The economy of freight

Never-ending railway lines
Freight trains that cross continents

It all started with the London Tube
150 years of underground trains
Dear readers,

It is certainly not new knowledge that goods transport is recording huge growth rates. The reorganization of the political landscape in the 1990s, particularly in Asia and Europe, brought about the social and economic structures that made globalized markets possible for the first time. In the two decades between 1990 and 2010 alone, the global volume of cross-border goods trade almost tripled – and there is no end to this trend in sight.

At the same time we can observe a rapid process of urbanization. According to UN estimates, as early as 2025 there could be over two billion people living in cities with populations of over 500,000. This presents an enormous challenge for logistics experts, since transport routes are often not able to cope, and options for expansion are limited. The problem applies to both established cities and modern logistics hubs.

How can transport be organized, among this sprawl of interfaces and junctions, so as to avoid unnecessary waiting times, holdups and harmful emissions? In this issue of como two examples – the expansion of the duisport logistics hub and the smart traffic control system in Potsdam – demonstrate how intelligent IT solutions can elegantly and reliably improve the situation.

Long-distance transport, linking different regions and crossing continents, often presents a whole other set of questions. Highly economic operation over the entire logistics chain is critical, as well as the fact that goods transport remains fault free and safe in every respect. Safety, efficiency and resource-friendly operation are key reasons why even more logistics managers will opt for rail transport in the future, especially when moving heavy goods. Transporting goods by rail is considerably quicker than taking the sea route, particularly over long distances, and significantly less expensive than air cargo.

Many challenges in rail transport can be overcome with the aid of individual automation solutions. Safety technology for rail systems has proven itself for over 150 years. Siemens has been on board from the beginning and still plays a key role in the onward development of innovative technologies for rail automation – a current project is the recently opened Marmaray Tunnel, a rail connection under the Bosporus that links together the European and Asian parts of Istanbul.

However, different continents also present different kinds of challenges. You can find out how and why in the following pages. Read about the development of rail freight in the United States, about stand-alone rail networks merging on the Australian continent, and about current projects on the double continent of Eurasia.

I hope you enjoy this issue of como.

Yours sincerely,

Kevin Riddett
Siemens Rail Automation, Freight and Products

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Transport and logistics are considered foundations of a prospering economy – and when business is booming, the transport volume rises in turn. But how will additional freight transport be accommodated when the roads in Europe are full? Which rail routes can play a greater role in terms of trans-European freight in the future? And do European policy-makers need to become more aware of their strategic responsibility? An interview with Professor Sebastian Kummer, Head of the Institute for Transport and Logistics Management at Vienna University of Economics and Business.
In general terms, is Europe equipped for further growth in freight transport? And can our roads accommodate even more truck traffic than they already do today? As a whole, the transport volume will continue to rise — there is no doubt about that. However, at least when it comes to the roads, long-distance transport faces a dilemma for another reason. On the one hand, the political and economic pressure to further reduce emissions can be expected to increase; and on the other hand, greener long-haul trucks with alternative drive systems are simply not available. So additional growth on the roads in the coming years could be slowed by new legal regulations, perhaps even blocked altogether.

So we’re going to see a major opportunity for rail and barge transport?

To a certain extent, yes, though certain factors point toward more rail, as the highest growth in volume will be for long-distance transport. There are several reasons for this: Firstly, the division of labor between the East and the West is becoming more pronounced. Secondly, Europe’s economic links, including those with the republics of Central Asian, are becoming more stable. And thirdly, Western Europe and China are forging even closer trade relations. Barges cannot meet this demand; the railways will have to take on most of the load.

Though rail transport across Europe and Asia has its own complications . . . Of course, there are considerable challenges in transcontinental rail transport. For instance, Europe and China have standard-gauge rail networks, while the Iberian Peninsula, Finland and countries in the CIS region have wide-gauge networks. So there are technical barriers. Yet the exchange of goods between the countries of the East, Central Asia and Western Europe has risen dramatically in recent years. In this respect, I believe there is considerable growth potential in the rail routes into Southern Europe, through Turkey and into the East. Turkey has recognized this and continues to expand its transport routes. A current example is the newly opened Marmaray Tunnel that runs beneath the Bosporus between the European and Asian parts of Istanbul — here the trains run on standard-gauge tracks all the way to the Caspian Sea.

One solution for switching between standard and wide gauge is to use gauge-changing facilities, where the wheel disks can be shifted on the axles or the bogies can be changed. You yourself are currently involved in an international standardization project. Do you see this as a solution for different gauge widths?

The International Union of Railways (UIC) and the Organization for Cooperation of Railways (OSShD) founded the working group “Automatic Gauge Changeover Systems” in 2011 for standard gauge and Russian and Iberian wide gauge. Gauge changeover is a useful technology, but in freight transport it’s better suited to shorter routes, by which I mean a few hundred kilometers of direct cross-border transport. Not only does it involve additional investment costs for wagons and facilities, it also increases energy consumption and wear on vehicles. In the long term, therefore, building fixed infrastructure is technically and economically preferable to gauge changeover. Spain, for example, intends to change practically its entire network to standard gauge for this reason.

China also appears to attach great value to high-performance rail corridors. However, the transport routes constructed so far run through countries with a wide-gauge network, which means unloading and reloading twice. Now experts are discussing the interesting idea of laying a standard-gauge route heading south through Kazakhstan and into Europe via Turkey — rather than through Russia — eliminating the need to reload . . . . .

. . . and this new route will come, I am absolutely certain. It will give freight carriers the choice of how to get from the western border of China into Western Europe: by heading north via Moscow or by taking the southern route via Istanbul. Incidentally, the European Commission has defined both transport routes as strategic freight transport corridors. For us Europeans all this development is heading in the right direction — but we also have to set up our infrastructure within Europe accordingly and think about how to handle flows of goods arriving via this new southern corridor.

Are there not other positive approaches, for example the current plans to extend the Russian wide-gauge route from Košice in eastern Slovakia to the Danube in the Vienna-Bratislava economic region?

This idea has been around for a few years, and now the project appears to be actually getting underway. All the participating states — Russia, Ukraine, Slovakia and Austria — have a great interest in the project being implemented, and of course from an Austrian perspective I support it too — because I am convinced that it will have a very positive impact on the economic region.
As long as projects are being coordinated between nations, national interests are going to play a major role, and in the end the transport ministers will agree on the lowest common denominator. But this is no way to realize European-wide, integrated transport concepts – the best ideas are always going to be held back by countries protecting their vested interests. In Russia or China, on the other hand, such projects are always regarded from both a macroeconomic and a political standpoint. Russian Railways certainly views a project like the wide-gauge extension through Slovakia to Vienna as a political project, as it would help to strengthen direct links between Russia and the Danube region.

Is it generally easier to implement these kinds of projects in countries like Russia and China?

Poland, as a standard-gauge country, also already has some 1,520 mm routes. Why does it not figure in the current plans? In Russia in the 1990s, considerations were made to use the existing wide-gauge route into the Silesian mining region and to extend it. But Poland was primarily interested in links to western regions. The reasons for this are historical, though today the Polish economy could have a greater interest in an east-west route running through the country. Overall my impression is that infrastructure projects in Europe are often only evaluated very one-dimensionally.

So is there a need to go beyond the corridor plans and establish an integrated freight transport concept – a strategy for managing further growth in transport volume as smoothly as possible?

That’s how I see it, and I believe this is one of the major weaknesses of EU policy. We hear many statements of political intent from Brussels when it comes to transport infrastructure. In my opinion there are many more questions to be answered. Which modes of transport make sense on which routes and are worthy of funding? Where do we need to create or strengthen hubs? How can we simplify, for example, legal regulations and safety and information systems?

A European strategy would certainly be very desirable, since all these things have to be planned and implemented on a supranational level. Yet the national mechanisms of separation appear, for historical reasons, to still exert quite a strong influence. Do the political structures in the EU today actually give rise to supranational concepts at all?

