Measure by measure

There's no time to waste: passenger transport worldwide is set to rise by around 1.6 percent each year up to 2030. This may sound harmless, but it soon adds up – after all, current statistics show that almost 1,000 billion passenger-kilometers are traveled each year in Germany alone. This kind of increase cannot be managed by having even more cars on the roads. More and more people within the catchment areas of cities and metropolitan areas are already using trams, subways and suburban trains for their daily commutes to work as well as their shopping and leisure journeys. However, even public transport capacities can rarely be expanded to the extent necessary to match demand. So how can a growing influx of passengers be managed comfortably, economically and safely? The solution is automation.

More and more people are using public transport in urban catchment areas.

Metro in Guangzhou: semi-automated for energy efficiency.

The traffic burden in urban catchment areas is reaching dramatic proportions all over the world; in cities such as Munich, London or Bangkok this has been apparent for some time. Although subway and metro trains are among the most advanced means of transport out there, they often struggle to cope with the constantly rising numbers of passengers. Systems suppliers such as Siemens are therefore increasingly looking to automation technologies in order to allow more traffic to pass along designated routes without compromising safety. And because computers perform certain actions more quickly and precisely than humans, automatic train control systems are increasingly being employed for controlling, monitoring and coordinating train operation.

The extent to which the performance of a metro or subway train can be improved in practice also depends on the level of automation (see info box on page 15). Some semi-automated systems display current driving instructions to the driver on the operator console and continuously monitor the permitted train speed. Others automatically complete the journey between two stations or even take over train operation entirely as a driverless system. The fact that passengers can be even safer in such trains than with a driver made of flesh and blood is thanks to, among other things, the proven principle of automatic block signaling. If trains are traveling one behind the other on the same route, they have to constantly keep a safe minimum distance apart.

Moving block keeps trains in motion

With the classic method, called the fixed block method, the route is divided into fixed “blocks.” When train 1 enters such a block, stop signals bar any following trains from entering this block. Only when train 1 has left the block again is the next train allowed to enter. The modern moving block method, on the other hand, works with the current position of the train rather than just the block it is in. The position is transmitted by the vehicle itself to receivers along the track. If the length of the train is also measured, as is the case with mass-transit systems such as metros and subways, the estimated braking distance – and thus the actual safety clearance required – can be calculated very precisely. Therefore, the next train does not have to wait at the start of a blocked section; it can drive at a safe distance behind the first train. Trackside signals are no longer required (see info box on page 16).

With Trainguard MT, the modular train control system from Siemens, the moving block principle makes headways of just 80 to 90 seconds possible – allowing the capacity of an existing metro line to be increased by more than 50 percent. No wonder Trainguard MT is now the most popular train control system, used by over 20 metro operators worldwide.

The Chinese capital Beijing is one example. Here, in the run-up to the 2008 Olympic Games, the 25-kilometer subway Line 10 between Wanliu and Jinsong and a 6-kilometer branch to the Olym-

The U-Bahn in Munich is highly valued by passengers.

pic Park were constructed from scratch and equipped with the latest control and safety systems. Thanks to Trainguard MT, moving block technology in combination with continuous bi-directional data communication by WLAN radio could be installed for the first time in the Beijing Subway network. This not only means short headways, it also allows the system to react quickly to the current passenger volume.

The fact that Siemens has given its automation platform a modular design also brings other benefits: Trainguard MT uses standard interfaces and is scalable, which means that it remains highly flexible in case infrastructure is upgraded or refitted. For instance, a system that has been previously installed once can simply be adapted to new requirements or subsequently upgraded step by step from supervised operation to semi-automated and even driverless operation. This was the case with New York City Subway's Canarsie Line, which dates back to the 19th century when steam trains traveled between East New York and the Canarsie Pier. In 2006, this was the first place in the world where Siemens completed such an upgrade. Though the process was hardly noticed by the passengers, it is remarkable in certain respects: For one, the line was upgraded from conventional signal technology using the fixed block method to automatic train control with moving blocks. Furthermore, in the transition period trains were in operation both with and without Trainguard MT components. The trains

Computer colleague in the next seat

The various levels of train automation
in public transport systems:

