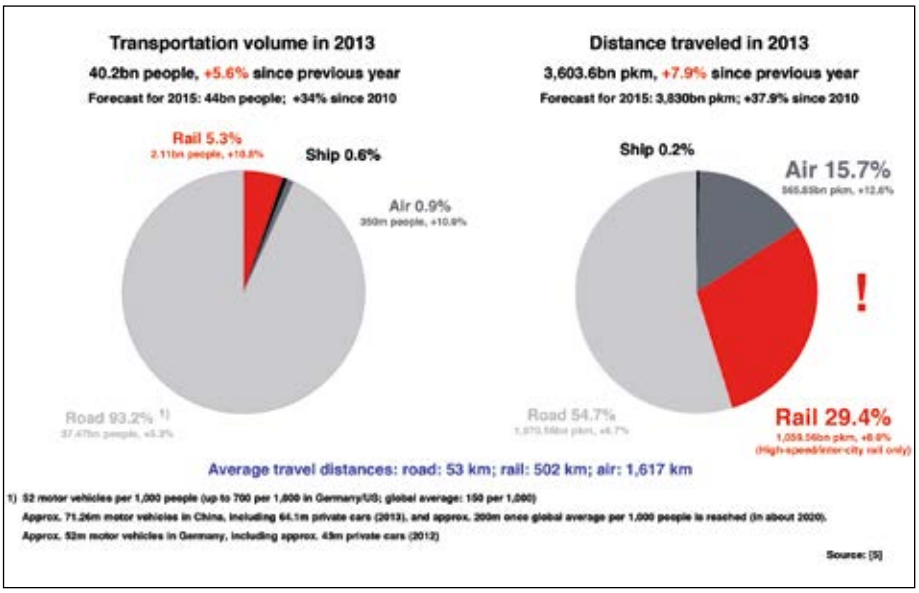
1. BACKGROUND INFORMATION ON THE TRANSPORTATION SYSTEM IN CHINA

China's economy has been growing at a significant rate for years now, and this is expected to continue in the coming years. From the current perspective, China can also be expected to be politically stable in both the medium and long term. However, China differs from other countries in a number of ways that are worth mentioning here. The upgrading and construction of new transportation infrastructure is seen as being an essential foundation for lasting economic development and is therefore an important issue for China's central government. The integrative interlinking of rail and air is thus a key component of transportation policy.

China is the only country in the world to have a program for the short-, medium- and long-term development of the transportation system as a whole. The construction and upgrading of the transportation infrastructure, as set out in five-year programs, has always been ad-hered to so far. The financial resources for this are available thanks to China's currency reserves.

As a result of the restructuring of the transportation system in China and the transfer of responsibility for rail transportation policy planning to the Chinese Ministry of Transportation and Communications (in March 2013), which is now responsible for road, air, water and rail transportation, the chances are good that the different transportation systems can be integrated.

FIGURE 1: Overall transportation situation, long-distance passenger transportation in China, modal split in 2013



2. TRANSPORTATION SITUATION AS A WHOLE IN CHINA

As in countries all over the world, roads account for a high proportion of all transportation in China (figure 1). However, the relatively high percentage of long distances accounted for by rail travel compared to road and air travel is worthy of note. One reason for this is that the Chinese central government began to make huge investments in rail (high-speed and inter-city (IC) rail travel) at an early stage, and particularly in the last 15 years or so (figure 2).

In China there are 246 cities with a population of over a million, whereas in Europe there are only 25. Around 70 of the population of Europe lives in urban areas, and China will also reach this level of urbanization in the medium to long term. In view of the rapid growth of Chinese cities, the focus following the upgrading of the high-speed/inter-city network since the 12th five-year plan (2011-2015) will turn to a greater extent to the development of the urban rail network (figure 3).

The information on the development

of the transportation system as a whole is given for the years from 2011 to 2015 (12th five-year plan). The basic data comes from 2010 and is complemented by forecasts until 2015. The medium-term picture in terms of road, rail and air travel shows that road travel and air travel double every five years or so, while long-distance rail travel doubles every five to seven years. Urban rail travel also doubles roughly every five years. However, the highest rates of increase in transportation volume can be seen in air travel. Consequently, the development of air travel, the airports and the catchment areas of the airports was investigated with a view to improving the interlinking of rail and air travel at the cities' main transportation hubs by means of conventional and/or new types of rail systems or directly by means of high-speed/inter-city rail systems.

There are only a few airports on high-speed/inter-city rail routes (Hongqiao Airport with the new high-speed/inter-city rail station is one of them), so an investigation was conducted into the urban rail systems in Beijing, Shanghai and Nanjing. The links to the airports were discussed and assessed in terms of design, planning, engineering and operations with a view to making general statements about them. Relevant parameters were obtained, such as distances between the city centers and the airports ranging from around 12 to 65 kilometers, desired attractive travel times of 8 and 41 minutes and target train frequencies of 10 or 15 minutes. Express links from the main transportation hubs should be given particular priority [5]. As a result, suggestions for »

Mode of transport	10th five-year plan 2001–2005 in billions of yuan	11th five-year plan 2006–2010 in billions of yuan	12th five-year plan 2011–2015 in billions of yuan
Road and water Road (approx. 72% to 85%)	2,279 1,652	4,785 4,075	6,200 4,485
Rail	414	2,000	2,800 to 3,500 Approx. 82bn EUR p.a.
Air	115	1,100	1,500

Investment ratio in the 10th five-year plan for air/rail/roads: approx. 1:4:14
Investment ratio in the 11th and 12th five-year plans for air/rail/roads: approx. 1:2:4 and 1:2:3

Sources: China Statistical Yearbook 2002 – 2006, National Bureau of Statistics of China; Chinese Ministry of Transportation and Communications (MOTC), 2011, [5], CRC July 2014

FIGURE 2: Investments in road, rail and air transportation; Five-year plans 2001 – 2015

	Until the end of 2010	12th five-year plan 2011–2015	Long-term plan until 2020 or 2050
Urbanization 1)	47.5% 2)	51.5%	Target: 70%
Investment	450bn yuan	1,000bn yuan Approx. 26bn EUR p.a.	~ 100bn yuan p.a.
Line length	1,471 km (1,442 km under construction)	2,500 km 3) Up to approx. 440 km p.a. 52m EUR/km	Total 2020: approx. 6,100 km 2050: approx. 11,700 km
Number of lines	53	Approx. 96	Total 2020: approx. 177 2050: approx. 289
Number of stations	977	Approx. 1,600	2020: approx. 3,950 2050: approx. 7,550

