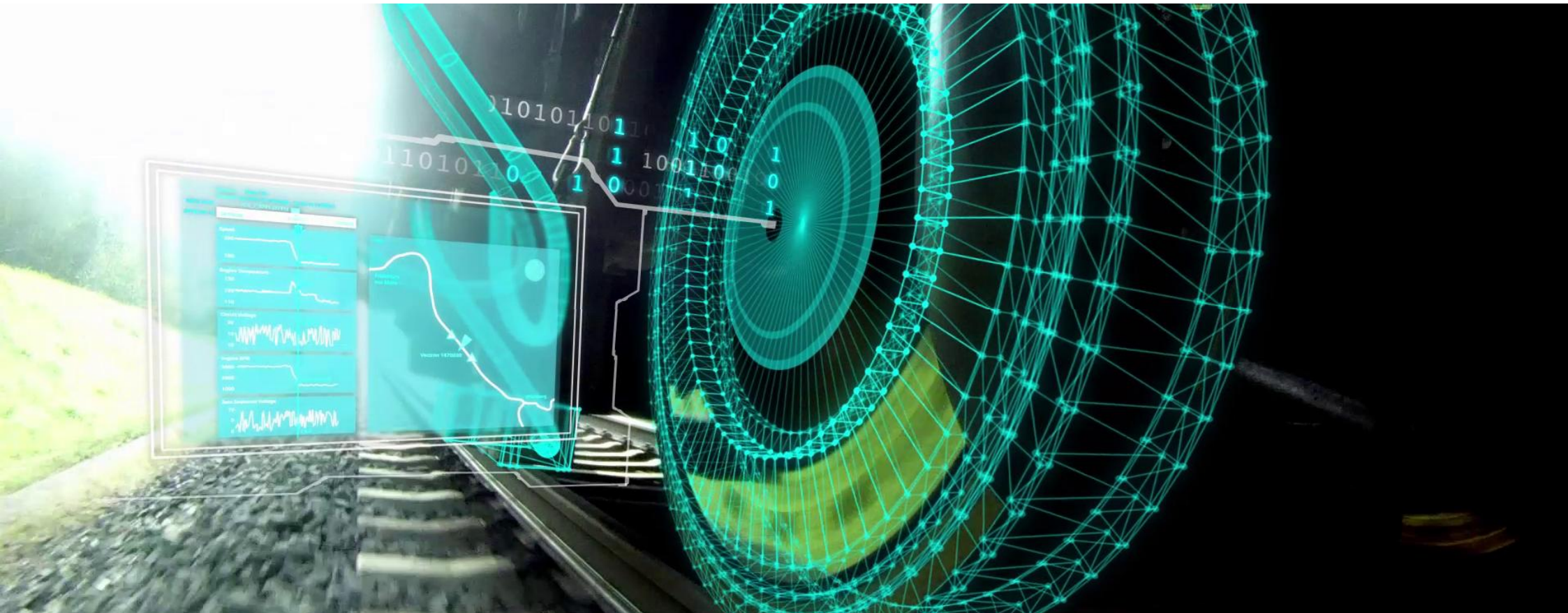


Automated driving by rail

Positive impact of rail market transformation

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

SIEMENS



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



Positive impact of rail market transformation

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

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High Density mainline

- Capacity increase on existing infrastructure
- Mixed traffic
- Interoperability
- High availability of the overall system
- High safety/security requirements

Low Density mainline

- Low operating costs
- Reduction of equipment
- High safety/security requirements

Freight

- Energy savings
- Interoperability
- Equipment on the train
- Driverless train operation
- High safety/security requirements

Mining

- Precise stopping
- Robust high-end solutions
- Driverless train operation
- High availability requirements
- Lower safety/security requirements

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

SIEMENS



Highly automated (GoA 2)



- ✓ Beijing Linie 10 (2008)
- ✓ Budapest Linie 2 (2008)
- ✓ Guangzhou Linie 4+5 (2008/10)
- ✓ Paris Linien 3, 5, 9, 10, 12 (2009)
- ✓ Algiers Linie1 (2010)
- ✓ Nanjing Linien 2+1 (2009/10)