Driver-controlled operation

- No assistance systems
- Driving by sight

Semi-automated operation

SCO – Supervision and Control Train Operation

- Manual driving and braking
- Supporting displays in the driver's cab
- Continuous speed monitoring

STO – Semi-automated Train Operation

- Manual departure and braking
- Automatic driving between stations
- Automatic stopping and opening of doors

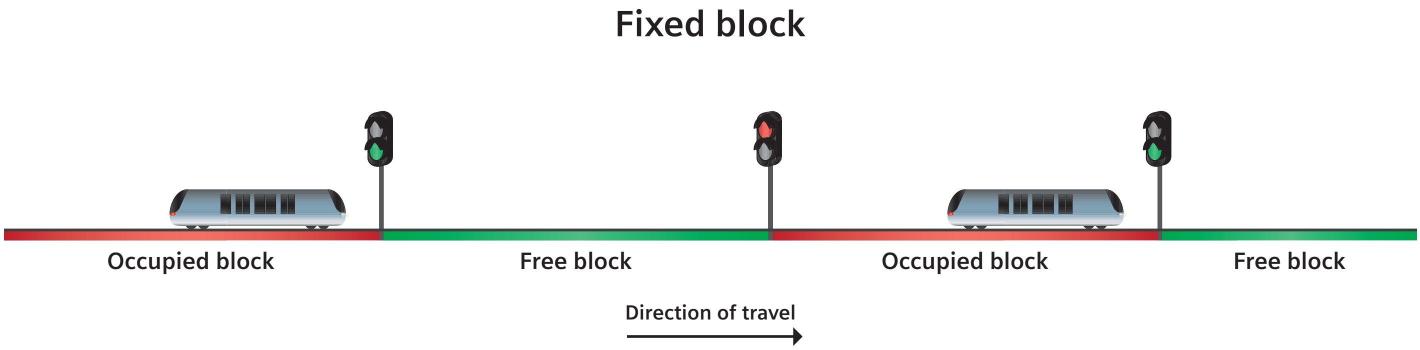
Driverless operation

DTO – Driverless Train Operation

- No driver required
- Train attendant can intervene in emergency situations
- Operation is automatically controlled and monitored

UTO – Unattended Train Operation

- Designed for operation without a driver or train attendant
- Operation is automatically controlled and monitored



Kept at a distance

If several trains are traveling one behind the other, line blocks ensure that they remain a safe distance apart.

With the classic method, known as the fixed block method, the line is divided into fixed sections which are guarded by stationary signals. When a train drives into a block, the entire length of the block is barred to all other trains by the rearward signal. Only when the front train is known to have left this block is a following train permitted to enter it. These fixed blocks have a significant influence on headways.

are controlled via radio using Communication Based Train Control (CBTC).

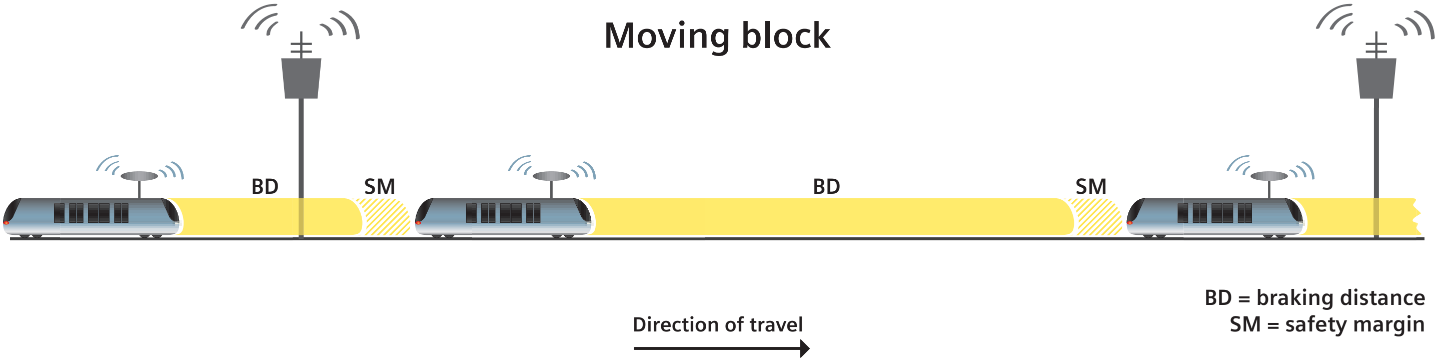
In Finland the transport authority of the city of Helsinki (Helsingin Kaupungin Liikennelaitos, HKL) has given Siemens the initial task of modernizing the existing 21-kilometer, 17-station metro line. In this case, not only the metro line but also the train depot is being automated without any interruption of service. The entire system has been designed to cope with temperatures as cold as -40°C. In 2013 the first 51 automatic trains, which can also be coupled with the existing trains, will go into operation. By 2014 a new line in the neighboring city of Espoo is to be ready for operation: 14 kilometers in length, with seven stations and also equipped for driverless operation.

