Automated driving by rail

Positive impact of rail market transformation
Exponential growth of digitalization will change rail and road transportation enormously – and has already begun!
Positive impact of rail market transformation

Challenges in mainline, regional line and freight traffic

Potential for optimization through automatic train operation

"ATO over ETCS"

Outlook
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Outlook
### Current challenges of different railway operators and their expectations of automation solutions between the priorities of different requirements

<table>
<thead>
<tr>
<th>High Density mainline</th>
<th>Low Density mainline</th>
<th>Freight</th>
<th>Mining</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Capacity increase on existing infrastructure</td>
<td>• Low operating costs</td>
<td>• Energy savings</td>
<td>• Precise stopping</td>
</tr>
<tr>
<td>• Mixed traffic</td>
<td>• Reduction of equipment</td>
<td>• Interoperability</td>
<td>• Robust high-end solutions</td>
</tr>
<tr>
<td>• Interoperability</td>
<td>• High safety/security requirements</td>
<td>• Equipment on the train</td>
<td>• Driverless train operation</td>
</tr>
<tr>
<td>• High availability of the overall system</td>
<td></td>
<td>• Driverless train operation</td>
<td>• High availability requirements</td>
</tr>
<tr>
<td>• High safety/security requirements</td>
<td></td>
<td>• High safety/security requirements</td>
<td>• Lower safety/security requirements</td>
</tr>
</tbody>
</table>
Siemens is global market leader with EUR > 3.0 bn order intake in the last five years for highly and fully automated mass transit solutions.

### Highly automated (GoA 2)

<table>
<thead>
<tr>
<th>Solution</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beijing Linie 10</td>
<td>2008</td>
</tr>
<tr>
<td>Budapest Linie 2</td>
<td>2008</td>
</tr>
<tr>
<td>Guangzhou Linie 4+5</td>
<td>2008/10</td>
</tr>
<tr>
<td>Paris Linien 3, 5, 9, 10, 12</td>
<td>2009</td>
</tr>
<tr>
<td>Algiers Linie 1</td>
<td>2010</td>
</tr>
<tr>
<td>Nanjing Linien 2+1</td>
<td>2009/10</td>
</tr>
</tbody>
</table>

### Fully automated (GoA 3-4)

<table>
<thead>
<tr>
<th>Solution</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Istanbul Linie 1</td>
<td>2008</td>
</tr>
<tr>
<td>Suzhou Linie 1</td>
<td>2012</td>
</tr>
<tr>
<td>Guangzhou Guang-Fo</td>
<td>2010/12</td>
</tr>
<tr>
<td>Chongqing Linie 1</td>
<td>2011/12</td>
</tr>
<tr>
<td>Beijing Olympia Linie 8</td>
<td>2012/13</td>
</tr>
<tr>
<td>New York PATH</td>
<td>2017</td>
</tr>
<tr>
<td>Metro Nuremberg</td>
<td>2006</td>
</tr>
<tr>
<td>Barcelona, Linie 9</td>
<td>2009</td>
</tr>
<tr>
<td>Metro Paris Linie 1</td>
<td>2011</td>
</tr>
<tr>
<td>Sao Paulo Linie 4</td>
<td>2012</td>
</tr>
<tr>
<td>Budapest Linie 4</td>
<td>2014</td>
</tr>
<tr>
<td>Metro Riad</td>
<td>2018</td>
</tr>
</tbody>
</table>

**Solutions for GoA 2-4**

- CBTC/Trainguard MT
- Controlguide
- Sicas
- Westrace
- Airlink

**New orders 2014/2015 (extract)**

- Buenos Aires Linie C, Queens Boulevard New York City, Xian Linie 3 (China), Fuzhou Linie 1 (China), Sosa Wonsi (Korea)

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*Year = Commissioning/Start of Operation, GoA = Grade of Automation, ATO = Automated Train Operation, CBTC = Communications-Based Train Control, 1) Siemens Mobility Products/Systems/Solutions for Rail Automation*
Opportunities for railway operators by increasing the grade of automation