1) Global average approx. 50%; Europe approx. 70%
2) Actually around 35% (due to the status of migrant workers)
3) Urban rail vehicle market: 1,000 to 6,000 vehicles p.a. at 4-6 rail cars per vehicle

Sources: Chinese Ministry of Transportation and Communications (MOTC), 2011-2014, own estimates [5]

FIGURE 3: Investments in urban rail transportation; 11th and 12th five-year plan and long-term plan until 2050

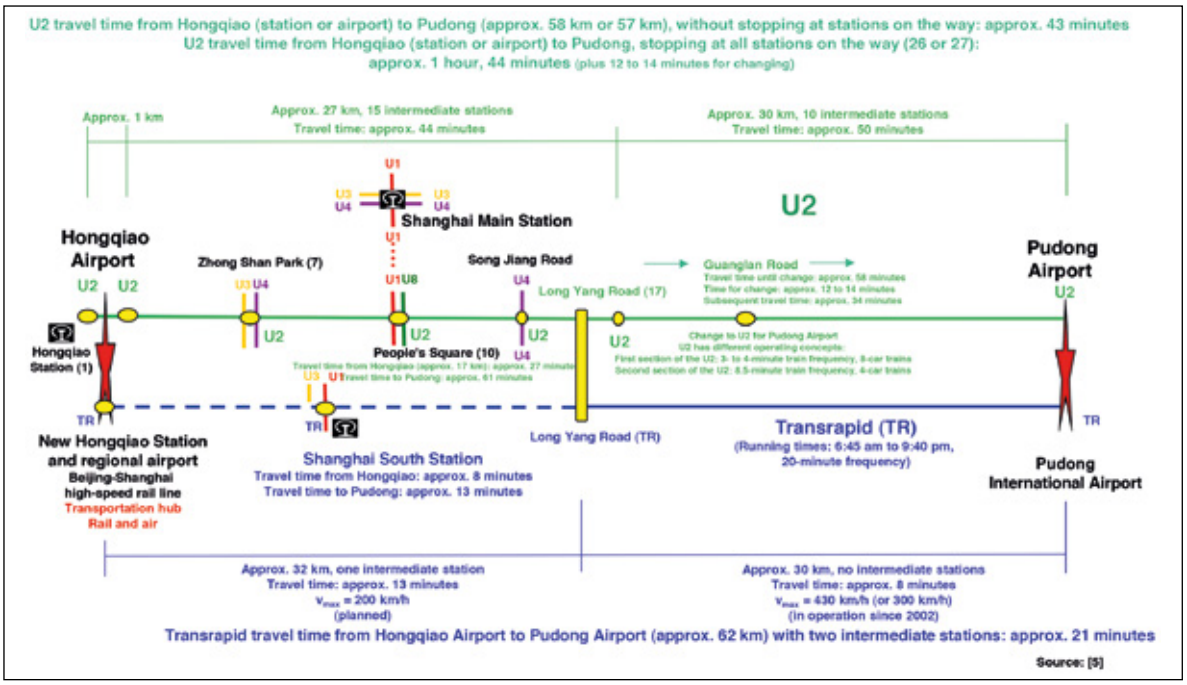


FIGURE 4: Airport links in Shanghai to Hongqiao Airport and Pudong Airport Travel times by Transrapid maglev rail link and metro (U2)

Key data on the operating cycle
Versions I to III; versions II and III with express trains (no intermediate stops)

	Version I	Version II		Version III	
	Without intermediate stops	Trains with 3 intermediate stops	Express trains without intermediate stops	Trains with 9 intermediate stops	Express trains without intermediate stops
Maximum speed	**100 km/h**	**100 km/h**	**100 km/h**	**80 to 100 km/h**	**100 km/h**
Total travel time [1]	23.9 minutes	**32.2 minutes**	23.9 minutes	**45.8 minutes**	23.9 minutes
Total stopping time	0.0 minutes	6.0 minutes	0.0 minutes	15.0 minutes	0.0 minutes
Stopping time per turn	6.1 minutes	7.8 minutes	4.2/8.0 minutes	6.7 minutes	4/8.2 minutes
Cycle time	**60 minutes**	**80 minutes**	**60 minutes**	**105 minutes**	**60 minutes**
Frequency	5 minutes	5 minutes	10 minutes	5 minutes	10 minutes
Number of trains for an operating cycle	12	22		27	
Number of reserve trains (+20%)	3	5		6	
Total number of trains	**15**	**27**		**33**	

1) Including 7% timetable buffer

Sources: Simulation calculations by Mnich, P.; Fritz, E. IFB; Mnich, P.; SHI, Y.: Alumni Seminar at CDHK, Oct. 2009, [5]

FIGURE 5: Nanjing airport link (type C-1 urban rail train)

improvements were obtained that serve as a model for the purpose of future planning.

If you consider that only very few of China's 190 or so current airports have an urban rail station, to the detriment of most of these airports' attractiveness and usability, the potential for improvement is clear. It is worth mentioning here that China is currently planning around 50 new airports. Taking into account the size of the country, the increasing volume of traffic and the fact that China as a whole is expected to reach the economic level of Western industrial countries some time around 2030, these plans seem reasonable.

An examination of the key transportation-related and economic data of the two regions in which the three cities are located indicates that they are the engines driving the growth of the Chinese economy as a whole. The key difference is just that the Bohai Rim region, in particular the city of Beijing, is the political heart of China and, as the capital city, Beijing is central to all transportation projects. The Changjiang Delta region, on the other hand, is primarily a center of finance, but it also includes one of China's most important industrial regions: the triangle formed by the three cities of Shanghai, Nanjing and Hangzhou. Consequently, the results of the investigation in terms of transportation systems and operations in these two regions can be reliably applied to other regions and cities, provided specific local circumstances are taken into account.