The computer takes control

Indeed, computers are increasingly taking on the task of controlling subway trains – even when the operators do not wish to completely do without human drivers. Experience shows that computer-calculated processes seldom function at their opti-

U-Bahn control center in Nuremberg: the U2 does not need a driver. Soon the metro in Helsinki will be driverless too.

Moving block



The moving block method does without fixed sections of track and stationary signals. The required distance between two trains is calculated by taking the braking distance of the rear train at the current speed and adding a safety margin. This margin is constantly recalculated during the journey and directly transmitted to the train control in the driver's cab, which automatically slows down a following train that is traveling too quickly. The trains stay in motion, and because the blocks move along with the trains, the distances between the trains can be kept to a minimum and they can run more frequently.

mal level when people take control of the machines. This is why Siemens has developed the driver assistance system ATO (Automatic Train Operation), which can be directly integrated into the Trainguard control system. If a train is equipped with ATO, the driver gives the signal to depart, and can intervene in case of danger. However, the automation takes care of the driving between stations and exactly where to stop at the platform. The system is precise to the second and particularly energy efficient: using the stored route profile, it calculates how it should accelerate and brake before bends or switch points in order to arrive at the next station on time while using the minimum amount of energy. Field tests comparing ATO with human drivers – who occasionally press the brake too hard and then accelerate more – have shown that ATO reduces the energy required for an average journey by 20 percent, and in some cases as much as 30 percent, while maintaining the same journey time. ATO systems have already been employed successfully for some time in the metro systems of major Chinese cities such as Guangzhou and Beijing.

Line 10 of the Beijing Subway: ATO assists the driver.

Driverless systems are by no means a rarity these days either. Along with particularly energy-efficient operation, they bring another key benefit: the operators can react very flexibly to unexpectedly high passenger volumes and get trains out onto the track in record time – without having to worry about personnel shortages. These advantages did not escape the metro operator ViaQuatro from the Brazilian city of São Paulo, which has a population of 11 million. ViaQuatro is operating Latin America's first-ever driverless subway train equipped with Siemens control and communication technology. The recently constructed Line 4 extends the metro network of the continent's largest metropolitan area by 11 stations and a length of 12.8 kilometers, and connects with the existing lines 1, 2 and 3.

The quiet metro on rubber tires

The technology of the driverless Val system appears unusual in comparison: its electric trains drive along a dedicated track like railroad trains, yet have rubber tires like road vehicles. There are certain reasons for using these tires: First, Val trains are

Continue on page 24

particularly adept at coping with inclines and are significantly quieter than railroad vehicles when taking sharp bends. Second, rubber tires allow the trains to depart quickly and stop at a precise point at the stations. This is particularly important, since the platforms – as is usually the case with driverless train systems – are separated from the track by safety doors. These only open once a train has stopped and close again before it departs.

Eleven fully automated metros of this type have been in use worldwide for a number of years. These include the so-called people movers at O'Hare Airport in Chicago and Orly and Charles de Gaulle airports in Paris. Lines in the French cities of Lille, Toulouse and Rennes as well as in Taipei and Turin also operate without a driver. Siemens is currently constructing a Val system in Uijeongbu, Korea. In Rennes a second metro line is due to open at the end of 2018; the new Line B will be largely underground, with a total length of 12.6 kilometers and 15 stations heading southwest and northeast from the city center. Each of the Cityval two-car trainsets offers space for up to 100 passengers. The number of trains in operation can be flexibly adjusted to changing passenger volumes, thereby enabling the metros to run every 150 seconds during rush hour or even more regularly if necessary. The system is designed for a capacity of 4,000 people per hour per direction, and this can be increased to up to 15,000 people.