- The preconditions for additional solutions in today's railway systems are excellent
- High potential for economic optimization
  - Energy saving
  - Increase in track capacity
  - Increase in operational flexibility
  - Increase of punctuality
  - Precise stopping
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“ATO over ETCS”

Outlook
Automation functions from mass transit can be adapted successfully for mainline

<table>
<thead>
<tr>
<th>Partially automated</th>
<th>Highly automated</th>
<th>Fully automated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supervised by driver</td>
<td>Reduced driver supervision</td>
<td>System is responsible</td>
</tr>
</tbody>
</table>

GoA – Grades of Automation according to IEC/EN 62290-1

1. **Driver in cab**
   - Ensure safe movement of train
   - **Automatic Train Protection** e.g. ETCS

2. **Driver in cab**
   - Drive train
   - **Driver Advisory Systems** DAS

3. **Train attendant on-board**
   - Supervise track
   - **Automatic Train Operation** ATO

4. **No staff on-board**
   - Supervise passenger transfer, train status, incidents and emergencies
   - **Driverless and Unattended Train Operation** DTO/UTO
ETCS has become the worldwide standard for automatic train control systems and is the fundament for a sustainable development of railways

Trainguard solutions for ETCS Level 2

- GSM-R or other radio system (e.g. TETRA)
- Driver-machine interface
- Interlocking
- RBC
- Ballise antenna
- Odometer
- Radar
- Eurobalise position calibration
- Eurobalise position calibration
- Track vacancy detection

ETCS = European train control system
RBC = radio block centre
ATC = Automatic Train Control
SBI = Safe Block Interface
RBC = Radio Block Centre
GSM-R = Global System for Mobile Communications - Railway
TETRA = Terrestrial Trunked Radio
Market tendencies

- Assistance solutions in low density and freight traffic segments are in high demand
- ATO over ETCS is in demand in the United Kingdom, Netherlands and Germany
- Fully automated driving (driverless/unattended)
  - Complex layout of tracks
  - It is not possible to completely isolate the network from any outside influences (e.g. with fences, over- and underpasses etc.)
- In addition to the technical challenges, the systems in Europe have to be harmonized
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Outlook
ETCS and ATO in the railway system

Operational tier
- Operator
- Driver
- Communication/operational rules
  - Interlocking control
  - Vehicle control
  - Train control

Technical tier
- Route
- Vehicle
- ETCS

ATO
Overall system concept

**Traffic Management System (TMS)**
Coordinates train movements

**European Train Control System (ETCS) trackside**
Radio block centre and eurobalises
Provides safe movement authorities

**ATS – ATO communications via ETCS and GSM-R radio**

**European Train Control System (ETCS) on-board**
On-board equipment
Ensures safe train movements

**Automatic Train Operation (ATO)**
On-board equipment
Ensures optimum train movements
ATO allows an optimal utilization of capacity through a shortened headway due to a consistent mode of operation

- ATO ensures an exact realization of the speed profile at any time (minimal energy consumption at a fixed timetable)
- ATO stops more precisely
- Some notifications and warnings are suppressed by ATO to avoid confusion
ATO can reduce energy consumption by 15 to 20 percent

- The energy-optimal driving curve is calculated in realtime by the ATO and comprises four different types of driving: full acceleration, cruising, coasting and full braking
- The driving curve is optimized for every train run and is not based on a limited amount of profiles
- On top of that, ATO reduces wear and tear of brakes and CO₂ emissions
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Outlook
Further developments are happening on the basis of ETCS

Within the scope of the EU initiative Shift2Rail, more aspects are developed further

European committee work

- Standardization of ATO over ETCS
- Same requirements for interoperability as with ETCS
  - Option 1: With ETCS as an integrated ATO
  - Option 2: ATO as a standalone product
Thank you for your kind attention