The central theme of all transportation-related, operational and technical investigations began with the analyses of traffic on the roads, in particular the roads to the airports, as well as the entire urban rail network, with a particular focus on the links to the airports. As far as the high-speed/inter-city route network between the cities is concerned, particular attention was given to the main urban hubs (stations) of the long-distance rail network. The focus here was on how these hubs of the long-distance rail network are integrated in the urban rail network (both in terms of the locality and transportation) and whether the airports can be reached without changing and/or by means of express links (i.e. whether there are at-tractive options). With regard to whether the airports have favorable rail links (urban rail and high-speed/inter-city networks), the volumes of passengers at the airports and the relative percentages of domestic and international passengers play an important role, as do the prospects for the development of the individual airports. The core rail network of the Changjiang Delta region (Shanghai – Nanjing – Hangzhou) was analyzed in detail for three key reasons. First: The new, 300 km rail line between Shanghai and Nanjing, part of the new high-speed line from Shanghai to Beijing, with a total length of 1,300 kilometers and total travel time of around five hours, is the busiest route in China. Second: This route is a typical Chinese high-speed/inter-city link either with stops or without them (in the case of express services). Third: The core rail network of the Changjiang Delta region (population: approx. 156 million) with an expected air traffic passenger volume in 2015 of around 180 million passengers, almost 80 percent of whom are domestic passengers, is of particular interest in terms of travel to and from the airports by rail.

3. CATCHMENT AREAS OF THE AIRPORTS AND USAGE OF RAIL AND AIR TRAVEL

On the basis of traditional transportation-related investigations of the airport catchment areas, these areas have a radius of around 100 to 200 km. The issue of the accessibility and development potential of the airports becomes particularly interesting when the catchment areas are affected by new high-speed/inter-city lines, for example. The new transportation links and the travel times from the point of departure to the airport influence the development potential of the airports. Compared to the static radius model, an analysis that uses travel time-dependent distance measurements of the most important modes of transport allows the volume of traffic to and from the airport to be ascertained more precisely. Fundamental to this process is that the rail transportation infrastructure is incorporated into the assessment of the potential of an airport and is accorded some priority. The distribution of the population in a region generally largely reflects the transportation

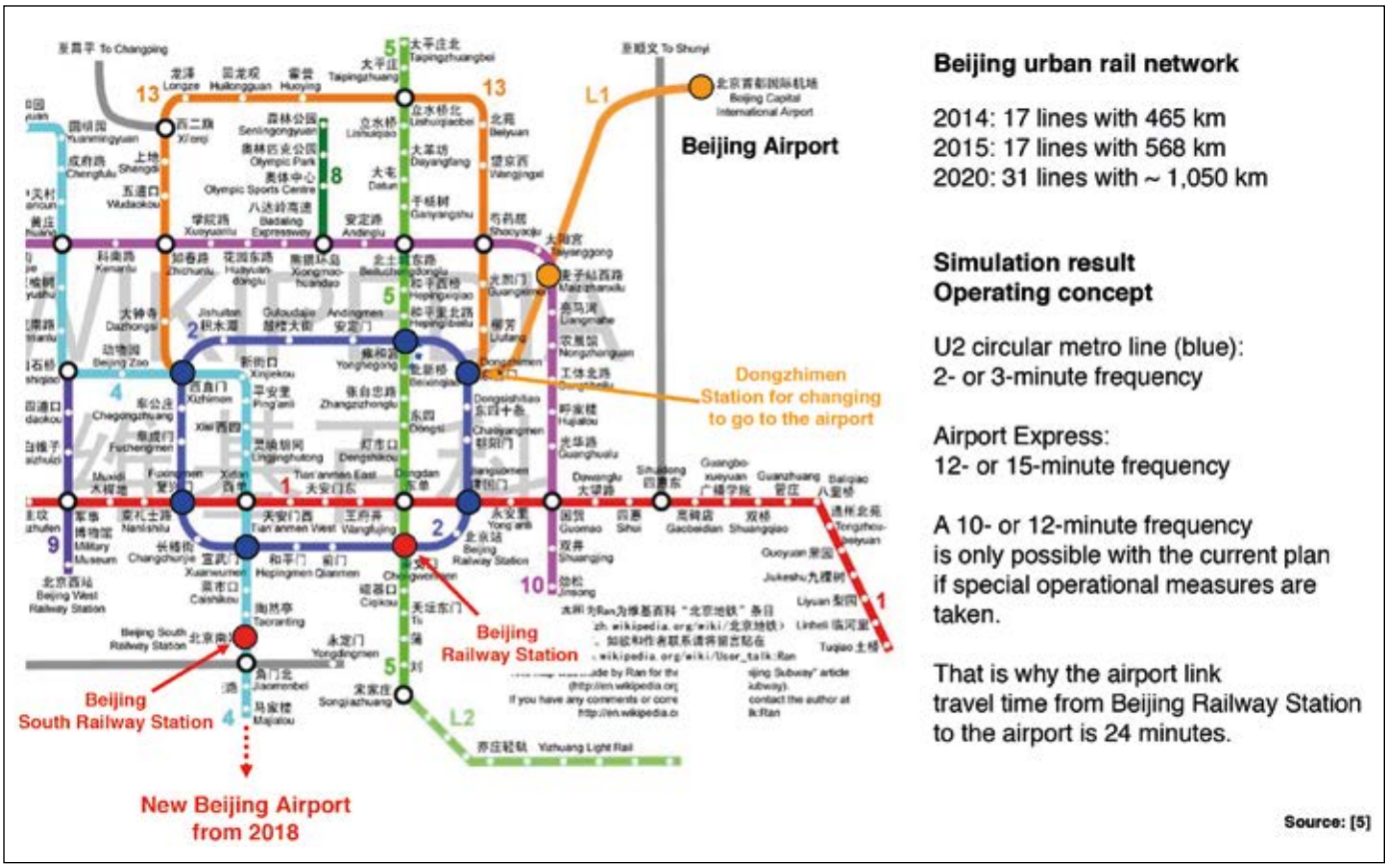
infrastructure and vice versa. Thus, the rail lines in the surrounding area of the airports or serving the airports directly have a decisive influence on the development of the airports themselves. Since this model of travel time-dependent distance measurement (where the travel time is calculated based on the average speed achieved, not the maximum speed) of the most important modes of transport is a decisive assessment parameter, the transportation examples from the Changjing Delta region, the economic and transportation triangle formed by Shanghai, Nan-jing and Hangzhou and the airport links in Shanghai (figure 4), Nanjing (figure 5) and Beijing (figure 6) in the Bohai Rim region were examined. The key finding was that the catchment areas of the airports increase in size from around 100 kilometers for a journey of roughly an hour to 90 minutes by car to around 300 kilometers for a rail journey of about an hour. If the airports are not on high-speed/inter-city rail lines (e.g. Shanghai Pudong Airport as opposed to Shanghai Hongqiao Airport), it has to be asked whether there are good, fast urban rail links (metro, light rail or other rail systems) to the airports from the high-speed/inter-city rail stations. The selected examples in both regions show that only urban rail lines that do not have mixed operating concepts (trains stopping at all intermediate stations and express services that do not stop) have been implemented. This increases the travel times between the main station in the city center and the airport by around an hour. Due to the long travel times, these purely conservative airport links are not very attractive.