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Is it generally easier to implement these kinds of projects in countries like Russia and China?
Sebastian Kummer studied economics and philosophy at the University of Tübingen and business administration at the University of Cologne. He gained his doctorate at the WHU – Otto Beisheim School of Management in Koblenz, where he worked as a research assistant up to 1996 and qualified as a professor with his work on “Environment and corporate value – tasks and tools of value-oriented environmental management.” In 1996 and 1997 he was offered faculty positions at the University of Bayreuth, HHL Leipzig Graduate School of Management and Dresden University of Technology. He subsequently began as a substitute professor for business administration at Dresden University of Technology, specializing in transport management and logistics, and he was later appointed as a university professor. Since 2001 he has been the Head of the Institute for Transport and Logistics Management at Vienna University of Economics and Business.

Sebastian Kummer is also the Scientific Director of the Austrian Society for Traffic and Transportation Sciences (ÖVG), a Board Member of the Austrian Logistics Association (BVL) and a Scientific Advisory Board Member of the German Logistics Association (BVL). He is a joint editor of the scientific journals Logistics Management and International Transportation.

Definitely. Owing to their history of planned economies, both countries have a strong predisposition toward rapid planning and implementation. While we in Europe spend decades discussing projects and decades longer putting the plans in place, these countries identify the strategically crucial infrastructure and start building. This may not by very pluralistic from our perspective, but it is very effective.

Especially since a rail route alone is not the whole solution. It requires corresponding roads, port facilities... ...exactly. Let’s just take the previous example of a wide-gauge link to Vienna. At least at the terminus a container transfer facility is required for the standard-gauge railway. Yet this needs to be close enough to the Danube to also allow containers to be reloaded onto barges. Ideally it would also include air transport, and certainly trucks as local and regional distributors. You might call it a quadrimodal terminal.

All a question of clever planning? It’s more than that, because the whole thing always has to be planned and paid for by various interest groups. Passenger transport is constantly on the rise as well, which means it is competing with goods transport for use of the available routes – and this applies to all successful economic regions, not just the greater Vienna area. The greatest challenge of all, in my eyes, is the fact that right now we often reach the capacity limits of our roads and railways at peak times, and yet we still have this future volume growth to accommodate. And it can only be overcome with integrated solutions.

“When national interests play a major role, in the end the transport ministers agree on the lowest common denominator. But this is no way to realize European-wide, integrated transport concepts.”
Going with the flow
Economic forecasts may not be as rosy as they were several years ago, yet global flows of goods continue to grow. Nevertheless, this positive trend poses major challenges for many sea and inland ports, airports and goods distribution centers, hubs, and intersections of goods handling.

For these intermodal logistics centers, the integration and synchronization of transport processes are crucial to their ability to compete. Clearly, alongside the performance of terminal facilities, a key factor is their accessibility, that is, how efficiently they are connected. What waterside restrictions affect ships coming into the port? Is a sufficient number of easily accessible railway sidings available? Can the truck driver use the approach routes without getting held up? And the overarching concern: will it still be possible to process the increasing flows of goods smoothly in the future?

These were also the questions being asked at duisport, the operator and developer of the world’s largest inland port. Situated at the point where the Rhine and Ruhr rivers meet, the port is ideally located. Its function as a trimodal logistics and transshipment center – connected by well-developed canals, numerous rail routes and a network of major highways – means it also serves as a hinterland hub for the seaports of Zeebrugge, Antwerp, Rotterdam and Amsterdam.

The port facilities, with a total logistics area of 1,350 hectares, are divided into several zones. The traditional core port in Duisburg and Ruhrtort has numerous extensions, including logport I and logport III on the left bank of the Rhine, logport II on the right bank, and other logistics locations in the Ruhr area. The statistics show over 20,000 trains and 20,000 ships per year coming into the 21 docks, which have a water area of 180 hectares and 16 kilometers of handling quays with rail connections. More than 110 million tons of
cargo were handled at Duisburg Port last year, including a container volume of 2.6 million TEU (1 TEU = a 20-foot container). Added to this are various warehouse and storage facilities, shuttle transport and other integrated services. Over 300 logistics companies, service providers and industrial suppliers have set up locations on the port site. Around 1,000 people worldwide are employed by duisport group and its subsidiaries, which include duisport packing logistics in Shanghai and Mumbai, and duisport consult, the group’s own team of logistics and port concept consultants. “Being able to offer the classic port business combined with various logistics services improves the stability of our earnings,” notes Erich Staake, CEO of Duisburger Hafen AG.

duisport: more growth is the goal

The group has had considerable success. Although the global economic motor has been spluttering of late, duisport’s business grew by 8 percent in 2012 – and the growth is set to continue. “Through targeted expansion and construction of new terminal capacities, we have created the conditions for future growth. In container handling we will record a double-digit increase this year,” says Erich Staake, who also makes the following forecast: “By 2015 we will have the capacity to handle five million standard containers per year.” The port operator is expanding the rail connections to the surrounding area and to the seaports through a huge investment program, and soon it will be operating more goods trains heading to Southern Europe and Turkey.

Naturally, this also poses greater demands on the local infrastructure – particularly the access roads to the terminals will have to cope with considerably higher volumes in the future. Even today these roads can become visibly busy at certain times of the day. This is why the company hired the Siemens Mobility Consulting team to carry out a targeted problem analysis and search for technological solutions. Incidentally, such a partnership has already proven successful in an international project to optimize the hinterland infrastructure at the Brazilian seaport of Port Santos. While duisport consult specializes in port and logistics concepts, the Mobility Consulting team, with its all-around expertise in business processes, proven hardware, automation technology and tailored IT solutions, brings to the table Siemens’ strengths in linking road and rail transport.

Step by step to optimum efficiency

The issue can be summarized very briefly: How do we control and optimize the flow of transport to and from the port facilities on the existing transport routes? How do we make better use of the available resources? It is also clear that the solutions have to be efficient and sustainable, that bottlenecks in the port network are alleviated as economically as possible, and that processes are streamlined where it makes sense.

For the purposes of their study, the consultants, who received support from Siemens experts for rail and traffic
technology, decided to focus on one of the port zones, logport I, as a pilot area. In cooperation with project managers from duisport, they initially identified critical areas in terminals and in the road and rail networks, and they projected the transport volumes for the years 2015 and 2020. At the same time they analyzed the potential and the limits of the existing infrastructure – and developed a future solution scenario based on technologies that are already available. The example of logport I allowed them to develop a practical step-by-step plan and a detailed cost-benefit analysis.

The first thing that became apparent was that, in some cases, the logport terminals are already hitting their capacity limits at peak times. Truck drivers have to cope with waiting times at certain points in the day, and forecasts indicate further growth: up to the year 2020 the transport volume could increase by around 65 percent. This would cause the access areas of the terminals to become overloaded. Long, wasteful holdups would lead to a lack of planning security for the haulers and shippers, and make it almost impossible to predict how long the ships and container trains would have to remain idle. Furthermore, there are unnecessary information gaps in the registration process. In other words, without targeted countermeasures this situation would lead to significant traffic problems, which would endanger the port’s growth and competitiveness.

A coherent transport management strategy

However, there are solutions – developed with proven, intelligently combined technologies – to optimize all the processes along the logistics chain. The recommendations basically involve three packages of measures:
- **Greater transparency**: In real time all important information on the general traffic situation as well as arrival times at the railroad terminal are registered and analyzed.
- **Tailored flow control**: Via IT interfaces the various actors, such as shippers, terminals and truck drivers, are supplied with route and slot information. As a result, traffic jams are avoided, waiting times are reduced, and additional capacities are freed up.
- **Establishment of an intermodal port control center**: All relevant information – for example on the traffic situation or arrival times of trucks, trains and ships – are bundled, processed and relayed to internal and external transport management systems to centrally control and optimize the port.

The term Intermodal Hub Control covers the measures that were developed in the first phase of the project. To optimize future handling processes at the port, road and rail transport logistics as well as projected arrival times of the different modes of transport need to be integrated and synchronized. By intelligently networking different modes of transport and information on currently available resources, logistics processes can be improved significantly.

