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Fact Sheet

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How does a driverless metro system work?

Automated metro lines are more energy-efficient and punctual, and optimize passenger service automatically and in real time.

- By 2050, the number of city dwellers will be around 6.4 billion people, almost double the number today, and means that about 70 percent of the world's population will then be living in cities.
- The capacities of mass transit systems can rarely be expanded to the extent actually necessary in that case. In order to make more efficient use of existing infrastructure, existing metro lines are being modernized and increasingly equipped with automatic train control and safety systems.
- On an automated line, trains can travel at shorter intervals one after another. The capacity of a metro line can therefore be increased by up to 50 percent. Short intervals, called headways, of 80 to 90 seconds are feasible. If passenger volume is high, additional trains can be deployed independently of the regular timetable. They can be automatically sent into operation straight from the depot at the push of a button.
- Automatically controlled vehicles consume less energy thanks to optimized acceleration, traction and braking processes. Depending on the degree of automation, energy consumption can be cut by as much as 30 percent.
- At the same time, the punctuality of the trains is improved. On the basis of the line data, the automated system calculates exactly how and at which point a train has to be accelerated and braked for it to arrive punctually at the next station.
- Former train personnel can now act as service personnel in the train or on the platforms, look after passengers, and provide information and a greater sense of security.

The various grades of metro automation (GoA 1-4)

The various grades of automation range from driver-assisting functions for control of the brakes and automatic speed control of a train through automatic and precise stopping of a train in stations, opening and closing a train's doors to possible remote control and fully automatic metro operation without drivers.

- In the **driver-controlled mode**, the metro train is driven without assistance systems. The driver drives the metro train on sight, while stationary light signals control railway operation.
- In **partly automated mode** (SCO – Supervision and Control Train Operation), the driver still drives and brakes the metro train manually. A train protection system continuously monitors its speed, however. Besides this, supporting information such as current movement orders are displayed to the driver in the driver's cab.
- In **semi-automated mode** (STO – Semi-automated Train Operation), although the driver starts the metro train manually, the automatic driving system takes over precision control of the movement between two stations on its own and also automatic precision stopping of the train at the platforms and opening of the doors.

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- In **driverless mode** (DTO – Driverless Train Operation), driving is controlled and monitored automatically, without human assistance. A train attendant can intervene in emergencies. The automatic driving system takes care of the departure, the movement between two stations, and the automatic and precision stopping of the train and opening of the doors. If required, the door is automatically opened again. When passenger volume is high, additional trains are automatically sent into operation straight from the depot at the push of a button.
- In **unattended mode** (UTO – Unattended Train Operation), train operation is also controlled and monitored automatically. However, there is neither a driver nor a train attendant on board. Additionally automated functions include, for example, the coupling and uncoupling of trains, stabling of trains, and extended remote control and remote repair options.

How does fully automatic control of a train work?

The movement authority and control commands are not indicated by signals, but are issued via data communication between the rail vehicle and the trackside equipment **(Communication Based Train Control, CBTC).** All CBTC systems operate similarly:

- A trackside computer tracks all trains in the assigned section of line and calculates an appropriate movement authority for each train. As a result, trains are routed continuously and can then run at shorter headways than when driven manually on sight.
- In fully automated mode, metro trains are driven by the **automatic train control (ATC)** in combination with control and protection of the line by interlockings.
- To this end, the trackside computers are constantly exchanging data with the computers of the higher-level system in the control center and the computers in the train by radio.
- On board the train, the **Automatic Train Operation (ATO)** system replaces the metro driver and controls the train's speed.
- The ATO computer is monitored and, if necessary, corrected by the **Automatic Train Protection (ATP)** system.