This brief description of the transportation studies carried out indicates clearly that when there is a lack of system planning in order to interlink different transportation systems, in this case rail and air, the benefits of high-speed rail system are either not seen or the travel times to the airport are too long due to the fact that the urban rail services to the airports are based on unattractive operating concepts.

In relation to the planning/design, technical and operational aspects of transportation system planning, the problems that exist and the recommendations that can be made are essentially as follows:

1. An urban rail line to and from the airport must be planned as part of a system. In other words, a mixed operating concept (express services as well as services that stop at intermediate stations) should be included in the plans from the outset. This has significant consequences for the track plan of the line and for the sizing and technical design and layout of the stations on the urban rail lines (see the Nanjing airport link).
2. If an airport link does not go directly to a rail hub, the rail system of the airport link must be compatible with the rail system of the urban rail network; then there is the possibility of a link through to the rail hubs (see the Beijing airport link).
3. If a check-in option is provided at a long-distance rail terminal, logistics concepts have to be in place for passengers' luggage. If they are not, significantly more time has to be allowed for the journey (see the Hongqiao station, where there is a check-in option for Pudong).
4. In the case of airport links directly from a rail hub, it makes sense and is advisable to use new types of rail systems (pilot projects). Possible examples of this were the airport links in Nanjing (implemented with a conventional rail system) and Shanghai (part of the Transrapid high-speed maglev line). Any kind of magnetic levitation system or people mover system can be used – systems with or without wheels, monorail systems or sus-pension systems.
5. Before a new airport is constructed, either an express airport link service should be included in the plans in addi- »

FIGURE 6: Urban rail transportation in Beijing with airport link (part of the network map)



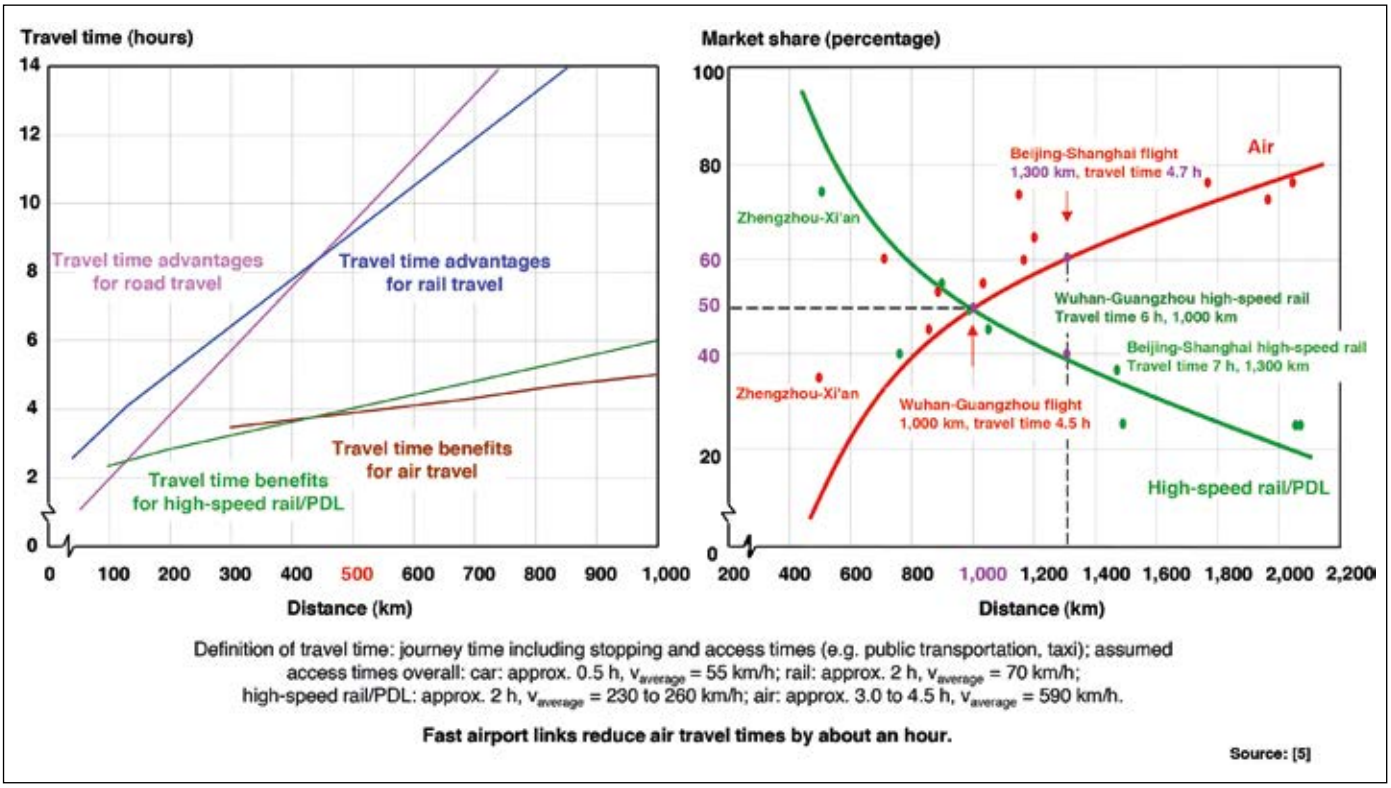


FIGURE 7: Travel times by road, rail and air depending on the distance involved and market shares of high-speed rail travel and air travel (direct links, China 2020)

tion to a conventional urban rail service with intermediate stops, or there should be a direct high-speed/inter-city rail link.

