SIEMENS

Ingenuity for life

Trainguard® MT

Optimal performance with the world's leading automatic train control system for mass transit

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Trainguard MT

Intelligent and future-oriented mass transit solutions for smiling cities

Cities are becoming increasingly larger and more complex. This also imposes increased requirements on mass transit systems. Their operators have to cope with rapidly growing traffic flows and passengers' rising expectations. Their success is measured against factors such as safety, punctuality, convenience and energy efficiency.

Siemens' intelligent and future-oriented mass transit solutions support operators in successfully meeting these challenges.

We regard our customers as partners who we support through our work in sustainably developing their urban environment and making their public mass transit both efficient and effective. You thus boost your passengers' quality of life and the attractiveness of your city as a business location.

The overall performance of mass transit systems depends largely on the performance of the automatic train control (ATC) system employed. With increasing automation, the responsibility for operations management gradually shifts from 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, driverless and unattended train operation.

The ATC system continuously indicates the current movement authority on the cab display and supervises the permissible train speed. Color light signals are therefore no longer required.

The modular and future-proven Trainguard® MT automatic train control system is Siemens' answer to the comprehensive requirements of urban rail transport today and offers the latest standard in automation at different levels.

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.

Benefits
Short headways by implementing real moving-block operation
Cost-effectiveness
Scalability and upgradability
All automation levels STO, DTO, UTO
Maximum reliability, availability and safety
Economical maintenance
Support of mixed-traffic environments
Flexible refurbishment and migration solutions
Support of holistic rail automation solutions
Energy-efficient driving (saving of traction power)
Remote connectivity and monitoring

Performance | Scalability | Upgradability | Mixed traffic / mode | Life-cycle costs

The advantages of Trainguard MT

Key factors for efficient transportation in mass transit

Higher performance

Trainguard MT is a high-performance CBTC (communications-based train control) system which enables operators to maximize their network capacity and throughput. Headways of 90 seconds or less are achieved by using the real moving-block principle for train separation in combination with continuous, bi-directional communication free-propagation radio. This means the number of trains in operation is increased and more passengers are transported at the same time, resulting in a more punctual service and higher passenger satisfaction. All automation levels are supported from semi-automated (STO) till unattended train operation (UTO).

Better scalability

Trainguard MT can operate at 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 short 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.

Easy upgradability

When the demand for higher transport capacity arises, existing Trainguard MT installations can easily be upgraded to reduce headways and to increase the level of automation. The level of automation goes from interlocking operation to semi-automated train operation (STO) or unattended train operation (UTO) 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 already installed system components. By using these key concepts, Trainguard MT allows stepwise 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, i.e. both Trainguard MT- and ETCS-equipped trains can be operated together. Trainguard MT is therefore the optimum choice for mixed-traffic environments. The range that each train can travel is expanded, whether normal trains, express trains, suburban trains, mainline trains or freight trains. Furthermore, it is possible to operate both semi-automatic trains with driver and fully automatic trains without driver on the same route simultaneously.

This also increases system availability during the upgrade or migration phases of an existing train fleet or signaling system. Trainguard MT can be used in addition to existing train control systems and offers flexible modernization strategies to the customers.