Safety is the top priority

A little detour into main line transport: train automation is increasingly moving into the spotlight here, too, although this is primarily for safety reasons. The greater the speed of the trains, the harder it is for a human driver to remain in complete control of the system. For instance, the so-called moment of shock – that moment between recognizing a danger and reacting to it – delays the braking process dramatically at high speeds. If the driver has to think for just a single second, a train traveling at 300 km/h has already covered a good 83 meters at full speed. Modern high-speed trains with their enormous kinetic energy also require braking distances that are hard for a car driver to imagine: An ICE3 trainset traveling at 300 km/h, for instance, will only come to a stop after around 2.8 kilometers, even when making an emergency stop using all available braking systems. At 330 km/h the braking distance increases to 3.3 kilometers.

This is where the traffic safety system ETCS, which Siemens has helped to design, comes in. The long-term purpose of ETCS is to replace the various national rail safety systems for regional and intercity trains and ensure safe travel throughout Europe. ETCS uses a principle similar to mass transit systems and knows all the information about a route, including any inclines and the permitted top speeds. It continuously verifies that the train is traveling at the correct speed in the planned direction and makes sure that slower speeds are adhered to when passing next to works on the line or through stations. ETCS also involves different levels of control: depending on how the route is equipped, the system ensures adherence to the commands of trackside signals (Level 1), makes it possible to dispense with trackside signals thanks to continuous data communication (Level 2), and supports continuous moving block signaling (Level 3). However, the trans-European rail network of conventional and high-speed cross-border routes has a total length of almost 100,000 kilometers – a universal upgrade is therefore only feasible in the long term.

Canarsie Line, New York: upgrade during operation.

Line 9 in Barcelona: Spain's first fully automated metro line.

Safe and efficient: LED technology for light signals

Signals for trains have to function reliably and be monitored – otherwise the risk of an accident increases.

Dirk Zimmermann, expert for LED signaling.

Countless light signals regulate rail traffic around the world. Up to now they have used incandescent lamps, but the shift towards light-emitting diodes (LEDs) is well underway: Siemens already fits around 60 percent of all its light signals with LED technology – and these little lights bring numerous benefits when used in rail transport.

For instance, LEDs are real energy savers, consuming up to 80 percent less electricity than comparable incandescent lamps. They also continue to work reliably and without maintenance for years in harsh railroad environments – initial experience shows they can last for over ten years. Incandescent lamps would have to be replaced several times over the same period. LEDs also feature outstanding color intensity, which makes them easier to spot even in bright daylight. This particularly applies to white signal aspects, since the cold, bluish white of the LEDs is much easier to distinguish from yellow than the warmer white of conventional incandescent lamps.

"However, the electrical properties of LEDs and incandescent lamps are also very different," explains Dirk Zimmermann, a signal expert at Siemens Industry Railway Automation. "The cable, which often supplies electricity to signal lights that are spread out over several kilometers, can act as an antenna and 'pick up' external energy out of the air." This external energy is not enough to illuminate an incandescent lamp, but it can light up an LED. "A green light at the wrong time can be dangerous," says Zimmermann. For this reason, he developed a circuit with special control technology for the up to 60 individual LEDs which are built into an LED signal head. This control circuit enables the LEDs to work with the same electrical parameters as an incandescent lamp. What is more, the circuit even makes it possible to switch from daylight mode with high light intensity to glare-free night mode with low light intensity – without having to alter the control technology in the signal boxes.

Zimmermann and his colleagues are already working on a new generation of signal lights that will be equipped with just a few LEDs – thus further reducing the amount of energy required.

Siemens technology: ViaQuatro control room in São Paulo.

Val system in Rennes: driverless with 150-second headways.

New concepts for “Complete mobility”

Using some fresh ideas from its Mobility Interaction Labs, Siemens hopes to allow multimodal operation processes to be controlled more easily and safely from the traffic routing centers of the future. In an interview with como, Marcus Zwick, Head of Strategy – Innovative Mobility Solutions, and Kim-Markus Rosenthal, User Interface Designer – Rail Automation, explain what this work is all about.

como: How might one imagine the work going on at the Mobility Interaction Labs?