One strategy – many applications

The next phase is already getting underway: a planned pilot project will gradually put the Intermodal Hub Control strategy into practice. User acceptance will be tested, and further improvements – such as greater planning security and better fault management – will be made for all those involved in the logistics chain. It should also become apparent how well the strategy can be transferred to similar cases – and thereby present an opportunity for duisport and Siemens to continue their successful collaboration in further projects.

Ultimately, many cargo airports, sea and inland ports, and other major handling centers around the world are faced with challenges similar to duisport. They have to protect their hinterland connections from the threat of transport chaos before they lose their appeal for logistics customers.

Just recently the duisport consultants received a contract from Dubai to develop a comprehensive concept for connecting the port of Jebel Ali to the hinterland. “For such a large seaport, an optimally integrated hinterland concept is essential to ensure that goods can be brought to and from the port quickly,” says Erich Staake. Jebel Ali, one of the world’s largest container distribution centers, will primarily be connected by rail. A direct rail link to Duisburg Port would appear to be a logical option.

“Only through integrated control of all modes of transport can logistics hubs deal with growing transport capacities.”

Dr. Padideh Moini Gützkow, Siemens Mobility Consulting
With industry and business being conducted on a global scale, clogged streets and increasing pollution, it would be a logical work. Indeed, the significance of rail freight over large distances and the double continent of Eurasia. In every case the goal is efficiently as possible. However, due to a variety of historical, are remarkably different.
long-distance freight transport is constantly growing. In light of step to shift more transcontinental freight onto the railway net-is noticeably on the rise, for example in North America, Australia to get the freight to its intended destination as quickly and geographical and political conditions, the paths toward this goal
USA – railways from coast to coast

With an area of 9.83 million square kilometers, the United States is the third-largest country on earth – the distance from Canada in the north to the Mexican border in the south is around 2,500 kilometers; from the Atlantic to the Pacific coast it is around 4,500 kilometers. Bearing such distances in mind, it made sense to create rail links between the north, which led the way with industrialization, and the west, which was later colonized on a massive scale.

Initially the most important transport routes were broad, water-abundant rivers. The first rail route on the continent was built in 1826 to supply granite from the quarries in Quincy, Massachusetts, to the loading point on the Neponset River. The first American railway company for regular goods and passenger transport, the Baltimore and Ohio Railroad, was founded in 1827. It built a line heading directly west to the Ohio River, a tributary of the Mississippi. The first part of the line was commissioned as early as 1830. Incidentally, from 1867 to 1914 this innovative railway company acted as a kind of intercontinental transport association. It offered passengers taking the ship from Bremerhaven to Baltimore the chance to purchase their tickets all the way to the Midwest while they were still in Europe, changing directly from the ship to the train at the pier in Baltimore.

The main focus, however, was on goods transport. Up to the late 1850s there were new railway companies springing up in all the East Coast states. By that point these companies of various sizes were operating a standard-gauge rail network between the Atlantic coast, the Mississippi River and the Great Lakes with a total length of 48,000 kilometers. However, due to the mountain ranges on the east and west coasts, it was not possible to travel by river or canal in every desired direction, which is why President Lincoln, during the Civil War in 1862, approved the construction of a transcontinental east-west railroad to California. The idea was to link California, which had become a U.S. state 12 years previously, with the rest of the country. As soon as the war ended, Union Pacific Railroad and Central Pacific Railroad began with construction.

Other transcontinental links were established up to the start of the 1880s, and even the Midwest was well connected by the railroad. In the densely populated Corn Belt, 80 percent of farms were soon within eight kilometers of a rail line, which was ideal in terms of supplying the national and international markets with grain, pigs and cattle.

The network reached its peak of expansion in 1916, with a total length of almost 410,000 kilometers. In the 1920s, however, increasing car traffic and the construction of transcontinental roads, such as the Lincoln High-

Length of all goods railways in the United States
way between New York and San Francisco and the “Mother Road” Route 66, signaled the start of a slow downfall for the railroads. Then, in the 1950s, when the economy was booming and many four-lane interstate highways were built following the model of the German Autobahn, the rail transport volume declined for such a sustained period that at the start of the 1970s there were hardly any trains running on most routes. Many railroad companies joined forces to form larger units, yet the rigid regulations of the Interstate Commerce Commission (ICC) prevented them from offering flexible pricing or services. Open competition was not possible. While almost the entire remaining passenger transport business was transferred to the state-owned company Amtrak, founded in 1971, rail freight companies were simply going bust one after the other. This only changed after the Staggers Rail Act deregulated the market in 1980. It lifted many restrictions on pricing, freight contracts and sales of rail lines, allowing the remaining railway companies to halt the dramatic downward trend.

**Strong momentum: container transport on the rise**

Today railways are again playing a major role in mass freight transport over long distances – with total annual revenues of $70 billion. Seven large, so-called Class I railway companies are state owned and operate a rail network of 156,730 kilometers. Added to this are 21 Class II shortline and regional railroads and 539 Class III local railroads, similar to the non-federally owned operators in Germany. Altogether the network of all goods railways has almost 223,000 route kilometers.

And the wagons are rolling: In 2011, for example, the Class I trains alone completed an estimated 2.8 trillion ton-kilometers. Some 24,250 locomotives and 1,283,000 freight wagons were in operation and each freight train transported on average over 3,538 tons. Approximately 39 percent of the total freight volume was coal, with chemical and agricultural products well behind in second place with around 10 percent. The statisticians attribute around 15 percent of the total freight to intermodal transport using truck trailers and containers. And this segment is growing fast: since double-decker wagons for two stacked containers came into regular use in the mid-1980s, each train has theoretically been able to transport twice as many units, resulting in considerably lower costs per container. Thanks to such innovations, transcontinental container transport has increased sharply in the United States in recent years. Now it is more economical to unload ship freight as soon as it reaches the West Coast and distribute it from there by rail. Looking at the figures, the seven major players in the freight industry have managed to increase their transport volume by 88 percent over the last three decades, despite their rail network contracting by 42 percent.
Improved safety – also for freight trains

It would be possible to do more, but most of the freight lines are not electrified and many have just a single track and are only suitable for extremely low speeds. Out of approximately 136,000 railroad crossings in the United States, only around 42,300 are equipped with barriers, 22,039 with flashing lights, and 1,196 with traffic lights, wigwags or bells. Nevertheless, the railroad companies spend an estimated $200 million each year on maintaining railroad crossing safety systems. Indeed, train safety in the United States has a long tradition that is also connected to the history of Siemens.

For example, around 1868 George Westinghouse developed the air brake and founded the Westinghouse Air Brake Company – its subsequent subsidiary Westinghouse Rail Systems is now part of Siemens Rail Automation. The Westinghouse Air Brake is the most widely used braking system for rail vehicles worldwide. This equipment was made mandatory in the United States by the Safety Appliance Act of 1893 – along with the semi-automatic coupler invented by Eli Janney. After this the number of accidents involving rail vehicles rapidly declined.

Most of today’s safety systems – including those developed and installed for many years by Safetran, which is now part of Siemens – are controlled electronically, and they directly or indirectly support railway personnel. These systems include braking control, digital speedometers, vigilance and alarm systems, shunting technology for journeys at very low speeds on train classification yards, and automatic charging stations on board the locomotives. To ensure safety along the railroad, operators count on reliable mechanical barriers, LED signals that can be installed wherever required, and warning and control systems for interlockings and remote-controlled devices. Complete modular systems prevent accidents at level crossings; the systems are delivered in containers and are a sort of turnkey solution. Proximity sensors activate the systems automatically, and the advance warning time adjusts to the speed of the train so that car drivers and pedestrians need not be held up for longer than necessary.