Selected new high-speed/inter-city rail lines were taken into account in the studies of the transportation systems in the Bohai Rim region in north-eastern China and in the Changjiang Delta region in central-eastern China. The potential for air passengers to switch to high-speed/inter-city rail travel, depending on the distances involved and taking into account travel time and travel costs, is as follows:

- → Distances of up to 500 km: high-speed/inter-city rail potential of up to 100%
- → Distances of 500 to 1,000 km: high-speed/inter-city rail potential of up to 50%
- → Distances of up to 1,500 km: high-speed/inter-city rail potential of up to 30%
- → Distances of greater than 1,500 km: low high-speed/inter-city rail potential (under 20%)

4. SUMMARY

When air and rail travel are integrated, the two modes of transport complement each other to optimum effect and their respective benefits can be fully exploited. Air travel is ideal for international journeys and domestic journeys of over 1,000 kilometers, while high-speed/inter-city and regional rail services cover journeys of up to 1,000 kilometers (figure 7). If this approach is to work, the key thing is that rail journeys have to offer attractive travel times. The prerequisite for this, however, is a good combination of the right operating concept (number of stops involved in a journey) and the maximum speed (a "reasonable" maximum speed in operation rather than the maximum possible speed!). Reference values here for a distance of around 1,000 km (Wuhan–Guangzhou) would be a travel time of around three and a half hours, for a distance of 500 km (Xi'an–Zhengzhou) a travel time of around two hours and for a distance of 300 km (Shanghai–Nanjing) a travel time of around one hour.

For airport links from urban rail networks, mixed operating concepts should be selected in order to provide direct, fast, attractive links to and from the major transportation hubs in the city without the need to change trains.

The operational issues associated with the selected link should be investigated in detail in the early stages of planning rail lines. This is the only way to ensure that there is sufficient scope to optimize the link subsequently. For this purpose there are various operational simulation software applications available that allow all country-specific, traffic-related and operational factors (distance from centers of business, network structure, etc.) to be taken into account in terms of system planning. It is important not just to obtain individual results in isolation but to discuss and assess them, taking traffic-related, operational and economic factors into account in a "whole system" approach. ◀

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Maintenance to ensure the fleet has a high level of operational reliability and safety

In depots and maintenance facilities for passenger and freight rail vehicles, the traction units, multiple units and vehicle fleet are maintained regularly and at the specified intervals all over the world using the required technical infrastructure. Modern methods are used to design these facilities.

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1. DESIGNING DEPOTS AND MAINTENANCE FACILITIES AT DB INTERNATIONAL

The services to be provided in the maintenance process range from maintenance during operation and repairs in the depots to maintenance with refurbishment and the replacement of entire components of the rolling stock in specialized maintenance facilities.

As a result of the constant procurement of new trains, the rolling stock is modernized more frequently these days. Thus, in addition to extending and adapting the buildings and technical equipment for the regular maintenance and repair of the trains, it is necessary increasingly often to build new facilities for new train generations.

DB International's teams of experts have many years' worth of knowledge and experience of upgrading and building new depots and maintenance facilities both for Deutsche Bahn and private-sector rail and public transportation companies. This involves structuring and sizing the facilities and designing the buildings and technical equipment as well as implementation management and transfer to the customer and also includes management and operational issues revolving around the maintenance process and the logistics of spare parts and fuels.

The experienced gathered in design, planning and project implementation in Germany is valued highly by DB International's clients and partners throughout the world.

For example, our vehicle and maintenance facility specialists are helping the Passenger Rail Agency of South Africa (PRASA) with the redesign of two model facilities for the new vehicle generation for the public transportation systems in Johannesburg (Braamfontein Workshop) and Kapstadt (Salt River Workshop).

A consortium consisting of T.Y.Lin, DP Architects, MVA (Systra), ARUP and DB International successfully completed the preliminary design for the extension of the Kim Chuan Depot for the Land Transport Authority of Singapore in October. The underground stabling and maintenance facility for driverless MRT trains, which was designed in 2001 and 2002 with the involvement of DB International and went into operation in 2009, is being extended and will be the largest facility of its kind in the world. At the same time, Singapore's largest bus depot is taking shape above ground for 550 rigid, articulated and double-decker buses.

In Germany, designing the new ICE facility in Cologne for DB Fernverkehr AG, for which DB International is the general contractor, is currently the biggest challenge facing DB International's engineers. It will be possible to maintain all of the vehicles of the ICE fleet and the new vehicle generation (ICx) for long-distance travel here in the future. »

FIGURE 1: 3D design for the modernization of the Salt River Workshop in Cape Town (Source: PRASA/MDK Architects)

FIGURE 2: Visualization model for the feasibility study (Source: Erik Eifler)

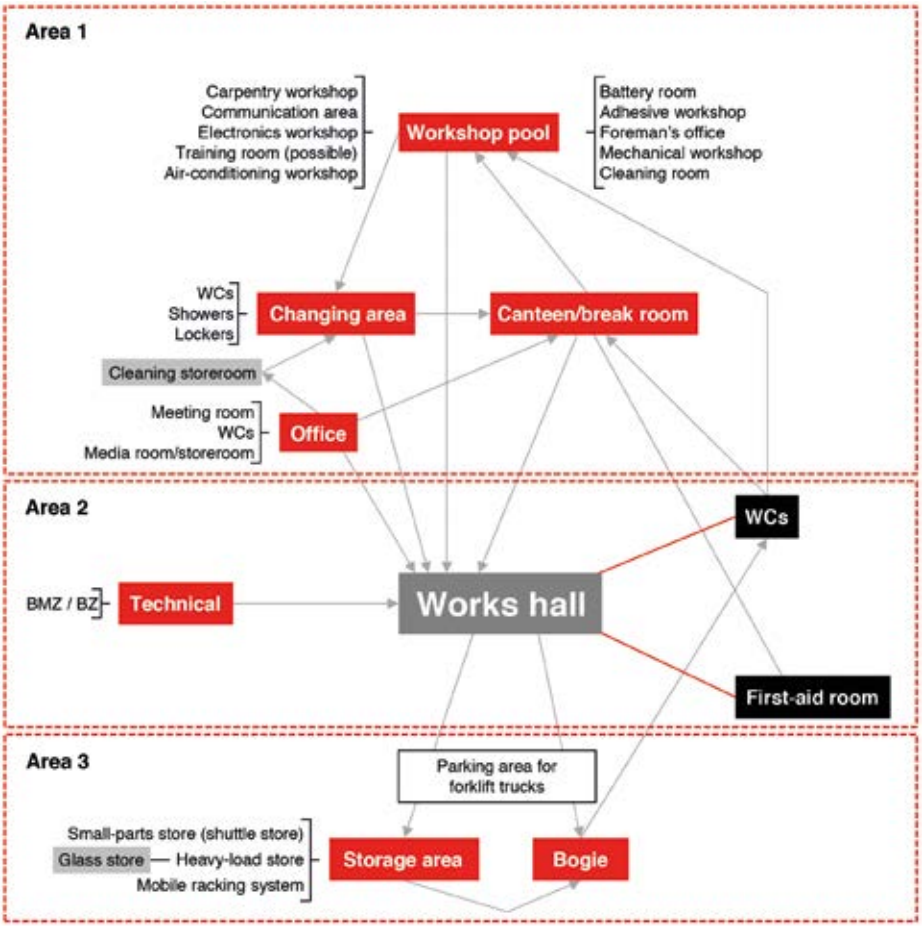
In order to address this demanding task, the design team is making use of building information modeling (BIM).

