Trainguard MT
The scalable automatic train control system for maximum flexibility in modern mass transit

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Ensuring mobility is one of the big challenges in our society. We need networked traffic and information systems to remain mobile in future – for safe, cost-effective and environmentally friendly passenger and cargo traffic. That is why, with “Complete mobility”, Siemens creates integrated efficient transport and logistics solutions, from infrastructure equipment for rail and road traffic, rail vehicles through to airport logistics and postal automation.

Key elements of “Complete mobility” are efficient solutions for optimizing the flow of traffic – solutions that are situation-based, intelligent and holistic.

There is a continuous increase in the need for transport in the world’s rapidly growing metropoles.

More and more passengers have to be carried by public transport – on their way to work or home, to leisure or education facilities or for shopping. Efficient mass transit systems, which are capable of being quickly adapted to new requirements, are therefore to be seen as one of the most important factors for maximum mobility in cities and for the promotion of urban and regional economic development.

The overall performance of a mass transit system depends largely on the performance of the automatic train control (ATC) system employed. With increasing automation, the responsibility for operations management gradually shifts from the drivers and operators to the system. An ATC system comprises functions for the monitoring, execution and control of the entire operational process. It can feature different levels of automation such as driver-controlled train operation, semi-automated train operation and driverless operation. The ATC system continuously indicates the current driving instructions on the cab display and supervises the permissible train speed. Color light signals are therefore no longer required.

The modular and scalable Trainguard® MT train automation system is Siemens’ answer to the comprehensive requirements of urban transport today and offers the latest standard in automation at different levels.

The major benefits of Trainguard MT are:

- short headways
- cost-effectiveness
- scalability
- upgradeability
- maximum reliability, availability and safety
- economical maintenance
- support of mixed-traffic environments
- flexible refurbishment and migration solutions
- support of holistic rail automation solutions (complete mobility)
- energy-saving functions (green mobility)

As a modern modular ATC system, Trainguard MT offers all these features providing the basis for attractive, safe and efficient mass transit systems which satisfy the needs of both passengers and railway operators throughout the world.
The advantages of Trainguard MT

Key factors for efficient transportation

**Performance**
Trainguard MT enables operators to maximize their network capacity and throughput. Headways of 90 seconds or less are achieved by making best use of the moving-block working principle in combination with continuous, bi-directional communication via WLAN. This means the number of trains in operation can be increased and more passengers can be transported at the same time, resulting in a more punctual service and higher passenger satisfaction.

**Scalability**
Trainguard MT can operate in different train control levels. In suburban and commuter areas, where the required headways and train intervals are medium, intermittent train control is used. In metropolitan areas, where minimal headways and small train intervals are essential, continuous train control provides the required performance. By offering different train control levels, Trainguard MT is a highly scalable solution in terms of performance and costs. Thanks to its modular system design, Trainguard MT can be configured to exactly match customer requirements.

**Upgradability**
When the demand for higher transport capacity arises, existing Trainguard MT installations can easily be upgraded from fixed-block to moving-block operations. The level of automation can be upgraded from interlocking operation to semi-automated train operation (STO) or to driverless train operation (DTO), step-by-step, in accordance with the required functionality and performance. Upgrades can be implemented without interrupting operations and it is not necessary to uninstall any of the old equipment. By using these key concepts, Trainguard MT allows step-wise commissioning.

**Mixed traffic / mixed mode**
Trainguard MT can handle trains with different train control equipment at the same time in the same network. This allows for mixed fleets to be used on the same line. Trainguard MT is therefore the optimum choice for mixed-traffic environments. The range that each train can travel is expanded, whether normal, express trains, suburban trains, mainline trains or freight trains. At the same time, vehicles equipped for semi-automated or driverless operation can seamlessly change over to supervision and control operation on suburban line sections. This also increases system availability during the upgrade or migration phases of an existing train fleet or signaling system.

Trainguard MT can be used as an overlay system for existing train control systems and provides flexible migration strategies for the customers.
Matching operator requirements for upgradable train control methods and automation levels

Trainguard MT is a versatile and modular system which can be individually tailored to the railway operator’s needs. Different train control and automation levels can be implemented, depending on the requirements for performance and functionality.

The following train control levels can be used jointly or separately.

Intermittent train control (ITC)
Intermittent track-to-train communication allows fixed-block operation with continuous supervision and already offers automatic train operation (ATO) functionality. The intermittent train control level can be used for parts of the line with lower headway requirements or optionally as a fall-back level for parts with continuous train control.

Continuous train control (CTC)
Trainguard MT with continuous train control features a bi-directional WLAN transmission channel providing full moving-block functionality in combination with comprehensive ATO capabilities. Train separation according to the moving-block principle results in minimum headways, thereby enhancing system performance significantly. Color light signals can be reduced to a minimum or even completely omitted.

In CTC operation, the energy consumption of trains is optimized by intelligent ATO algorithms.

Depending on the chosen train control method, the following levels of automation can be implemented:

• **Semi-automated train operation (STO)**
The train is driven automatically from station to station and the driver merely initiates train departure.