Automatic train control systems, which perform tasks such as monitoring speed and can even intervene if necessary, were uncommon in freight trains and local trains for many years due to their lower speeds. Only in 2008 did it become mandatory by law to have a GPS-supported Positive Train Control System (PTC), although many vehicles and trackside equipment have still to be upgraded. This is another instance where Siemens can help to increase safety – after all, the Trainguard train safety system, which now fulfills the PTC standard as well as the CBTC and ETCS standards, has been demonstrating its reliability in many countries around the world for several years.

Positive Train Control: no compromises on safety

Automatic Train Control systems monitor a train’s journey and can also intervene in dangerous situations, for example by activating emergency braking. With Communication-Based Train Control (CBTC) systems, movement authority and control commands are not indicated to the driver by signals, but are issued via data communication between the rail vehicle and the trackside equipment. A trackside computer tracks all assigned trains on the line and automatically provides the on-board computer with guidance data. Alongside the European Train Control System (ETCS), this category includes Positive Train Control (PTC), which is to be introduced on U.S. routes nationwide.

The PTC system architecture includes the back-office server, which records parameters such as the train headways determined by GPS signal, compares these with safety and line regulations, and transmits relevant driving instructions to the train’s On Board Unit (OBU). Wayside Interface Units (WIU) along the route monitor signal and switch settings and also forward this data to the OBU, which monitors the train’s speed and applies the brakes if necessary to comply with regulations. All sub-systems are in contact with one another via a communication cloud.

Siemens is present on the global market with numerous train safety systems, including the Trackguard and Trainguard product families, which can meet the PTC standard as well as CBTC and the various ETCS standards. One system that works like a PTC is the Siemens Sentinel system. It is currently being implemented on a 900-kilometer mine railway in Mozambique and in Australia.
When the originally separate British colonies on the Australian continent came together to form the Commonwealth of Australia on 1 January 1901, they created the first state that covered an entire continent. Equally remarkable is the enormous scale of the country, which extends around 3,700 kilometers from north to south and roughly 4,000 kilometers from east to west.

Due to the climatic conditions, the population and industrial locations are distributed very unevenly. The Western Plateau, which makes up around 60 percent of Australia’s landmass, is covered in great arid deserts, smaller mountain ranges and inselbergs such as Uluru, also known as Ayers Rock. In the Great Artesian Basin is the driest region of the country, the Simpson Desert, as well as the continent’s largest river system and salt lakes, and freshwater lakes that dry up periodically. These western and central regions are largely uninhabitable – the vast majority of the population lives in the east of the continent near the coast.

Naturally, these specific conditions determine flows of transport in Australia. The outback, as the remote areas far from civilization are known, is dissected by just a few railway lines, but mainly by asphalt highways. Road trains – trucks pulling multiple trailers, sometimes as much as 53 meters long and weighing 140 tons – are used for transporting freight over long distances. Shifting goods transport from the roads onto the rail network is a slow process, and the reasons for this are historical.

90%

Estimated growth in rail freight in Australia until 2030

Continued on page 24
Whether iron ore, gold, coal or gravel: the scale of open-pit mining operations is gigantic. After excavation the raw materials are usually loaded straight onto dump trucks (up to around 60 tons total weight) or haul trucks (for even heavier loads – for example up to around 600 tons total weight) and transported to stations for further processing. Many haul trucks have diesel electric drives like locomotives: steadily running diesel motors with a generator produce the electricity for electric drive motors. These hybrid drives are better suited to the task than conventional diesel drives: electric motors convert almost all the energy into movement, which means they are more efficient and deliver maximum torque even from a standstill. Most importantly, however, they are largely maintenance-free. This is crucial, since even in large mines there are usually just a few of these very expensive haul trucks working around the clock. Any downtime has a major impact on the mine’s output.

Siemens therefore developed an AC drive system for haul trucks from well-known manufacturers such as Hitachi and Komatsu from Japan, and Belaz from Belarus, as well as from a few Chinese manufacturers. They can also be equipped with pantographs to draw their power from overhead lines when they are out of the pit. When running from the contact wire these trolley trucks have even more power, use less diesel and therefore offer benefits similar to electric locomotives – but without the need for a rail network, which would have to be constantly extended as the mining operation progresses. On the whole, Siemens offers a wide range of products and systems for mining – from conveyor and transport solutions to further processing of the raw materials.
Whether iron ore, gold, coal or gravel: the scale of open-pit mining operations is gigantic. After excavation the raw materials are usually loaded straight onto dump trucks (up to around 60 tons total weight) or haul trucks (for even heavier loads – for example up to around 600 tons total weight) and transported to stations for further processing. Many haul trucks have diesel electric drives like locomotives: steadily running diesel motors with a generator produce the electricity for electric drive motors. These hybrid drives are better suited to the task than conventional diesel drives: electric motors convert almost all the energy into movement, which means they are more efficient and deliver maximum torque even from a stand still. Most importantly, however, they are largely maintenance free. This is crucial, since even in large mines there are usually just a few of these very expensive haul trucks working around the clock. Any downtime has a major impact on the mine’s output.

Siemens therefore developed an AC drive system for haul trucks from well-known manufacturers such as Hitachi and Komatsu from Japan, and Belaz from Belarus, as well as from a few Chinese manufacturers. They can also be equipped with pantographs to draw their power from overhead lines when they are out of the pit. When running from the contact wire these trolley trucks have even more power, use less diesel and therefore offer benefits similar to electric locomotives – but without the need for a rail network, which would have to be constantly extended as the mining operation progresses. On the whole, Siemens offers a wide range of products and systems for mining – from conveyor and transport solutions to further processing of the raw materials.
For something as tall as a house, these are pretty nimble machines: the largest haul trucks transport up to 363 tons of mined material, have an output of up to 3,700 horsepower and a top speed of over 60 km/h. Diesel generators or overhead lines supply ample energy to the electric drive motors.
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After the mid-19th century, numerous private companies set up local and regional railway lines. The main reason was usually to transport iron ore, timber and other raw materials from the hinterland to the ports. However, each railway company chose their own most suitable track gauges. There were no plans to make connections with other lines or other colonies. As such, up to the end of the 19th century there were three different principal gauges in use: standard gauge (1,435 mm), which was known as Cape gauge due to its prevalence in South Africa, narrow gauge (1,067 mm) and Australian wide gauge (1,600 mm).

The rail networks merge together

When the federal railway company of the young Australian state built the first east-west connection, the Trans-Australian Railway, which opened in 1917, the problems of this development were immediately apparent: it was not possible to travel all the way along the route at first, as it consisted of different track gauges. For over half a century the situation remained largely the same. In the meantime the industrial sector opted to transport freight using road trains, thereby avoiding additional unloading and reloading. This meant that the importance of the rail network declined, as in the United States. Only since 1970 have trains been able to travel the entire east-west route without changing systems, with some stretches using three-rail track for standard and Cape gauge. Since then, the Trans-Australian Railway from Sydney to Perth has also played a greater role in freight transport.

While the majority of rail transport is operated by private companies, today the rail infrastructure is largely publicly owned in order to ensure equal opportunities for the operators. Of the 41,461 route kilometers in total – increasingly converted to standard gauge – almost 3,000 kilometers are electrified. Around 5,500 kilometers of private rail routes are primarily used to transport iron ore, coal and cane sugar.
Some mining companies in the Pilbara region in the north of Western Australia operate their own rail networks, which link the mining operations with ports on the coast. Pilbara has huge reserves of iron ore, and this is predominantly mined around the towns of Tom Price and Newman before being shipped via Port Hedland. The mining companies Rio Tinto Group and BHP Billiton, for example, own some of the world’s largest iron ore mines in this area.

Investment for growth in rail transport

In the sparsely populated industrial areas and uninhabited outback, most of the rail routes use single tracks over hundreds of kilometers. Unsecured level crossings are also found at many points. This is an area where things will have to change, as Australia’s transport requirements are on the rise.

For the current National Land Freight Strategy, the logistics experts estimate that truck traffic will increase by 50 percent up to 2030, and rail freight by as much as 90 percent. With this in mind, the authorities are increasingly opting for sustainable, resource-friendly and safe goods transport.