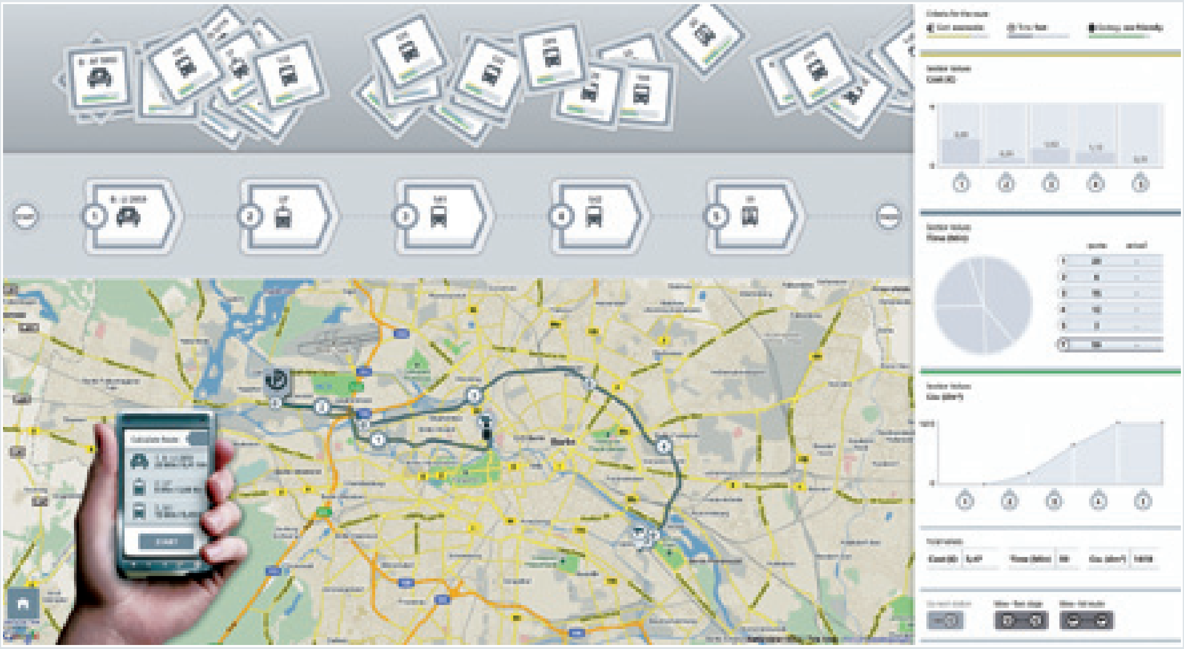
Marcus Zwick: The starting point is Siemens’s “Complete mobility” strategy. This involves providing universal, efficient mobility solutions for an integrated transport system. The task of the Mobility Interaction Labs is to examine the potential of new interaction technologies and to align this potential with the challenges of making mobility sustainable and fit for the future. This begins with the optimization of networked processes and goes right through to the economic analysis and implementation of new technologies.

como: So there is a focus on linking operating processes?

Zwick: It is only by intelligently linking various means of transport with the support of IT systems that the benefits of “Complete mobility” come to bear. But it‘s precisely this networking of traffic flows that presents a great challenge – one which primarily affects operators that have a portfolio containing various mobility products: trains, buses, rental cars, bicycles and so on. This is why we at the Mobility Interaction Labs are working on concepts regarding how intermodal operation can be optimally controlled from a traffic routing center or control room and how the individuals working in this environment can interact more effectively.

como: Have the requirements of operator stations in control centers changed in general terms?

Kim-Markus Rosenthal: Over the last ten years we have noticed that the volume of information presented and the number of technical devices at a work station in a control center are constantly rising. This increases the burden on the operators who are monitoring and controlling complex pro-



One to share: the innovative multi-touch screen operator console can receive up to 32 touch commands at once.

Kim-Markus Rosenthal

Marcus Zwick

cesses. In rail transport in particular, where safety considerations play an enormous role, it is a matter of developing new user- and workflow-oriented concepts.

como: What role do new information technologies play in multi-touch screen applications, for instance?