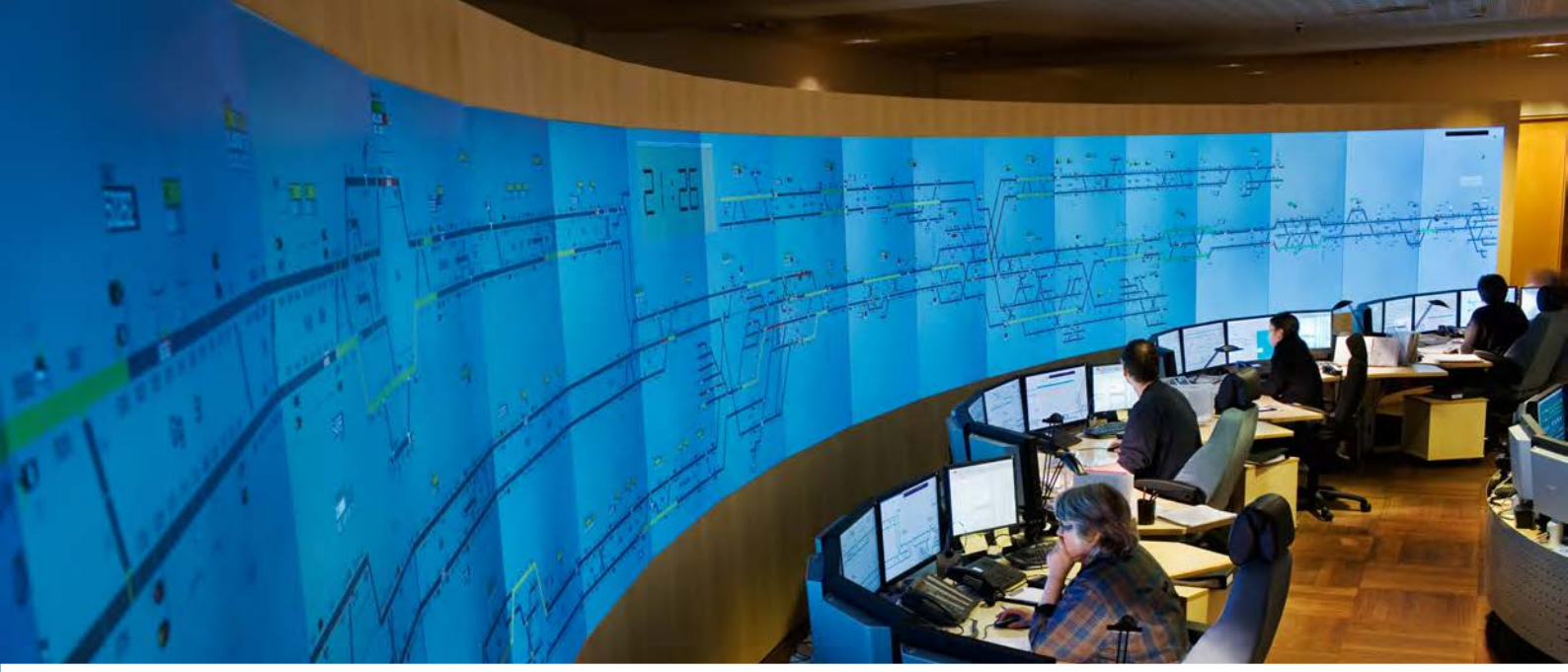
Reduced life-cycle costs

Trainguard MT optimizes life-cycle costs by reducing the number of outdoor elements to a minimum and operating the trains with an energy-efficient driving algorithm.

Trainguard MT uses fully electronic computer boards that are maintenance-free. Trackside transponders (Eurobalise) do not need external power supply or battery power and are maintenance-free.

Long-term quality

Siemens produces the safety-related hardware for Trainguard MT using state-of-the-art SMD components at its own plant and uses specially selected sub-suppliers, where necessary. In this way, we continuously ensure a constantly high level of quality. What is more, so that the system can function perfectly even many years later, we ensure that high-quality spare parts will be always available throughout the entire life cycle by means of alternative supply sources, re-design and long-term storage.



Matching operator requirements for upgradable train control 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.

Intermittent train control

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 as a temporary system during refurbishment and switchover periods.