For instance, the state government of New South Wales intends to reactivate and privatize the Cowra Lines, which were taken out of operation in 2007. These 200 kilometers of rail line connect Blayney, west of Sydney on the Western Main Line, and the main routes in the south. New intermodal road-rail terminals are to ensure that regional firms have an efficient connection between the ports, urban regions and other industrial areas of the country.

More generally, the National Land Freight Strategy aims to unify the track standards and regulations on the principal freight corridors, bringing about the requirements for national, integrated rail freight transport. Safety is one of the main focuses of the strategy. In 2010 Siemens equipped 146 level crossings with the latest safety technology for the state infrastructure operator WestNet Rail. The systems installed had proven themselves in operation around the world. By using innovative train proximity systems they increase safety as well as significantly shorten the closed phases of the crossing barriers.

Private railways such as the BHP Billiton Iron Ore line in the state of Western Australia, which links several mines with Port Hedland, are also catching up. Part of the 2,000-kilometer route has just a single track, and there are few places where the trains, over 200 wagons in length, can pass one another. Siemens therefore installed an Integrated Scheduling System that, based on the load in the mines and the occupancy of the ship berths, optimizes the use of the line capacity, the composition of the trains and even the vehicle fleet management.

There was a similar situation in the coal-mining region of Bowen Basin in the eastern state of Queensland, where several mining companies required greater transport capacities. Siemens therefore led the expansion project Goonyella to Abbot Point (GAP), a narrow-gauge line for trains with 106-ton wagons. The project included 69 kilometers of new line, 44 kilometers of existing track upgrades, 15 bridges and 6 passing loops. In addition, Siemens is currently supplying rail automation and signaling solutions for a new, 24-kilometer freight railway between the towns of Dingo and Bluff. From 2015 the line will transport 27 million tons of coal per year to the deep-sea terminal on Wiggins Island.

The rolling stock has also been modernized in recent years. For instance, Siemens was hired by Queensland Rail (Aurizon since 2012) to equip over 60 electric freight train locomotives from the 3100/3200 series with new electrical systems, increasing their power, traction, reliability and availability. The Cape-gauge locomotives operating on the Goonyella rail network transport anthracite to the seaports on the coast. Each train generally has 120 wagons, weighs around 13,000 tons and is pulled by three locomotives. Before the modernization in 2007, five locomotives were required. In the meantime, 45 new Siemens locomotives have been delivered to Aurizon.

Pacific National (PN), the second-largest private freight railway in Australia, has expanded its Cape-gauge fleet from 23 to 42 with new Class 7100, heavy-haul electric freight locomotives. PN transports 120 million tons of coal per year and covers over 90 percent of coal transport in New South Wales. Demand for efficient freight locomotives remains high: in January 2014 the 100th new Siemens locomotive type E40AC will be delivered in Australia.

The state government of New South Wales intends to reactivate several rail lines and make them fit for the future with road-rail terminals.
Whereas Australia is surrounded by oceans and easily recognizable as a separate continent, no one knows for certain where the border between Europe and Asia lies – to this day it has not been defined under international law. For this reason, the two continents are often described as the single entity Eurasia, a term from physical geography. This combined continent has an area of 55 million square kilometers and a current population of around five billion.

Such definitions were surely of less significance to the merchants and travelers of times gone by: Firmly anchored trading links have been in place between China and Europe since the Bronze Age. Around 2,400 years ago Greek historian Herodotus wrote about a network of caravan routes, which were referred to as the Silk Road in ancient Greece and Rome. Marco Polo traveled along this route in 1273. Once the Portuguese started actively trading with China via sea from 1514, the trading companies’ ship routes soon superseded this overland connection to East Asia.

However, the early 19th century signaled the start of the railway era. European countries built dense national networks on a relatively small scale. Soon plans were made for transcontinental routes: the Baghdad Railway was constructed in the Ottoman Empire and its successor states from 1903, with a considerable contribution from German firms. By extending the route of the Orient Express (Paris–Istanbul) and the Anatolian Railway (Istanbul–Konya), and by adding a branch to the south towards Damascus, this became the first transcontinental railway. It was 1940 by the time the entire Baghdad Railway was in use, and due to constant political unrest in the region freight is only rarely transported along the entire route.

In Russia plans for a railway line to the east coast, the Trans-Siberian Railway, began as early as the 1870s. It was built from 1891 to 1916 and electrified in stages from 1929. To this day the “Transsib,” with 9,288 route kilometers and over 400 stations between Moscow and Vladivostok, is the world’s longest railway route. An additional route through the Chinese Empire, the Chinese Eastern Railway, was created in 1903 to provide a shorter route to Vladivostok. This meant that Chinese goods such as tea and silk, as well as grain from Siberia, could reach the European part of the continent more quickly.

The political and economic division into East and West interrupted many of these trading routes for almost the entire 20th century. In the 1960s the United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP)
started a project called the Trans-Asian Railway (TAR). Its primary goal was to bring about a 14,000-kilometer rail link between Singapore and Istanbul, with onward connections to Europe, Southeast Asia and Africa, enabling continuous freight rail transport. However, its implementation has also been impeded by political and economic hurdles.

**Container freight on old trading routes**

The rapprochement between East and West from the late 1980s coincided with a growing demand for transport between Western Europe and China, the world’s new manufacturing powerhouse. The corridor projects of UN ESCAP – complemented by the Trans-European Network Transport (TEN-T) within the EU – were reignited with the aim of linking the growth markets in the Far East with Central and Western Europe.

A large proportion of this TAR railway network already exists. The Northern Corridor, for instance, running approximately 13,000 kilometers from Vladivostok in the east to Rotterdam Port in the west via China, Russia, Poland and Germany, uses the tracks of the Trans-Siberian Railway. It is also known as the First Eurasian Land Bridge and is increasingly being used by block container trains. These company trains use the Northern Corridor to transport, for example, car parts from Leipzig-Wahren or Wackersdorf in Bavaria to the BMW plant in Shenyang in northeastern China. The Trans Eurasia Express container train from Trans Eurasia Logistics (TEL) sets off each week from Shanghai and Beijing via Novosibirsk to Hamburg, Duisburg and Nuremberg – the entire network includes 13 European and 15 Russian train terminals. The journey time is 18 to 23 days, which is around a week shorter than the sea freight route.

In China the inland industrial locations are now growing more rapidly than those in the coastal provinces. In larger cities such as Chongqing and Chengdu, the capital of Sichuan province, the automotive sector in particular has made the step up to become one of the key industries alongside electronics and information technology. This is the reason the Second Eurasian Land Bridge was created a few years ago. It runs around 10,900 kilometers from Lianyungang Port in eastern China through central and western China to the Dzungarian Gate – a mountain pass on the border to Kazakhstan that was historically used by traders traveling along the Silk Road – and continues northwest toward Rotterdam, Duisburg and Hamburg.

The loaded containers spend a total of around 20 days on the route, saving almost two weeks compared to the sea route. They could arrive even sooner if they did not have to be reloaded at two points. The reason lies in the different track gauges along the route. While Western Europe, China, Iran and Turkey use the 1,435 mm normal gauge for their railways, trains in Northern and Central Asia and Finland run on Russian wide gauges of 1,520 mm.

The wide-gauge locomotives, which often have to pull heavy trains of over 50 wagons, are also a very particular breed. For instance, the eight-axle Granite 2E510 double locomotives have an output of around 8,800 kilowatts, are
New projects for quicker journeys

Up to now the wide-gauge tracks have ended in the west at the borders to Poland, Slovakia and Hungary. However, if the rail bosses in Russia, Ukraine, Slovakia and Austria have their way, newly built freight routes using Russian wide gauge will run all the way to the Austrian capital of Vienna in the future. An intermodal transshipment terminal could be built near the Danube. The greater Vienna area is ideally suited as a freight interface between Europe and Asia, as this is where three highly important inner-European rail routes come together: axes 17, 22 and 23 of the TEN-T priority program, which aims to improve standardization and links between transport systems in the EU interior market. A new Vienna transshipment terminal would open fast, direct routes into Northern, Western and Southern Europe.