2. BIM IN THE ICE FACILITY PROJECT IN COLOGNE

A modern industrial building for Deutsche Bahn

At one time, industrial building was the engine behind the development of modern architecture and was considered to point the way forward in terms of aesthetic trends. Economic and functional imperatives are of critical importance in this particular field of activity, requiring the designers to come up with intelligent solutions. Industrial buildings are subject to huge cost pressures. Consequently, the potential of industrial building projects is often not fully exploited. Yet it is still possible to meet the financial requirements of the developer without losing architectural quality, as many examples from the present day show. It is the job of architects to meet the demands of the present day to optimum effect, to combine industrial production processes with flexible usability, the facilitation of communication, appropriate use of space and aesthetic and functional demands and to include all this in the design.

FIGURE 3: Space allocation concept for the feasibility study



For the development of a new generation of ICE facilities for Deutsche Bahn, these requirements have to be combined in a design process with modern, sustainable solutions for the supporting structure, the building envelope, the building services and integration into the urban surroundings. In this project, the task is to reflect the progressive nature of the DB Group in the building and set a standard. While taking into account cost effectiveness, the architectural language needs to be compatible with modern workplaces and production facilities, bring about process optimization in the workshop layout and be compatible with the Group's commitment to a sustainable approach. The design needs to take into account the needs of the user, motivate the employees and encourage communication. Finally, the solution must be a visible reflection of the positive image of the DB Group with a high recognition value.

In December 2011, DB International won a competitive tender for the construction of a new maintenance facility for the ICE/ICx long-distance fleet of DB Fernverkehr within the framework of a feasibility study. In order to visualize the design idea for the customer, 3D technology was used.

The requirements to be met by the project

The design team received very positive feedback from DB Fernverkehr for its understanding and implementation of the task involved in the project. DB International was commissioned with overseeing the design of this cutting-edge maintenance facility for Deutsche Bahn's long-distance fleet. DB Fernverkehr AG will be investing around 220 million euros, of which 60 million will be for the construction costs of the building.

The list of technical designers in a normal DB infrastructure project exceeds the number required for the technical design of conventional construction projects. However, designing such an ultra-modern facility requires a far greater number of different technical designs. Laying out a large number of functional areas appropriately is a further particular challenge in this project, and it was only possible to do this using software-based generalized 3D cubes for the room allocation scheme in the design phase.

In addition to the main function of a 443-meter long works hall with four maintenance tracks and six different working levels, a four-story office and administration section is required with meeting rooms, a well-appointed visitor room and a canteen. An additional part of the building has six different ancillary workshops,

a changing room with 750 lockers and a two-story technical section. Important functions such as the air-conditioning testing room, transformer rooms and the large storage units are located in another part of the building. Space has to be provided for the materials of the various maintenance processes – special automated lift systems for small parts, pallets and lattice boxes on narrow-aisle racking with a height of over 7 meters and appropriate floor storage space for large items and wheel sets.

The facility is equipped with the latest machinery:

- Eight slewing cranes with longitudinal travel and a lifting capacity of 1.6 tonnes for replacing heavy and bulky parts on the roof of the long-distance trains, such as the air-conditioning system
- Wheel-truck replacement apparatus for replacing complete wheel trucks and other heavy components on the underside of vehicles. This also allows difficult maintenance work to be done
- A special test facility for a wheel truck that is linked logistically to the replacement apparatus carries out measurements on the wheel truck and adjustments to the suspension under a simulated load
- The maintenance tracks have bridges to allow wheelsets to be replaced quickly and easily and for moving working platforms
- Ultrasound hollow-shaft testing systems, air-conditioning workshop and other testing rooms and workshops

For sustainable construction and operations, a dynamic building simulation was run to design an ideal, efficient and sustainable power supply for the facility. In addition, there is a geothermal plant that uses groundwater for heating purposes in the winter and cooling purposes in the summer. A photovoltaic plant provides renewable energy to run the geothermal plant. The fire water tank is used to store heat, and this energy is used in winter to de-ice the trains. Further energy savings are made by using LED lighting in the office and social rooms as well as outside.

The design of the facade of the works hall uses large polycarbonate plates. These fit easily onto a fixed, fair-faced concrete base. The plates are in the various brand colors of Deutsche Bahn and, thanks to their translucency, make considerable use of natural daylight. A smart lighting control system adds artificial light, as required.

FIGURE 4: Visualization of the ICE facility in Cologne (working model of the design)
(Source: DB International/Scholz & Friends)

Introduction to design

In order to go about designing such a complex facility, the fundamental requirements were ascertained first so as to get an understanding of the scope of the design task. In addition to the usual conventional 2D design, the extent to which the design processes could be improved had to be determined.

It appeared to be very important to promote interdisciplinary cooperation between the various specialists and to be able to make the current design statuses available to all project participants in order to avoid any loss of information. In addition, it was necessary to show flexibility and design different versions. During this phase, a decision had not yet been taken on the number of maintenance tracks to be implemented and thus on how large the works hall had to be. Three, four or six maintenance tracks were under discussion. Thus, three designs had to be produced in parallel in the first design phase. The design team therefore searched for a solution in order to be able to derive three individual designs from a single design with alternatives. Linking the design with a quantity structure and costs in the design model turned out to be important because, when they are not linked, the quantities and masses have to be added manually, which can result in errors. Moreover, using this efficient methodology saves time when making subsequent changes to the design and allows visualizations to be created quickly, making it easier to present the ideas developed to the customer and the partners involved in the project.

These requirements are met by using building information modeling (BIM) and BIM-capable 3D software, which has been used since the preliminary design phase in the first quarter of 2012 to realize the building design.

Building design: data structure and project processing

For the purpose of design, a central building model was created in which the architects do their design work. A team of eight architects is now working on the model in parallel, and the most important three specialist designers, who deal with the structural design, machine technology and technical building equipment, are included.