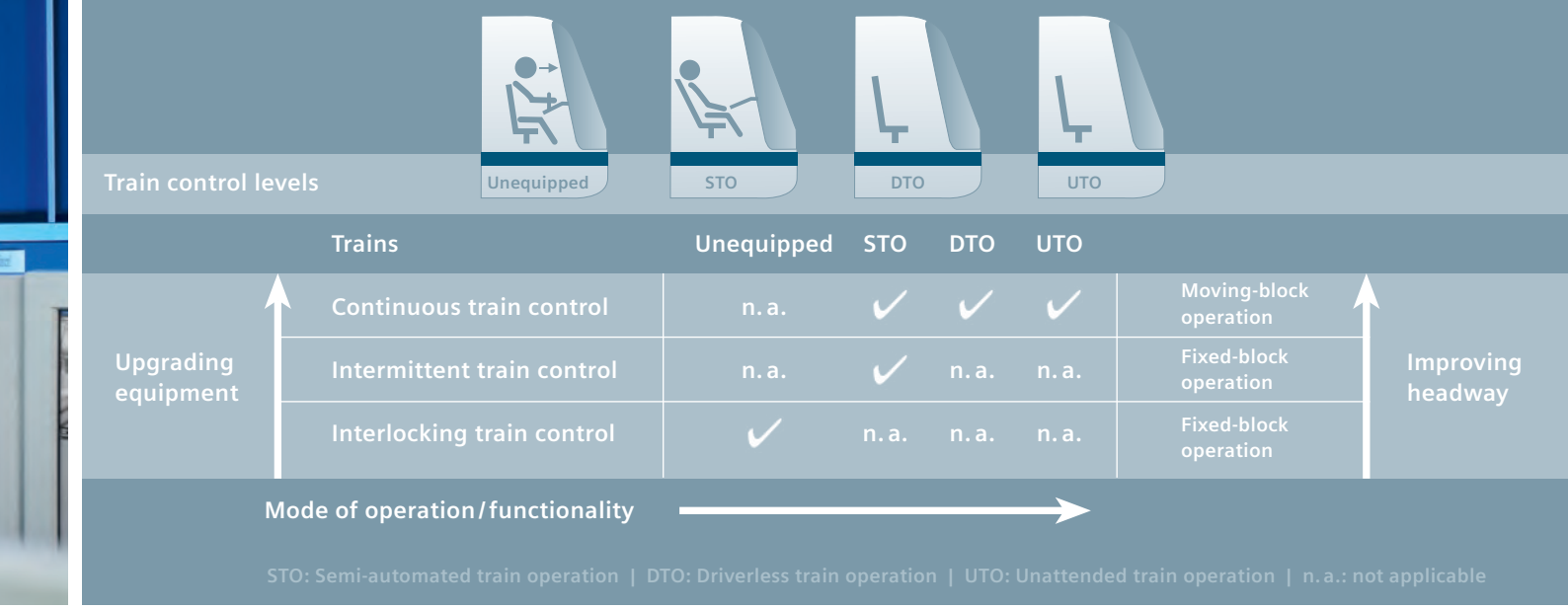
Continuous train control

Continuous train control (CTC)
Trainguard MT with continuous train control features a bi-directional radio transmission channel (CBTC) as well as real 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)**
  Train movements are fully automated and a driver is no longer required. Passenger transfer, automatic departure and reversals are handled by Trainguard MT. An attendant is present onboard the train to manage at least emergency situations.
- **Unattended train operation (UTO)**
  At this level of automation, additional safety-related measures are needed because there is no staff onboard a train. Safe departure and arrival of the train, including door closing and opening, is controlled automatically.



Comprehensive greenfield solutions
Efficient refurbishment and flexible migration strategies

Installation

Greenfield installation

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

- Controlguide® for automatic train supervision (ATS)
- Trainguard® MT for automatic train protection (ATP) and automatic train operation (ATO)
- Trackguard® as interlocking (IXL)
- Clearguard® ACM axle counting systems (TVD)
- Trainguard® Eurobalise
- Airlink® radio communication system (COM)

Refurbishment

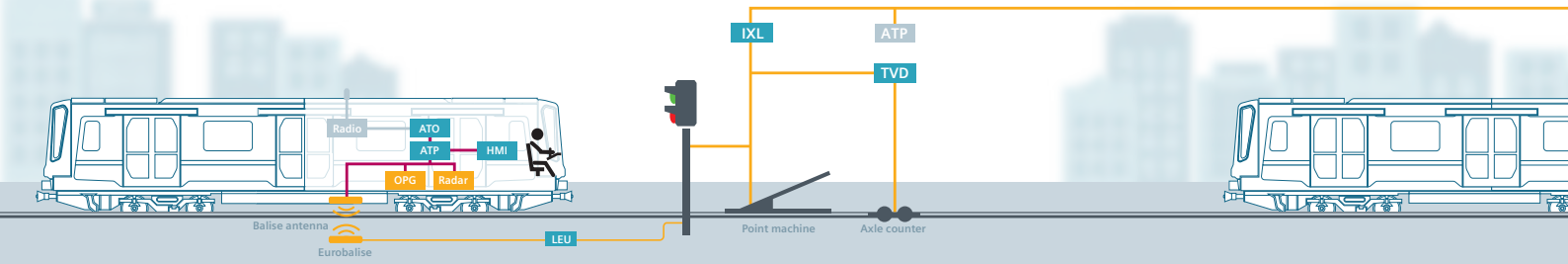
Refurbishment and migration

When lines are refurbished, Trainguard MT can be used as an overlay system for existing systems. This solution offers enhanced performance while preserving existing investment and minimizing disruptions to revenue service. Due 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 (CBTC) is also possible.