• **Driverless train operation (DTO)**
In this mode, train operation is fully automated and a driver is no longer required. A train attendant, who only takes actions in emergency situations, still remains on the train or at stations.
Comprehensive greenfield solutions
Efficient refurbishment and flexible migration strategies

Greenfield installation
The ideal solution for greenfield installation of a modern mass transit signaling system is the combination of Trainguard MT and the following well-proven Siemens components and systems used already successfully in various railway applications worldwide:

- Vicos® OC 100 and Vicos OC 501 for automatic train supervision (ATS)
- Trainguard MT for automatic train protection (ATP) and automatic train operation (ATO)
- Sicas® as interlocking (IXL)
- ACM axle counting system (TVD)
- Eurobalise S21 (COM)
- WLAN-based radio communication (COM)

Refurbishment and migration
When lines are refurbished, Trainguard MT can be installed as an overlay system offering enhanced performance while preserving existing investment and minimizing disruptions to revenue service. Thanks to its open system architecture and standardized interfaces, Trainguard MT is designed to work with other installed signaling systems and rolling stock. Step-by-step refurbishment starting with intermittent train control which is later upgraded to the continuous train control level is also possible.

Stepwise commissioning
Headways and the safety of existing systems can be improved by connecting balises to existing trackside signals to implement Trainguard MT with intermittent communication. As performance requirements rise, Trainguard MT allows cost-effective upgrading to higher system performance by adding components and subsystems such as WLAN communication for moving-block functionality. Headways are reduced and thus transport capacity is increased still further.

Train control levels

<table>
<thead>
<tr>
<th>Upgrading equipment</th>
<th>Trains</th>
<th>Unequipped</th>
<th>STO</th>
<th>DTO</th>
</tr>
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<tbody>
<tr>
<td>Continuous train control</td>
<td>n.a.</td>
<td>+</td>
<td>+</td>
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<tr>
<td>Intermittent train control</td>
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<tr>
<td>Interlocking train control</td>
<td>+</td>
<td>n.a.</td>
<td>n.a.</td>
<td></td>
</tr>
</tbody>
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Legend

- STO – Semi-automated train operation
- DTO – Driverless train operation
- n.a. – not applicable

Mode of operation / functionality
Modular system setup
Innovative and proven components

Trainguard MT integrates well-proven systems and components that have been in service worldwide for many years. Trainguard MT is based on the fail-safe Simis® computers. The system employs communication-based train control (CBTC) and European train control system (ETCS) technology. Trainguard MT is compatible with various third-party systems via standardized interfaces.

Scalable Vicos automatic train supervision systems (ATS)
The Vicos OC 500 and Vicos OC 100 operations control systems provide a wide range of proven automatic train supervision (ATS) functions from the local operator console to the highly automated centralized supervision and control center.

High-availability Sicas interlocking (IXL)
Trainguard MT employs the Sicas electronic interlocking system currently in service for mass transit systems and regional railways worldwide. Optionally, the system offers integrated interlocking functions.

WLAN communication (COM)
Trainguard MT uses WLAN for continuous communication. Since any train control application requires very high system availability, all WLAN components are fully redundant. The WLAN access points distributed along the track are connected alternately to two independent WLAN routers and overlap each other with their radio coverage. In this way, full radio coverage is maintained even if every second access point malfunctions. The WLAN servers are connected with mutual (cross-) redundancy and serve for example a complete line of a metro system, including depot areas.

Balises and lineside electronic unit
The ETCS-compliant Eurobalise S21 is used for intermittent track-to-train communication. The balise system uses a transmission system that is based on inductive coupling and data transmission with frequency shift keying. There are two different types of balises:

- Fixed-data balises are passive elements for train location without any connection cable. They transmit only fixed telegrams which tell the passing trains their absolute position in the network.
- Variable-data balises are connected to a signal via a lineside electronic unit (LEU). The LEU will reprogram the balise telegram every time the signal aspect of the connected signal changes. In this way the variable-data balise will always transmit the respective movement authority according to the current signal aspect.
Precise train locating using radar and odometer pulse generator
The Doppler radar sensor measures the train speed over ground by applying the Doppler effect. The odometer pulse generator measures the distance by counting the pulses derived from wheel rotation. By using intelligent sensor fusion algorithms, precise detection of the train speed and distance is ensured. Therefore, Trainguard MT can fulfill the ambitious stopping accuracy requirements of +/- 30 cm and less.

Reliable track vacancy detection (TVD)
The ACM axle counting system serves as a reliable track vacancy detection system. Trainguard MT also allows using other kinds of track vacancy detection systems (e.g. track circuits).

Ergonomic human-machine interface (HMI)
The ergonomic human-machine interface is the driver’s multifunctional operator console. It combines a high-resolution color TFT display, touchscreen operation and audible feedback.