Rosenthal: First of all, this idea is not entirely new. The Canadian scientist Hugh Le Caine developed a voltage-controlled synthesizer with touch-sensitive keys as early as the 1940s, and in 1982 Nimish Mehta from the University of Toronto presented the first practical finger pressure display. Today we believe that one of the greatest areas of potential for multi-touch screen systems is facilitating work on a production plan – particularly when it comes to processes that are somewhat out of the ordinary. Then you would have several individuals working around a control station who have to carry out various tasks simultaneously in order to solve the problems as quickly and efficiently as possible.

como: So the various threads come together on this touch-sensitive screen?

Zwick: That's right. With our Mobility Interaction Lab concept, a multi-touch screen with a diagonal of 1.27 meters serves as the information and control terminal of a routing system with results-based operator guidance. The system intelligently links together various systems and operating services and can receive up to 32 touch commands at once. I am certain that this concept will allow us to make working in operator control centers easier, significantly reduce the risk of mistakes through human error, and make a sensible and effective contribution to our journey towards "Complete mobility."

The old control center has had its day

Naturally, in the case of isolated systems such as metros and subways, this kind of conversion is easier to handle, especially since the operator control centers normally get a corresponding upgrade. For example, a portion of the New York City Subway, operated by New York City Transit (NYCT), was given a completely new integrated control center with an automatic train supervision (ATS) system. This is the world's largest ATS project, controlling 172 stations, 45 interlockings, 46 central engineering rooms, 1,758 operated units and 4,811 display units for up to 200 train movements at a time on 175 kilometers of track. Roughly one-third of all subway stations are controlled remotely from the operator control center in Manhattan.

Thanks to the ATS, which is based on the Vicos OC 501 operating system, the train control, trackside signaling, vehicle recognition and integrated voice and data communication are all taken care of

For high-speed trains, control technology is essential.

centrally. All subsystems are fully integrated into the existing supervision and data collection systems. The key functions include train supervision and tracking in real time, computer-aided train control and dispatching, timetable management and a good deal more. Bearing in mind that several different subway lines use the same sections of track and come together at various points of the network, plus the fact that regional and express trains also come into the equation, this is without doubt a very complex and sophisticated system.

The greater functionality such a control room is designed to have, the more important it is that the processes are displayed clearly and the mode of interaction is well thought through – with the goal of intuitive operation. Here, too, automation functions aid the controllers in making quick decisions and rid them of the burden of routine tasks. For example, headway adjustments can influence the journey and waiting times, and even complete driving profiles can be automatically altered in order to quickly and effectively compensate for deviations from the timetable. Without any manual intervention, the system then calculates headways based on the stations and the direction of travel or determines the order of the trains on the track – all in an effort to ensure optimal operation.

> ” When it comes to intermodal “Complete mobility” applications, the focus is also on the human-machine interface.

Yet the demands on transport and operations control systems are rising. Breakdowns and accidents show time and again that it is already difficult for operators to determine the correct course of action when presented with a flood of information and instructions in stress situations. And the flow of data is bound to increase with the intermodal applications of the future that involve various transport systems. One consequence is that Siemens engineers take particular care when developing human-machine interfaces (HMI) such as displays or control panels.

Guiding trains with fingertips

A current example is the Operations Control Interaction Lab, which Siemens used at Innotrans 2010 to present ideas about train control systems of the future. An expansive multi-touch screen operator console with a 1.27 meter screen diagonal can be used by several operators at once, thus offering completely new interaction possibilities. Multi-touch systems are touch-sensitive input devices for human-computer interaction, and they are able to detect and process several touches at once. The tips of the fingers can be used to plan and control the deployment of train fleets, monitor train journey times and infrastructure, avoid potential bottlenecks, fit in extra train journeys, and organize diversion routes. All operators can at least detect with a glance what their colleagues beside them are currently doing. This interplay of functionalities and roles cuts reaction times and facilitates coordination processes. The uniform visualization and the complete interaction concept of this collaborative working environment make operation intuitive and support the operator in efficiently controlling traffic flows.

Siemens Mobility Interaction Labs have expanded this study with some new ideas for the UITP Congress in Dubai. As always, the ultimate question is how to bring about smooth mobility combining various modes of transport – “Complete mobility” from a computer. □