Commissioning

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 radio communication for moving-block functionality. Thus, the headway and throughput are increased.



Intermittent train control with fixed-block operation

Modular system setup
Innovative and proven components

Trainguard MT integrates well-proven systems and components and is based on the fail-safe Simis computers. The system employs communications-based train control (CBTC) and European Train Control System (ETCS) technology. Standardized interfaces offer an optimum of interoperability.

Scalable automatic train supervision (ATS) systems

The Controlguide operations control system provides a wide range of proven train tracking, route setting and dispatcher-level functions from the local operator console to the highly automated centralized supervision and control centers.

High-availability interlockings

Trainguard MT employs the Trackguard electronic interlocking system currently in service for mass transit systems and regional railways worldwide. Optionally, this system offers integrated interlocking functions.

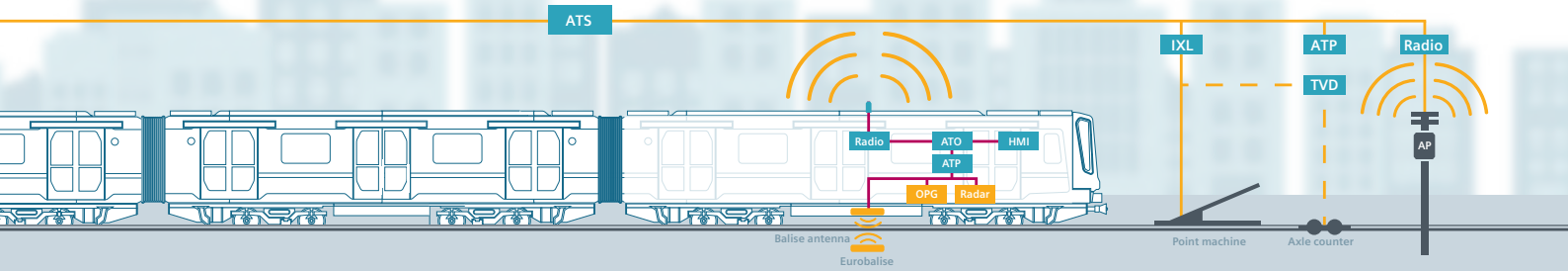
Radio communication (COM)

Trainguard MT uses Airlink, a WLAN-based radio communication system, for continuous bi-directional communication as the standard radio solution. In addition, Trainguard MT is prepared to support other radio technologies, e.g. LTE.

Since any train control application requires very high system availability, all Airlink components are fully redundant. The Airlink access points distributed along the track are connected alternately to two independent central system routers (CSR) and overlap each other with their radio coverage. In this way, full radio coverage is maintained even if access points fail.

The central system routers are designed redundantly and serve, for example, a complete line of a metro system, including depot areas.

Technical solution: CTC with STO, DTO or UTO (city center / metropolitan area)



Continuous train control with moving-block principle

Balises and lineside electronic unit

The ETCS-compliant Trainguard Eurobalise is used for intermittent track-to-train communications. The balise system uses a transmission technique 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 the purpose of train locating without any connection cable. They transmit only fixed telegrams which tell the passing trains their current position in the network.
- Transparent 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 transparent data balise will always transmit the respective movement authority according to the current signal aspect. Transparent data balises and LEU are used for ITC only.

Precise train locating using radar and odometer pulse generator

The 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.