Agreements were reached in advance on the workflow to be adopted for working together. These included the level of detail to be exchanged and the stipulation of uniform parameters and naming conventions. It is advisable to use the same software application, but this can generally only be ensured if the specialist designers come from the same company. If different applications are used, exchange formats have to be specified. It is advisable to transfer the data via an IFC interface (Industry Foundation Classes). If this is done, more model information is transferred than just the 3D building geometry consisting of the various construction elements. To avoid any discrepancies or inconsistencies, IFC-certified design software should be used.

Furthermore, to enable the design to progress, milestones have to be specified for regular data exchange. Only in this way can the current design information of other disciplines be made available and the progress of the design be reviewed and driven forward.

Specifying who is responsible for which construction elements is a key decision in the model, giving the design a huge boost in terms of innovation. In a conventional design approach, the architect has to update the 2D system with the design work of the »

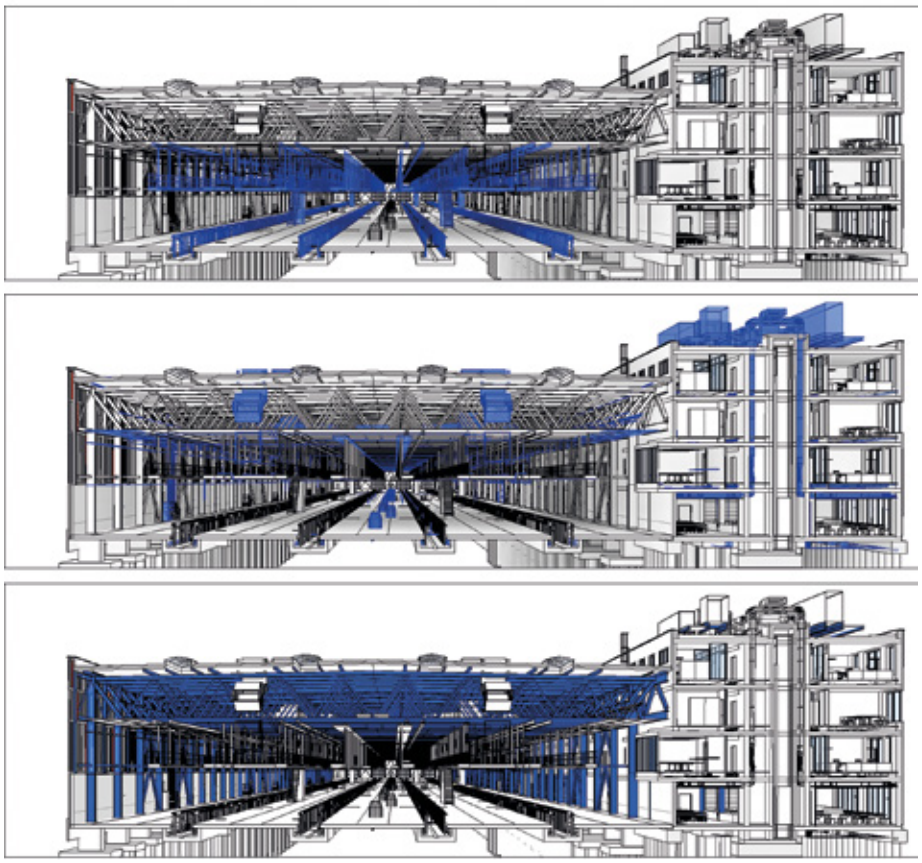


FIGURE 5: BIM model with machine technology (above), technical building equipment (middle) and structural design (below)

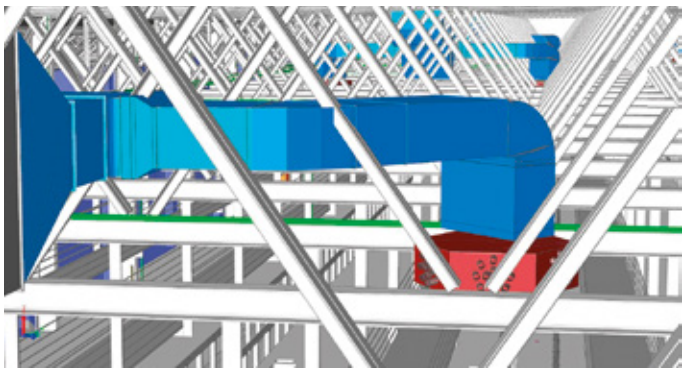
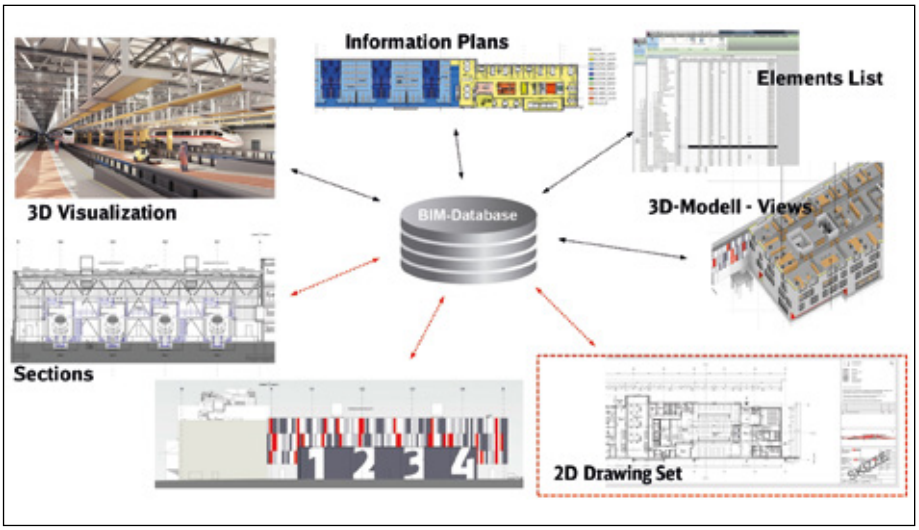


FIGURE 6: Collision of an element of the technical building equipment with the supporting structure

FIGURE 7: BIM data model



other disciplines. In the BIM approach, on the other hand, once the areas of responsibility are defined, all you have to do is manage the importing of the 3D design data. The figure below indicates the amount of design content that is not associated with the actual construction of the building but is nevertheless highly relevant to building design work (figure 5).

A further advantage of interdisciplinary 3D design is the fact that it is possible at any point in the 3D model to generate floor plans, sections and views and output them as conventional 2D views, thus saving a great deal of drawing work in the design phase. The designs of other disciplines are displayed at the same time. In the 3D design, collisions between the disciplines (figure 6) can be seen easily and eliminated.