Yet the time-consuming reloading of containers when changing gauge is also an issue here, which is why economic planners in the Far East are pushing for an entirely different project: China wants to build a new 3,000-kilometer freight route from the Kazakh-Chinese border via Kazakhstan and Turkmenistan into Iran. The notable aspect of this plan is that the route is to use normal gauge rather than Russian wide gauge. This means it will be able to connect to the Chinese rail network directly and run south of the Caspian Sea into Turkey using Iran’s standard-gauge network. From here container trains can reach Europe’s most important trade markets via the 14-kilometer Marmaray Tunnel under the Bosporus. Eliminating the change in track gauge would roughly halve the current journey time.

All these examples show that in a globalized world where long-distance transport volumes are constantly rising, transcontinental rail freight transport is more important than ever before. On electrified routes in particular, rail transport is more energy efficient and cost effective than airfreight, for example – and compared to the admittedly economical option of sea transport, the cargo reaches its destination considerably sooner. It is therefore only logical for transport experts around the world to continue their efforts to expand rail infrastructure.

Single-wagon transport: assembling freight trains with Siemens’ solutions

In some cases trains are required to transport individual wagons rather than an entire load of the same freight. In many countries this single-wagon transport is put together at shunting yards or classification yards with train formation facilities. First the wagons are assembled at their departure station and transported to the shunting yard. Here one or several wagons in a so-called entry group are uncoupled and allowed to roll into the correct sorting siding using just the power of gravity.

In order to stop the wagons precisely at the end of the train as they roll into the sorting siding, several sets of rail brakes are installed one behind the other. These controlled precision brakes have the task of individually reducing the speed of the passing wagon, and today this is carried out largely automatically. Siemens has already installed this shunting technology in many international projects. As well as controlled hydraulic rail brakes of various types and the corresponding microprocessor control, Siemens supplies Controlguide dispolino – software solutions for logistics and dispatching tasks including fleet and crew management of company transport, scheduled services and handling facilities. This technology makes Siemens a leader in integrated shunting yard solutions on the international market.
Goods transport using electric railways is rightly considered a particularly productive, energy-efficient and environmentally friendly solution. The eHighway, developed by Siemens, brings these benefits to the road network.

Shifting more goods onto the rail network is not always possible. This creates a need for reliable and environmentally friendly road transport solutions. Since electric vehicles offer the most potential in terms of ecological and economic benefits, in 2011 Siemens developed the eHighway, an integrated concept for electric-powered trucks, as part of the ENUBA research project funded by Germany’s Federal Environment Ministry. The principle is for e-trucks equipped with hybrid drive systems and intelligent pantographs to draw power from overhead lines while driving, like trolley buses, then complete their local journey without causing emissions (see como 8/2012). The infrastructure and vehicles were tested on a specially built test track in Groß Dölln in the German state of Brandenburg. The system was assessed in terms of economic feasibility and CO₂ reduction potential.

The current follow-up project, which runs from 2012 to 2014, focuses on optimally integrating the drive technology and pantographs into the vehicles and providing the necessary traffic control systems. Here Siemens is working in partnership with the commercial vehicle manufacturer Scania, while Dresden University of Technology and other institutions are carrying out accompanying research. The goal is to develop the eHighway as a complete system that can be deployed on public roads, which means solving all the related technical, legal and economic issues. As such, it is entirely in keeping with the German government’s current Mobility and Fuel Strategy, which describes drive system and fuel options for an energy transition in transport up to the year 2050.

For this second research project a new, extended test track was commissioned in Groß Dölln. It is tailored to mirror real operating conditions. A bend was added to the track, along with a newly developed contact wire that is adjusted to the shape of the bend and allows vehicles to keep traveling at speeds of up to 90 km/h. Two more features found on most highways were also installed: a gantry and a road sign supported by a cantilever. Since the contact wire has to remain a safe distance beneath the road signs, the catenaries and carrying cable were lowered so that the pantograph can remain in constant contact, even when traveling at full speed.

The eHighway concept is particularly beneficial to the environment and the economy on highly frequented long-distance routes and shuttle routes, for instance between ports and factory sites and logistics centers, or between mines and transshipment centers. The initial pilot projects are already at the implementation stage.

In Sweden the central authority for transport, Trafikverket, has opened a tender for pilot routes for heavy electric goods vehicles with a continuous electricity supply. The goal is to compare and evaluate various systems before deciding which technology Sweden will incorporate into its national transport planning. If an eHighway pilot project goes ahead, it could be the first application of this system on public roads worldwide and help Sweden to achieve its goal of bringing about a transport sector that no longer depends on fossil fuels by 2030. Among other industries, Swedish iron ore mines such as the Kaunisvaara project in Pajala, near the Finnish border, could derive a huge sustainable benefit from an eHighway system. Rather than using diesel trucks to carry the crude ore around 150 kilometers to the iron ore railway line, this journey could be made by environmentally friendly e-trucks.

In California Siemens has teamed up with the automaker Volvo and local truck retrofitters in order to carry out a pilot project with the South Coast Air Quality Management District (SCAQMD). This involves demonstrating how various truck configurations work with the eHighway infrastructure in the area around the Ports of Los Angeles and Long Beach. The plan is to set up a zero-emission corridor on Interstate Highway 710, between the two sea ports and the inland railway hubs around 30 kilometers away, where shuttle transport using e-trucks will relieve the burden on this smog-plagued region. Project planning is already underway.
The opening of the London Underground 150 years ago marked the first step in the development of an urban transport system that has had huge success worldwide. Siemens has contributed to this success story with its pioneering spirit and innovative technology.
activities
S
ome call it the metro, others the underground or the subway, and in Germany and Austria it’s called the U-Bahn – but in principle they all mean the same thing: a public rail transport system that is primarily underground, free of intersections and operated independently from other urban transport systems. Metro systems provide mobility for people in over 150 cities around the world. With the advance of urbanization and the constant influx of new people into cities, the space for transport is becoming scarce, which leads to growing numbers of underground rail lines.

Underground trains have a long tradition, with examples stretching back over 160 years. In the booming district of Brooklyn in 1850, the oldest remaining U.S. railroad company, Long Island Rail Road, builds a stretch of its line under Atlantic Avenue using the cut-and-cover method. Although this urban railway tunnel is closed just a few years later, the idea catches on – including in the capital of the British Empire, which is plagued by massive congestion problems. Since the Royal Commission of Railways will not approve any overground railway lines in central London, the routes heading to London end at terminus stations outside of the city – and soon a growing number of shuttle coaches and horse-drawn buses is clogging up the streets.

London goes underground

So underground is the way to go. On January 10, 1863, the Metropolitan Railway, which preceded today's London Underground and gave its name to the metro transport system as a whole, opens an entirely underground line from the terminus station Paddington via Euston and Kings Cross to Farringdon Street in the city – the world’s first subway.

The route is constructed as a subsurface line using the cut-and-cover method, like in Brooklyn: a trench is excavated and roofed over, then a road is laid on top. In London the tracks of the subsurface lines going in each direction are built next to one another, around 5 meters under the surface, in a tunnel with a diameter of around 7.6 meters. However, thanks to technological advances such as tunneling shields, it soon becomes possible to quickly and economically dig tunnels through London's clay soil at a depth of 20 to 30 meters. This method is first used to build the Tower Subway beneath the River Thames in 1870. The diameter of these tunnels is less than half that of the subsurface lines, though the track gauge remains the same, and each track has a separate tunnel. These narrow tunnels give the entire London system its nickname, the Tube. The two partial networks remain separate from one another to this day – only on the overground line from Rayners Lane to Uxbridge do subsurface and deep-level trains run directly alongside one another.

In 1897 Siemens Brothers delivered the world’s first multiple unit train with gearless drive axles in the bogies – the ancestor of today’s metros.