Remote connectivity and monitoring

The signaling system can be connected through a Data Capture Unit (DCU) as the one-way data gateway for the secure connection of the signaling network to a remote storage medium (server) over the IoT. Via MindSphere, the open, cloud-based IoT operating system from Siemens, operators can analyze and merge operational and historical system data, timetable information and weather forecasts or information on major events in a city. This helps to improve the performance of your operation and the utilization of your assets. Furthermore, maintenance can be done more efficiently and system availability can be increased. Intelligent analysis can reveal failures by predicting them in advance and fixing them before they actually happen.

Reliable track vacancy detection (TVD)

Trainguard MT works without any track vacancy detection system. During normal operation, all trains report their position cyclically to the Trainguard MT wayside units. In case of disturbances, the TVD can be used to detect non-reporting trains so that operation can be restored to normal within a short time and with minimal interference. Furthermore, TVD can be used for mixed-traffic and non-equipped train operation.

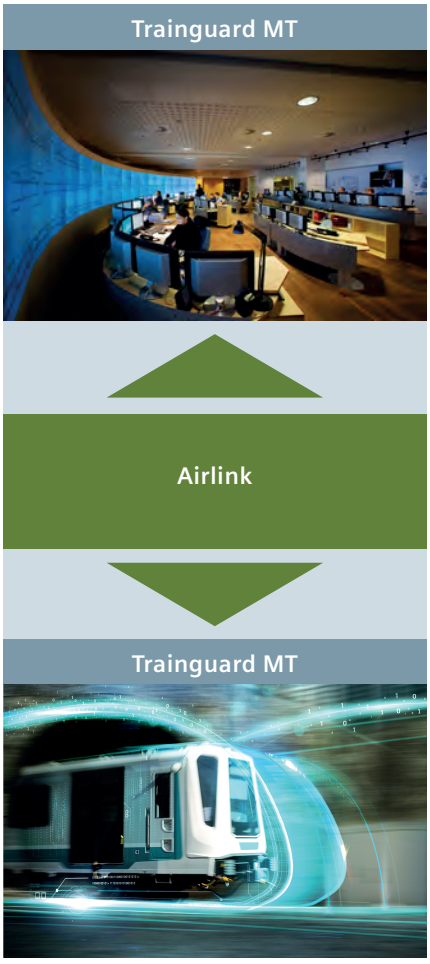
If required the Clearguard ACM axle counters can serve as a secondary track vacancy detection system. Trainguard MT also allows the use of other kinds of track vacancy detection systems (e.g. track circuits).

Ergonomic human-machine interface (HMI)

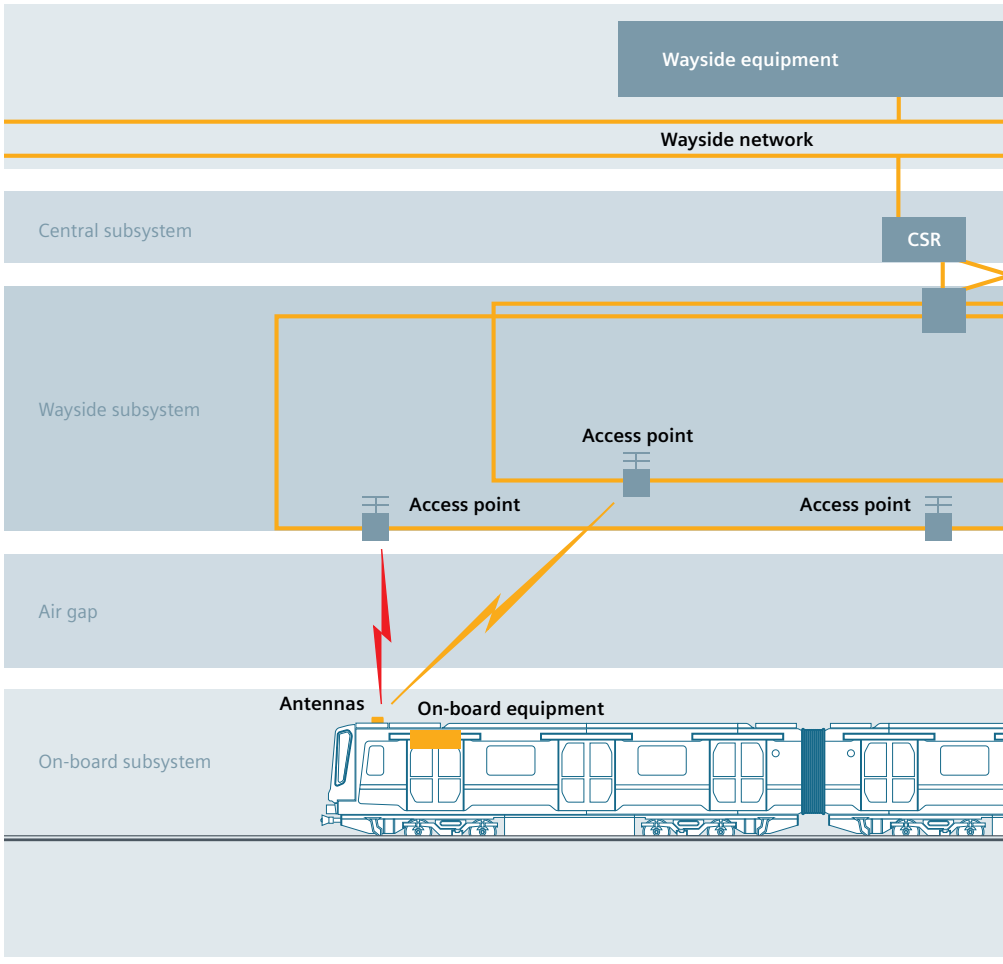
The ergonomic human-machine interface is the driver's multifunctional operator console. It combines a high-resolution color TFT display, touch-screen operation and audible feedback.