Compared to a conventional 2D design, high-quality visualizations can be created with the 3D working model. These allow the ideas and solutions of the design team to be presented effectively to the customer or used in public relations work. By transferring the 3D working model to a different application, it was possible, for example, to create light simulations to allow good use of daylight.

In addition, all parameters and construction elements can be analyzed in lists, for example for schedules of rooms or masses and quantities. This also improves the design quality (figure 7).

DB International is currently aiming to bring together the key disciplines involved in building design nor just in a data model with exchange intervals but in a way that will allow them to carry out design work in parallel on a single model. The whole process thus comes very close to being visionary BIM design (figure 8).

Introduction to 5D

The project team was able to test the link to 5D design in detail during the design phase. The objective in working with the developers of a market-leading software application for tendering, awarding contracts and invoicing in construction was to calculate costs reliably on the basis of the designed 3D construction elements and to create a simulation of the construction process.

Cost calculation

To facilitate analysis, all 3D construction elements were encoded and a naming convention was implemented. The 3D design data was exported to a specially created file and then uploaded in the software for tendering, awarding contracts and invoicing. In the environment for tendering, awarding contracts and invoicing, the various construc-

tion elements were subdivided into selection groups and allocated to corresponding items in the bid specifications, in this case a cost calculation. Some of these groups were queried from the 3D model by means of programmed formulas. This step initially appears to be very time-consuming, but it was very efficient for all the subsequent phases. This is because, once the construction elements are linked with an item, the costs of any changes are calculated automatically. This significantly reduces the amount of effort required for the changes that occur on an everyday basis during the design phase, in particular when compared to the manual changes that were necessary previously. The fact that the masses and quantities for the items in the bid specifications from the 3D model can be used is worth emphasizing. The tables can be sorted again quickly on the basis of the required parameters (figure 9).

FIGURE 8: Visualization of a color scheme (BIM working model, detailed designs)
(Source: Kirill Gagarin)

Construction process model

The creation of a construction process model, in other words the linking of time and costs with the construction elements in five dimensions, is a powerful tool for the visualization of processes on the construction site. Even in the early phase, processes can thus be visualized that previously existed in the form of Gant charts in seemingly endless designs. However, this is not to reject the traditional schedule, which continues to be an important project management tool and is still required as a basis for 5D design.

The added value of 5D design obtained from linking costs and time lies in the output of a video film showing the progress of construction. In an animation, the software for tendering, awarding contracts and invoicing shows the progress of construction, provides a view of the conventional Gant chart and the current status of the item analogously to the construction progress model and, in parallel with this, the costs involved up to this point. The quality of the construction scheduling can thus be improved, and the construction supervisors can monitor progress more easily because they have an overview.

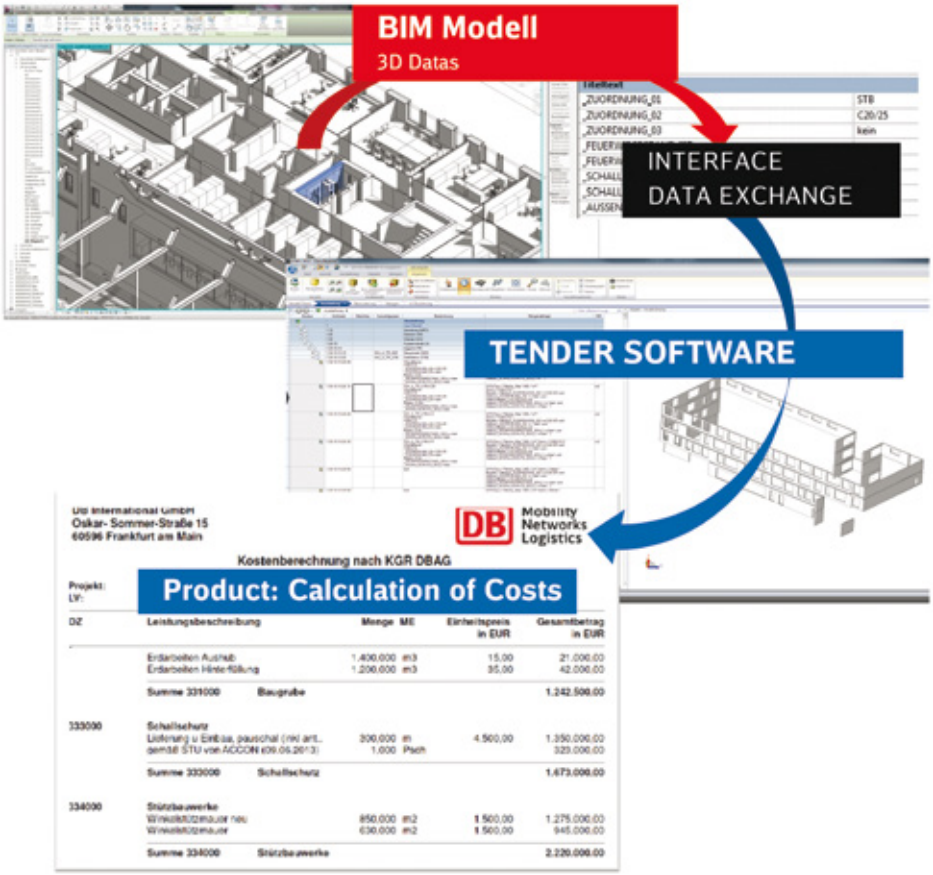
DB International believes that the particular benefits of the 3D model created in the 5D workflow are seen in tender preparation and the awarding of contracts to the companies that are to do the construction work. Because the 3D construction elements can be allocated to individual bid specifications, the items can be visualized. This makes items clearer, and the allocation to bid specifications means that the tenders of the companies competing for the work are comparable and that errors are avoided in the preparation of tenders. All parties benefit from the potential, resulting in a higher level of quality and a lasting reduction in the time that has to be invested.

3. CONCLUSION

It was the right decision to take this innovative approach to design for the project to construct the new ICE facility in Cologne. Experience has shown that, despite the amount of advance effort required, when it is used correctly, the 3D/5D technology can result in significant reductions in design effort overall, and particularly when subsequent changes are made. The clients thus receive visually innovative and resilient design solutions.

Building information modeling methodology will continue to be developed in order to realize what is still only a vision in the industry: namely that it should be possible to use the methodology right from the initial project idea to the ultimate dismantling of the building. ◀

FIGURE 9: Workflow for using 5D with software for tendering, awarding contracts and invoicing



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