Hurdles on the way to electrification

At first the underground trains are powered by steam locomotives – this remains the leading technology until the mid-19th century. Today it’s hard to imagine the experience of these 28,000 daily passengers, with steam and soot filling the tunnels. This only changes after the Berlin entrepreneur Werner Siemens develops a workable electric drive system. At the Berlin Industrial Exposition of 1879 he presents the first electric locomotive, and in 1881 he opens the world’s first electric tramline in Lichterfelde, Berlin. He also plans an electric rapid transit network, but the Prussian bureaucracy resists the project for another two decades.

In England the family is represented by Siemens Brothers & Co., owned by the Siemens brothers Werner, Carl and Wilhelm (later known as Sir William). They also present the locomotive from the Berlin exhibition at Crystal Palace in London in 1882. Although the Tube gets its first electric power from Siemens generators in 1890, its first electric locomotives are supplied by an English company. However, the powerful Siemens drives soon outstrip the competition: in 1891 Siemens Brothers supplies its first two electric locomotives to the London Underground, followed in 1897 by the world’s first multiple unit train with gearless drive axles in the bogies – the ancestor of today’s metros, rapid-transit trains and high-speed trains. By 1908 the Tube is fully electrified.

Metro is booming – in Europe and America

The principle of underground rail also arouses interest elsewhere. The year 1875 sees the opening of the "Tünel" line on the European side of Istanbul, an underground funicular railway from the terminus of the Orient Express to the district of Beyoğlu. Aside from people, it also transports horses and carriages, and it is therefore not a metro in the usual sense. For this reason, the Budapest Metro, which begins operation in 1896, is considered the world’s second-oldest subway line – and the first electrified underground rail system with regular service in continental Europe.

It is worth noting that the approval authorities in Budapest make precisely the inverse objection to those in Berlin: they refuse to let the two transport companies build a tramline over the boulevard Andrássy út, yet they are in favor of an underground line. And so it comes to pass that Werner von Siemens completes his metro project in Hungary’s capital, rather than in his home city of Berlin.

In the major U.S. cities the idea of an independent rapid transit system also prevails in the late 19th century.
The first electric locomotive was presented in 1879.

A broad tunnel profile: the London Underground in the first years.

Small-profile train on the Berlin elevated railway at the Görlitzer station.

Opening of the New York Subway in 1904.

Metró Budapest is the world’s second-oldest rail network.

London Underground: escalators and magnificent design.

Latin America’s first metro opened in 1913 in Buenos Aires.
Poster Art 150: until January 2014, the London Transport Museum is presenting a Siemens-sponsored exhibition of posters from the Tube’s 150-year history.
An elevated railway opens in Chicago in 1892, and in 1987 Boston opens an underground streetcar line – an idea that would be rediscovered 70 years later in the light rail systems of numerous cities. New York follows in 1904 with its Subway system. Four years later a second suburban railroad opens in New York, the Port Authority Trans-Hudson (PATH), which runs under the Hudson River from Manhattan to the neighboring state of New Jersey via two tunnels. This line still exists today and is currently undergoing extensive modernization using Siemens technology: radio-based train control will shorten the train headways, enabling up to 290,000 passengers to use the service each day, with no alterations to the line itself required.

After years of debate Berlin also finally opens a regular metro line on February 15, 1902: the electrically driven underground and elevated railway operated by Siemens & Halske. It runs between the stations Stralauer Tor and Zoologischer Garten. Most of the line runs on a viaduct, but later extensions through the city center and wealthy districts run underground. Berlin is also where the term “U-Bahn” comes from – to distinguish it from Berlin’s urban, circle and suburban lines operated by Deutsche Reichsbahn, which have been collectively known as the “S-Bahn” since 1929.

To this day, like the London Underground, the U-Bahn has a small and a large tunnel profile with the same track gauge (1,435 mm), and two vehicle types: the early small profile lines – now known as U1 to U4 – are built for trains with a “tram width” of 2.30 meters. The later large profile lines are designed for a train width of 2.65 meters.

Decades of car dominance

As early as 1920 it becomes apparent that cities will be shaped by car and motorcycle transport in the decades to come. In the years between the two world wars only a few metro systems go into operation: in Spain’s capital Madrid in 1919, in Barcelona five years later, and Asia’s first metro in Tokyo in 1927. The first underground rapid transit train in Moscow opens in 1935. It features stations built particularly deep underground and splendidly decorated as “working class palaces” – though these can also serve as air raid shelters.

In Western countries the focus in the 1950s is on mass motorization. Train passenger numbers are constantly on the decline; the private car sets the standard for travel. Urban planners in West Germany, Western Europe and the United States redesign car-friendly city centers with plenty of space for traffic and parking while dismantling many urban rail lines. In the Soviet Union and other Eastern European states, on the other hand, the number of private cars remains relatively limited and numerous metro operators are established. Leningrad gets a new subway in 1955, followed by Kiev, Tbilisi, Baku and several other major Eastern cities. The metro system in Budapest is expanded, adding two modern lines. Aside from the subways there are tram networks such as the MetroTram in Volgograd.

At the end of the 1960s, however, Western Europe also starts to think differently: the growth of individual mobility has led to urban sprawl, ever-larger space requirements for traffic, a dependence on oil, and increasing environmental pollution due to emissions and noise. In many cities the freedom of the automobile now simply means the privilege of sitting in traffic in your own car. Now transport planners develop light rail as an alternative model, using simpler, tram-like vehicles. These usually have their own tracks, but can go underground to bypass the traffic in city centers and also make use of existing tramlines. In 1966 Stuttgart opens the first tunnel section of its underground tram, forming the core of its current light rail system. Soon Frankfurt and Cologne follow suit.

The only other German cities to build full U-Bahn systems are Munich and Nuremberg. The Bavarian capital departs from the existing concept of an underground tram and opts for a full U-Bahn, which begins operation in 1971, in the run-up to the Olympic Games. While many vehicles from this initial period are still in use today, since 2002 Siemens has supplied modern “C-car” trains.

The youngest German U-Bahn begins operation in Nuremberg the next year – this city had also originally planned a tram network. In 2008 Germany’s first fully automatic U-Bahn goes into service on Nuremberg’s U3 line. As part of the RUBIN Project, Siemens enables a type of operation on a shared stretch
of the U2 line that has not been seen anywhere in the world before: driverless and conventionally driven trains run alongside one another. This continues until 2010, when the U2 vehicles are also fully automated. The major benefit of this approach is that the trains can be upgraded while service is still running.

**Metro boom in Asia**

In the emerging nations of Asia, with their rapidly growing metropolitan regions and megacities, the only way to cope with the constant influx of people is with high-performance rail systems that are independent from road traffic. For instance, in December 1999 Bangkok opens the two lines of its “Skytrain” elevated rail system, and Bangkok’s largely underground metro system goes into operation in July 2005. Both systems are equipped with Siemens technology.

In the People’s Republic of China, in particular, transport planners are placing great faith in underground rail – the country currently has over 25 metro systems in planning, construction or operation. The Shanghai Metro, opened in 1993 with 12 lines, is one of the fastest-growing subway systems in the world. A consortium between Siemens and Adtranz, which built the first two lines, sets the standards for signal and safety technology.

Although the metro of the capital Beijing is the first in the People’s Republic of China, until 1977 it is only open to civil servants. Today it has ten lines with a total length of over 450 kilometers and transports up to ten million passengers per day. At 50 kilometers, Beijing’s line 10 is the longest metro line in the world equipped with the latest CBTC and Trainguard MT control technology.

**New vehicle concepts, smart rail automation**

These days metro systems are becoming increasingly important – with modern vehicles as a replacement and supplement for existing fleets or for new routes. A current example is Poland’s first underground system, the Warsaw Metro. Its line 1, almost 23 kilometers in length, has been running since 1995 and carries up to 568,000 passengers each day. A second, 32-kilometer line is under construction, and the operator Metro Warszawskie has decided to use 35 six-car trains from the new Inspiro generation of metro vehicles, 15 of which will run on the existing line 1. The trains have been specially tailored for Warsaw’s requirements and can carry up to 1,450 passengers at a time. Thanks to their lightweight construction, energy-saving lighting and energy-recovery technology, they are extremely energy efficient and economical.