Airlink

Secure IP-based radio propagation for track-to-train data communications

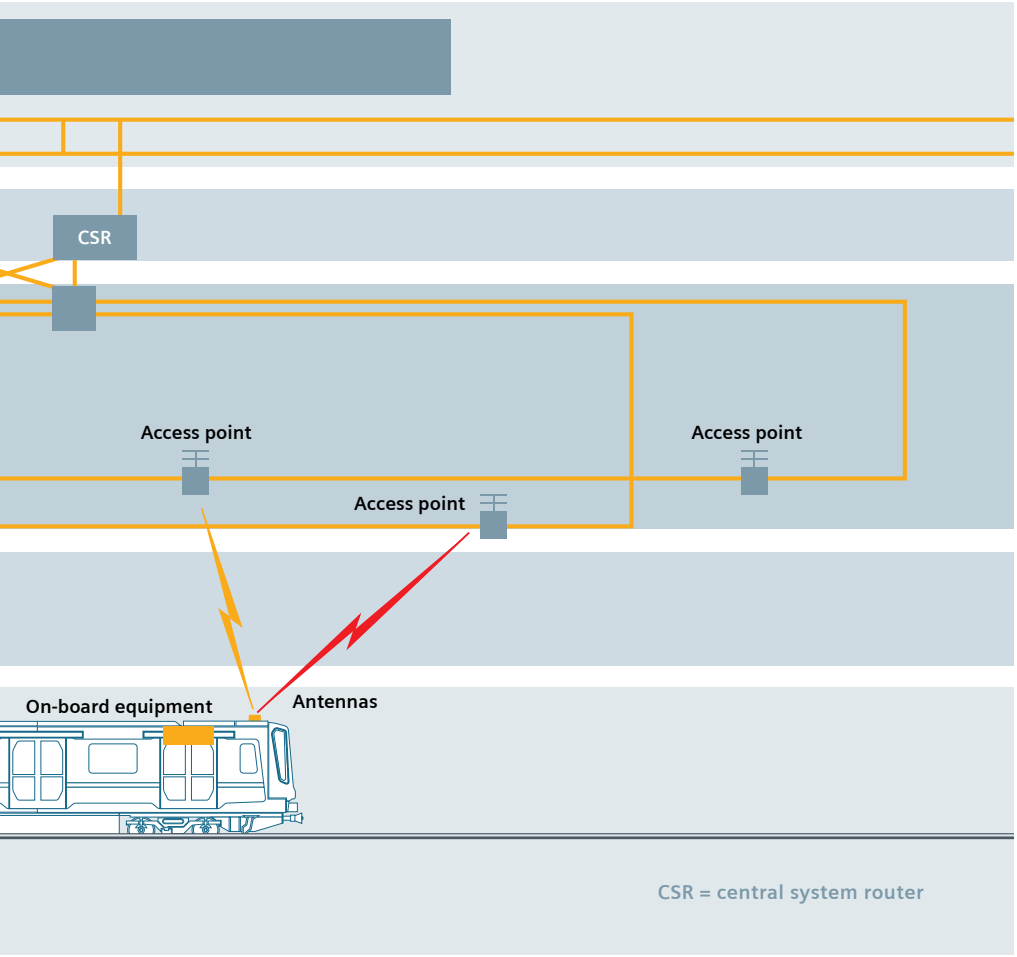


System overview



The Airlink radio communication system guarantees a highly reliable seamless and redundant flow of information between the track and a train.

Secure, reliable connectivity between trains and the wayside infrastructure is a fundamental requirement in a CBTC system. Therefore, Siemens has developed the Airlink radio communication system to ensure continuous and smooth operation of its Trainguard MT automatic train control system. Airlink supports all levels of automation from semi-automated to fully automated train operation and ensures highly efficient train operation.



System overview

Train radio units establish multiple wireless connections to the access points along the track. Handover from one radio cell to the next (roaming) is seamless.

To avoid signal data packet loss, the radio system uses a controlled roaming algorithm, with at most one roaming radio module at a time while the other active radio module stays tuned to the currently linked access points. The central system router managing communications is linked to the radio backbone network. The network is connected to the access points via parallel fiber-optic cables.

Highest security

High-level firewalls and security functions in line with well-known and proven standards based on EN 50159 are provided. Encryption and authentication via IPsec (Internet Protocol Security) using HMAC-SHA-256 in combination with configurable key exchange intervals prevent unauthorized access or manipulation of data to secure communication.

Platform concept

Airlink is a powerful and flexible hardware and software platform. The system provides completely transparent IP-based communication and comes fully integrated, with outstanding communication performance in terms of both reliability and security.

Airlink is designed for use in demanding railway environments such as rail transport on open lines or highly automated metro systems in tunnels.

Radio technology

Airlink operates in line with WiFi standards using either worldwide available free (ISM bands) or licensed frequency bands.