Technical solution of ITC with STO
Intermittent train control with fixed-block operation

Technical solution of CTC with STO or DTO
Continuous train control with moving-block principle
Airlink – track-to-train connectivity

The need for high-speed connectivity between moving vehicles and the wayside infrastructure is continuously increasing. Whether with automatic train control (ATC), closed-circuit television (CCTV), multimedia passenger infotainment, fleet management (eFleet), effective diagnostics or maintenance support, rail traffic becomes more efficient, powerful and attractive for both rail operators and passengers – thanks to the reliable Airlink broadband radio communication system.

Trainguard MT is a CBTC (communication-based train control) system that uses a high-performance communication channel not restricted to vital information. Trainguard MT provides a holistic train control solution integrating other applications on the same communication channel (e.g. CCTV).

Platform concept
Airlink is a powerful and flexible hardware and software platform with the ability to support a variety of applications concurrently. The system provides completely transparent IP-based communication, regardless of the number and kind of applications it is carrying. It comes fully integrated, with outstanding communication performance in terms of both bandwidth and quality of service. Airlink is designed for use in demanding railway environments, whether mainline transport on open lines, highly automated metro systems in tunnels, or mixed operation.

Multiple radio devices and technologies
To provide the necessary bandwidth for multiple applications, a single radio link is often insufficient. Airlink can exploit the combined bandwidth of multiple radio links. The available bandwidth is scalable through the degree of radio coverage and the number and type of integrated radios. The system can manage several radio links on different channels at once, making use of different communication technologies simultaneously, such as WLAN (WiFi) and GPRS or dedicated technologies.
**System overview**

From the on-board unit, multiple wireless connections are established via antennas to various access points along the track. The on-board units roam seamlessly between the different access points, providing uninterrupted service.

All radio components can be implemented with full redundancy to offer maximum availability. The access points along the track are then connected alternately to two independent fiber-optic networks and provide 100% overlapping coverage. In this way, seamless radio coverage is maintained even if single access points fail.

The servers controlling communication are connected with mutual redundancy and serve, for example, the complete line of a metro system, including depot areas.

**Key benefits**

| **Multiple applications** | From automatic train protection (ATP) through passenger information to CCTV and remote diagnostics, all applications make use of one single platform. |
| **Scalable bandwidth** | Airlink provides cumulative bandwidth of multiple radio links for maximum design flexibility of availability and data throughput. |
| **Cost-effectiveness** | Future-proof investment is ensured by the upgradability of bandwidth, applications and radio technologies. The platform concept reduces maintenance and life-cycle costs. |
| **Superior comfort** | Growing bandwidths offer ever-increasing options for enhancing passenger comfort with state-of-the-art infotainment. |
| **Environment adaptability** | Dynamic and seamless roaming between radio technologies dependent on the surrounding environment and the needs of the applications at a given time and location. |
Guangzhou Metro Lines 4 and 5
Siemens is responsible for designing the signaling system for Guangzhou Metro Lines 4 and 5, using Trainguard MT as the automatic train control solution. Line 4 is 41.2 km long with 14 stations from Huangzhou to Huangge. Line 5 is 31.3 km long with 21 stations from Jiakou Station to Wenyuan Station. 30 trains run on Line 4, and 45 trains will run on Line 5 with headways of only 90 seconds. Besides the operations control, electronic interlocking and train control systems, the project also includes two test tracks and a training center.

The project has been implemented step-wise in three stages, demonstrating the scalability of Trainguard MT. In stage 1, only interlocking functionality without automatic train protection (ATP) was available. In stage 2, ATP functionality with intermittent train control (fixed-block functionality) was added. In the final stage, full moving-block functionality with WLAN radio was introduced, allowing maximum performance and shortest headways.

Guangzhou Lines 4 and 5 are a milestone in the development of Siemens state-of-the-art-technology, aiding the improvement of public transport in a growing megacity.
Beijing Metro Line 10 and Olympic Branch Line 8

Beijing’s metro Line 10 is also equipped with the most up-to-date signaling and control system from Siemens. This is the second project in China after the metro lines 4 and 5 in Guangzhou to be equipped with the innovative Trainguard MT automatic train control system.

Trainguard MT will make it possible to run trains at shorter headways and adjust operations more quickly to changing passenger volumes.

Line 10 is about 25 kilometers long and extends from Wanliu in the northwest of the metropolitan area over a total of 22 stops to Jinsong in the southeast. With its four stops and about 6 kilometers of track, the Olympic Branch Line connects Line 10 with the Olympic Park. Both lines run completely underground and have commenced passenger service in July 2008.

This is the first time that moving-block technology in combination with continuous bi-directional data communication by WLAN radio is used in Beijing’s Metro network. Moreover, the intermittent train control level is based on lineside electronic units and balises and is implemented as an additional fall-back solution.

The next Trainguard MT projects will be Nanjing Line 2 and Istanbul Line 1. Nanjing Line 2 with an integrated CCTV channel will be commissioned in 2009. Istanbul Line 1 with a line length of 24 km and 16 station plus depot will be commissioned stepwise until 2010. In phase 1, the ITC level will be implemented until 2009 and in phase 2, the CTC level will be implemented until 2010.
Siemens AG
Industry Sector
Mobility Division
P.O. Box 3327
38023 Braunschweig
Germany

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