Exponential growth of digitalization will change rail and road transportation enormously – and has already begun!
Siemens meets key transportation sector requirements

The needs of passengers and motorists

Operators and cities have to react

Siemens solutions provide

Guaranteed availability

Maximum throughput

Enhanced passenger experience
Digitalization is key to fulfilling customers' demand for availability, throughput and passenger experience

- **Guaranteed availability**
  - Smart data analytics for infrastructure and vehicle service
  - Combining high vehicle/infrastructure performance with best-in-class service and maintenance

- **Maximum throughput**
  - Integrated resource management
  - Software for next-generation train control
  - Next-generation digitally enhanced interlockings

- **Enhanced passenger experience**
  - Passenger information and assistance systems
  - Broadband and entertainment services
  - Automated fare collection »be-in/be-out«
Levels of automation in the rail and automotive sectors. Autonomous systems for rail operation are more mature than those for road traffic.

GoA Levels 0 – 4 = Grade of Automation according to International Electrotechnical Commission / Commission Electrotechnique Internationale, International Standard 62290-1

SAE Levels 0 – 5: Automation Levels defined by the Society of Automotive Engineers (SAE)

1 © Siemens AG 2015
Page 5  December 8, 2015
2 Jochen Eickholt
Automation / Digitalization of mobility market expected to grow rapidly

Share of connected people as % of world population

<table>
<thead>
<tr>
<th>Year</th>
<th>World Population (in bn.)</th>
<th>Connected</th>
<th>Not connected</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>5.7</td>
<td>5.7</td>
<td>0.7%</td>
</tr>
<tr>
<td>2005</td>
<td>6.5</td>
<td>6.5</td>
<td>15.0%</td>
</tr>
<tr>
<td>2015</td>
<td>7.3</td>
<td>7.3</td>
<td>75.3%</td>
</tr>
</tbody>
</table>

Rail and road market in € bn.

<table>
<thead>
<tr>
<th>Year</th>
<th>Electric</th>
<th>Digitalization/Automation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>&lt; 50</td>
<td>&lt; 50</td>
</tr>
<tr>
<td>2015</td>
<td>67</td>
<td>&gt; 85</td>
</tr>
<tr>
<td>2025</td>
<td>&gt; 85</td>
<td>&gt; 85</td>
</tr>
</tbody>
</table>

The market for highly and fully automated transportation is growing rapidly.

### Mainline and freight rail

<table>
<thead>
<tr>
<th>Year</th>
<th>GoA 0-1</th>
<th>GoA 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>7.9</td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td>9.3</td>
<td></td>
</tr>
</tbody>
</table>

**Rail control world market**
incl. Industrial, Mining in € bn.

**Mainline and freight on path to higher automation**

- **Partially automated**: Supervised by driver
- **Highly automated**: Limited driver action
- **Fully automated**: No supervision by driver

**Mass transit on path to higher automation**

### Mass transit

<table>
<thead>
<tr>
<th>Year</th>
<th>GoA 0-1</th>
<th>GoA 2-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>3.2</td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td>3.8</td>
<td></td>
</tr>
</tbody>
</table>

**Rail control world market**
in € bn.

---

1 GoA Levels 0 – 4 = Grade of Automation according to International Electrotechnical Commission / Commission Électrotechnique Internationale, International Standard 62290-1

© Siemens AG 2015

Page 7  December 8, 2015
Siemens is global market leader with > € 3.0 bn. order intake in the last five years for highly and fully automated mass transit solutions

<table>
<thead>
<tr>
<th>Highly automated (GoA 2)</th>
<th></th>
<th>Fully automated (GoA 3-4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guangzhou Line 4+5</td>
<td>(2008/10)</td>
<td>Guangzhou Guang-Fo</td>
</tr>
</tbody>
</table>

Solutions for GoA 2-4 1)

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

Order Intake 2011-2015

<table>
<thead>
<tr>
<th>New orders 2014/2015 (extract)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buenos Aires Line C, Queens Boulevard New York City, Xian Line 3 (China), Fuzhou Line 1 (China), Sosa Wonsi (Korea)</td>
</tr>
</tbody>
</table>

GoA = Grade of Automation, ATO = Automated Train Operation, CBTC = Communications-Based Train Control, 1) Siemens Mobility Products / Systems/Solutions for Rail Automation