Siemens also is active worldwide in the technical equipment of rail lines, for example in the creation of the metro system in Algiers. With over three million residents, the Algerian capital is the country’s largest city and most important transport hub. Line 1 of this turnkey project, which was led by Siemens and opened in 2011, is considered the first full subway system on African soil. The Cairo Metro, which began operation in 1987, came about as a connecting tunnel under the city center between two suburbs, and it is more comparable to a light rail system.

Algiers Metro line 1 reduced daily traffic in the city almost immediately, and the first expansion is due to go into operation as early as 2015. This new portion will also be equipped with the Trainguard MT control system, which allows train sequencing to be adjusted to the passenger volume while also optimizing operating safety, train reliability and availability. It uses the moving block principle to allow the trains to travel at an optimal distance from one another, while automatic train operation maximizes their efficiency in terms of time and energy.

Similar benefits are expected in Riyadh, the capital of Saudi Arabia. The city of five million people plans to construct a cutting-edge metro network with six lines and a total length of 175 kilometers. Siemens will supply a turnkey metro system for lines 1 and 2. This will include Inspiro trains, electrification, signal and communication technology, and equipment for fully automatic, driverless operation.

**Retrofitting is today’s global trend**

However, new systems are expensive and take many years to build. Particularly in the rapidly expanding megacities of Asia and South America, where modern transport solutions are urgently needed, time and money are often in short supply. For this reason operators are increasingly retrofitting their existing lines with smart control and safety technology. It typically allows twice the number of trains to operate on the same line – an economical and time-saving solution for increasing passenger capacity.

Subways such as those in London, Paris, Istanbul and Madrid have already been upgraded; other metros such as the PATH line between New York and New Jersey are currently planning or implementing modernization measures. Copenhagen, Denmark’s capital, is another example. As part of its aim to become a CO2-neutral city, it is updating the signal technology of its light rail network. Between now and 2019, without interrupting services, Siemens will equip five lines and 135 trains with the Trainguard MT system and deliver Trackguard Sicas interlockings and train supervision technology. Meanwhile, in São Paulo, Brazil, Siemens is helping to modernize metro lines 8, 10 and 11. The three lines carry over a million passengers per day using 136 trains, and again the retrofitting will take place while normal service continues. Here Siemens is delivering the CBTC system SIRIUS, including WESTRACE electronic interlockings, point machines and LED signals.

So the 150-year success story of underground rail is far from over. Metros, with their high capacities, lighten the load on road traffic and help protect the environment – and when it comes to sustainable mobility, this is more important than ever.
1/2  Everything under control: the metro control centers in Hong Kong and São Paulo
3  Energy efficient: Inspiro trains for up to 1,450 passengers
4  A passenger favorite: the U-Bahn in Munich
5  U3 in Nuremberg: driverless since 2008
6  Positive expectations: modern metro network for Riyadh
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Green light for clean air

The residents of Potsdam, the Brandenburg state capital, can breathe easy: in spring 2012 the German city was equipped with an environmentally driven traffic control system. This innovative solution uses Siemens technology, and initial results show a noticeable improvement in air quality.
Particulates are no laughing matter. Scientists all over the world agreed long ago that these fine particles can trigger allergies and respiratory diseases. This led the Environmental Protection Agency (EPA) in the United States to set a concentration limit in micrograms per cubic meter ($\mu g/m^3$) for so-called PM10 particles, which have a diameter of under 10 micrometers and are also known as particulate matter. Other regions followed suit: the current European Union regulation states that a PM10 average of 50 $\mu g/m^3$ can only be exceeded a maximum of 35 times per calendar year. In many cities, however, adhering to this limit is a tough challenge.

In road transport the exhaust from diesel engines is the main source of particulate matter in the air, and this is evident in Brandenburg’s capital Potsdam. In 2011, for instance, the PM10 concentration limit on the busy highway Zeppelinstraße, which runs from the southwest through the city center, was exceeded on 53 days – far more often than allowed. So the Potsdam transport planners took action: they hired Siemens to upgrade the existing traffic management into an environmentally driven traffic control system that sustainably cuts air pollution.

**Small measures – big effect**

It is clear that emission levels are particularly high when vehicles are stuck in traffic, as they constantly stop and go and engines are idle for long periods. The goal of a green traffic control system is therefore to enable traffic to flow more constantly. With this aim in mind, the traffic computer, which went into operation in spring 2012, not only evaluates traffic volume data from the installed traffic eye systems – it also receives measured values on the weather conditions and harmful emissions. It uses all this information as a basis for controlling a network of 30 light signal systems on frequently congested roads in the city.

This means the traffic light control can react directly to heavy traffic situations and critical environmental conditions. If pollution is approaching the permitted limit, the red-light phase of so-called ramp meters on the roads that access the highway are extended. As a result, the traffic density in the city center falls, traffic jams can largely be avoided and, thanks to the “green wave” of phased traffic lights on the highway, traffic flows swiftly toward the city center. What is more, journeys at peak traffic times only take a few minutes longer than at other times of the day.

**Would a low-emission zone be more effective?**

The strategy is not entirely new, and installing ramp meters is usually only one of several tools. The package of measures employed in Potsdam also includes separate bus lanes and priority at traffic lights for public transport, since ultimately the transport planners want to encourage more drivers to switch to buses and trams. They also intend to add more bike lanes, create park-and-ride systems, and have pedestrian crossings change to green more quickly.

Admittedly, in some places such measures are not sufficient to notably reduce emissions – as was for example the case in Düsseldorf, the state capital of North Rhine-Westphalia. Here pollution only fell significantly once ramp meters and bus lanes were combined with speed limits and a low-emission zone. The Brandenburg Ministry of the Environment, Health and Consumer Protection also requested a study into the effects a low-emission zone would bring – with surprising results.

A Level 3 low-emission zone, whereby only vehicles with certified low emissions (indicated by a green sticker) could drive into Potsdam, would have cut PM10 emissions by just 1 $\mu g/m^3$ or 5 percent in 2010, and in the reference year 2015 the yearly average PM10 values would have fallen by just 3.5 percent. The reason for this fairly weak impact could be the influence of the low-emission zone in the neighboring city Berlin; since 2010 only cars with a green sticker have been allowed to drive through Berlin’s city center. For this reason, it is estimated that by 2015 only four in one hundred cars from Potsdam and the surrounding area would even be affected by the introduction of a low-emission zone.

**Air is better, traffic is flowing**

In Potsdam, however, the environmentally driven traffic control system is showing pleasing results even without additional measures. This was revealed by an initial evaluation shortly after the system went into operation. Air quality measurements by the Brandenburg Ministry of the Environment, Health and Consumer Protection verified that emission values in excess of the permitted limits were recorded far less frequently in the second half of 2012 than in the prior-year period.

In the center of Potsdam, for example, for the year 2012 as a whole the sensors only recorded excessive values on seven days. The measuring station on the busy and highly polluted Zeppelinstraße only recorded excessive values on 24 days, compared to 53 days the previous year. To quantify the impact: particle matter emissions caused by transport in the third quarter of 2012 were around 4.4 percent lower than in the prior-year period, while nitrogen oxide (NOx) emissions from transport fell by around 2.2 percent. The air quality has improved – and in contrast to the previous situation, only around one-tenth of vehicles get stuck in traffic jams at all.

Now it is a matter of fine-tuning. With the aid of ongoing measurement data, the threshold values and traffic light phases will be optimized and ramp metering locations assessed as the system continues to operate. In addition, on certain routes a Siemens camera system will record journey times in order to adjust the traffic light control to the current traffic situation even more precisely. Then Potsdam’s residents will really be able to breathe easy.