Necessary measures when converting a metro line to driverless operation

Specific equipment for the line and platform protection

Besides the infrastructure commonly used for metro platforms, such as elevators, escalators, fire extinguishers, fire detectors, platform edge markings, radio, emergency lighting, emergency exits and so on, the stations along automated metro lines feature special equipment for safeguarding automatic driving operations:

- In automated mode, the section of track in metro stations is equipped with a **platform track monitoring system** whenever there are no platform doors that shield off the track area. The monitoring system triggers an alarm if a person or a large object should fall into the track area. Depending on how far away an approaching train is, immediate emergency braking is initiated or the train continues on to the beginning of the next platform and stops there. Trains in the adjacent stations are also prevented from departing. A message is sent in parallel to the operations control center and the service personnel on the platform.
- The **platform barrier doors**, which are necessary for automated operation, shield the platform from the line. Trains are prevented from departing if someone enters the track area unannounced.
- Should a person run into the tunnel, **intrusion monitoring** takes effect and stops trains or hinders them from departing.

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- **Remote surveillance of platform tracks and platforms** allows additional interventions. Video images of the track area appear automatically in the control center, enabling the employees there to undertake suitable measures. For better assessment of a disruption, the video sequence beginning ten seconds before the triggering of the alarm is available to the control center via a history memory.
- During automated operation, adequate numbers of **service personnel** are available to act as passenger contacts along the line. This also has a positive impact on the passengers' sense of security. The employees on the platform are there to rectify problems or to organize further help. They can also control the automated vehicles manually in the event of a fault.

Specific train equipment:

In addition to the usual train infrastructure, special safety guidelines and safety requirements, such as emergency brake, fire extinguishers, emergency lighting, audible signals and door monitoring, are provided for driverless metros.

- For example, driverless metros also benefit from a special obstacle detection feature. It initiates braking as soon as an obstacle is detected.
- These metros also possess derailment detectors, which detect a derailed car, and, if applicable, safely stop the train and report the incident to a control center.
- Furthermore, there is no longer any gap between platform and train. Gap bridging at the doors sees to this. This makes it easier for persons with reduced mobility and partially sighted persons to get on and off. Bridging also prevents passengers from falling into the gap between the platform edge and the vehicle.
- Door gap monitoring, which is capable of detecting even thin and flexible objects, contributes towards enhancing safety. The train cannot start off until all doors are correctly closed.
- Emergency door release is locked as soon as the train starts moving. If the train stops in the tunnel due to a disruption, doors remain locked until the operations control center has initiated safety measures, such as stopping oncoming traffic and deactivating the power supply to the power rail. The tunnel lighting is switched on automatically as soon as the traction current in the tunnel is deactivated.
- All vehicles must be equipped with the most up-to-date fire detection technology. A call point featuring an emergency call button enables a direct voice connection to the driver or, in the driverless mode, directly to the operations control center. Thus, an emergency can also be reported during train movement.

Special safety elements for driverless operation

- After an emergency call or actuation of an emergency brake by a passenger, the situation in the vehicle can be assessed from the control center with the aid of passenger area surveillance. Necessary measures can be initiated without delay.
- The trains are equipped with surveillance cameras throughout. The video images are transmitted to the control center by means of a radio LAN. This enables incidents to be registered directly by the control center and countermeasures to be initiated.
- If a fire should break out in the car, the installed smoke detector and temperature sensors become active. They detect hazards as they arise. The sensors trigger an alarm in the control center and the train is stopped automatically at the next station, where personnel can investigate the cause of the fire alarm.
- A public-address system in the passenger area serves for the announcement of operational and traffic information. Besides advising passengers in an emergency, it is used to supply passengers with general information.

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- If required, passengers can contact the operations control center at any time via the emergency call point. A passenger who triggers an alarm is connected directly via digital radiotelephony.
- Shortly before doors close, visual and audible signals announce closing by means of flashing light at the doors and a beeping sound. The combination of both also reliably signal to persons of impaired vision and hearing that the doors are about to close.
- During automated operation, the monitoring facilities detect whenever the prescribed speed is exceeded and then automatically brake the train.
- Distance measurement is the basis for essential functions of the train protection system (ATP onboard computer), such as observing headways, approaching stops or monitoring speeds. This is why the ATP onboard computer continuously measures the distance that is traveled. The information on the current position of the vehicle is updated regularly.

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