© Siemens AG 2015
Shorter headway and higher passenger throughput through automatic train control from Siemens

- Trainguard MT from Siemens for automatic train control
- CBTC\(^1\) operations control system together with Automatic Train Operation allows driverless train operation
- Most heavily traveled and oldest Metro line in Paris, 17 kilometers long, up to 725,000 passengers a day
- Driverless metro system increases capacity during peak periods by 20%
- Energy savings of 15%

\(^1\) CBTC: Communications-Based Train Control
Riyadh’s fully automated metro system: transporting the equivalent of a small town’s entire population every hour

Metro Riyadh – closed system

- World's largest urban transport project with 7 metro lines, total length of 175 km
- Turnkey systems for Lines 1 and 2: Metro trains, electrification, signaling/communication, interlockings
- Signaling and train control technology ensure that trains can operate at 90-second intervals
- High operating frequency enables the system to handle 21,000 passengers per hour
Nürnberg's metro system offers driver-based and driverless operation, and is an example of Siemens’ lead in semi-closed systems

- Driverless system with 99% punctuality
- Flexibility: Additional trains can be deployed and automatically sent into operation straight from the depot
- Driverless metro system increases capacity by 50%
- 85 second headway
- 15 percent energy savings
Automatic train operation enables seamless transfer between regional transport and mass transit beginning spring 2016, currently in test operation

Desiro City on Thameslink Line – semi-closed system

- Maximum throughput (trains per hour) increased 25% through automatic driving
- Improved energy efficiency – through lightweight construction and intelligent systems
- Automatic Train Operation (ATO) for ERTMS Level 2 (European Rail Traffic Management System)
- Long-term maintenance by Siemens in two new depots
- “Always connected“ – innovative passenger information system
Ulm, Germany: Intelligent driver assistance guides tram driver through city traffic

Vehicle detection
- 2 autonomous stereo-cameras
- Camera for signal detection
- Camera

Person detection
- Radar
- Laser scanner

Ulm – open system
Siemens already provides roadside infrastructure designed to replace the physical infrastructure with safe communication

- In 2014 Siemens, NXP and Honda launched a large-scale test run with connected cars
- The “Communicating Cars”-initiative demonstrates the practical benefits of intelligent transport systems (ITS) and their suitability for everyday use
- The test corridor stretches from Vienna to Rotterdam – 1,300 km across Europe
- Low priced interconnected sensor networks are key elements for intelligent road transportation
From product business via driver assistance systems and Automatic Train Operation to autonomous driving – what is required?

Rail
- Automatic Train Operation
- Extended Operations Control Center
- Radio Block Center
- Remote Control
- Radio-operated Approach Indicator
- Hazard Detection
- ETCS1 On-Board Unit
- Driver Advisory System
- Rail2X2
- ...

Connected by
- Management Center
- Integrated Mobility Platform
- Vehicles and Infrastructure communicate with each other

Road
- Magnetic sensors
- Traffic Management
- Traffic Controller with WLAN
- Video-/Radar detectors
- Loop Detectors
- Traffic Computer
- Fleet Management
- eBus Charging
- Car2X2
- ...

Key portfolio elements
- Extended Operation Control System
- Hazard Detection System
- Remote Control System
- Driver Advisory System
- Automatic Train Operation
- Automatic Train Protection Systems
- Interconnected Sensor Network
- Traffic-/Fleet management

1 ETCS: European Train Control System
2 Rail2X / Car2X: Vehicles communicating among each other and with infrastructure

© Siemens AG 2015
Vision 2050: The future of transportation will be exciting

- All vehicles will be autonomous (GoA 3\(^1\) or higher)
- Especially for low density traffic vehicles will connect/scale for larger distances (vehicle transporters or connected driving)
- Traffic flow supported by intelligent streets/roads and distributed control centers
- Safety levels will improve substantially for high and low density traffic
- Energy consumption will be reduced
- Capacities and flexibilities will be increased dramatically
- Seamless intermodal travelling will be standard

\(^1\) GoA Levels 0 – 4 – Grade of Automation according to International Electrotechnical Commission / Commission Électrotechnique Internationale, International Standard 62290-1
Thank you!

Innovation at Siemens | Press and Analyst Event | December 8, 2015 | Jochen Eickholt, CEO Mobility