Lowest risk of interference is achieved by means of diversity measures such as front/rear on-board equipment with four antennas, intelligent use of the frequency spectrum and a repetition of telegrams when indicated. LTE radio technology is also supported. If LTE is used Airlink ensures the secured data transmission between onboard and wayside ATC units.

Selected project references

The world’s megacities choose Trainguard MT

Beijing Line 10 – the world 's longest CBTC metro line
Beijing Metro Line 10 was built to serve the high level of passenger demand during the Olympic Games in 2008. For this reason, the high-performance Trainguard MT system was chosen to ensure reliable and convenient passenger service.

After a project duration of only two years, Line 10 together with the Olympic Branch was opened to the public in July 2008 with a total length of 31km. The line was extended to a ring line with a length of 57km in 2012, which makes it the longest CBTC metro line worldwide. Today, the line transports more than two million commuters per day.

Paris Line 1 refurbishment

Line 1 is the oldest subway line in the Paris metro network and carries 567,000 passengers per day. The project includes the refurbishment of line 1 (25 stations, 16,5km) signaling system to driverless operation (GoA4) without service interruption ("under rolling wheel"). The 49 newly delivered trains have been equipped with the CBTC onboard system Trainguard MT.

The first fully automated train was inaugurated in November 2011 and the full automation was completed in December 2012. The system provides now a headway of 85 sec.

S-Bane, Copenhagen

Siemens is modernizing the complete mass transit network in Copenhagen consisting of, in total, 170 km of double track and 135 passenger trains. The legacy system will be refurbished with the state-of-the-art Trainguard MT system including Sicas® ECC electronic interlockings and a new operations control system from the Controlguide family.

The project will be executed in six phases.
The first section (early deployment) has been put into operation at the beginning of 2016. With this modernization program, the customer, S-bane, aims to increase availability, improve safety and reduce headways for its commuter rail operations. The new system requires very little maintenance due to fully electronic control systems, the use of maintenance-free and low-maintenance equipment and the omission of wayside signals.

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