Solutions for GoA 2-4¹⁾

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

Fully automated (GoA 3-4)



- ✓ Istanbul Linie 1 (2010/12)
- ✓ Suzhou Linie 1 (2012)
- ✓ Guangzhou Guang-Fo (2010/12)
- ✓ Chongqing Linie 1 (2011/12)
- ✓ Beijing Olympia Linie 8 (2012/13)
- New York PATH (2017)
- ✓ Metro Nuremberg (2006)
- ✓ Barcelona, Linie 9 (2009)
- ✓ Metro Paris Linie 1 (2011)
- ✓ Sao Paulo Linie 4 (2012)
- ✓ Budapest Linie 4 (2014)
- Metro Riad (2018)

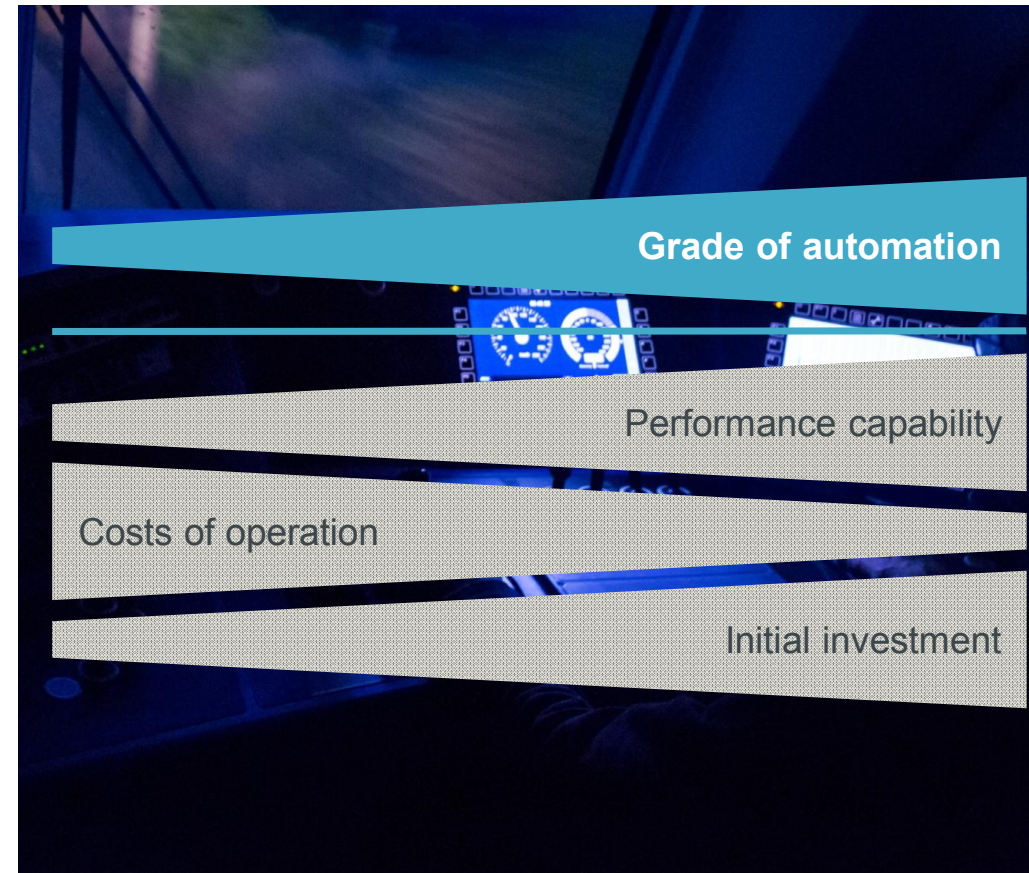
New orders 2014/2015 (extract)

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

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



Positive impact of rail market transformation

Challenges in mainline, regional line and freight traffic

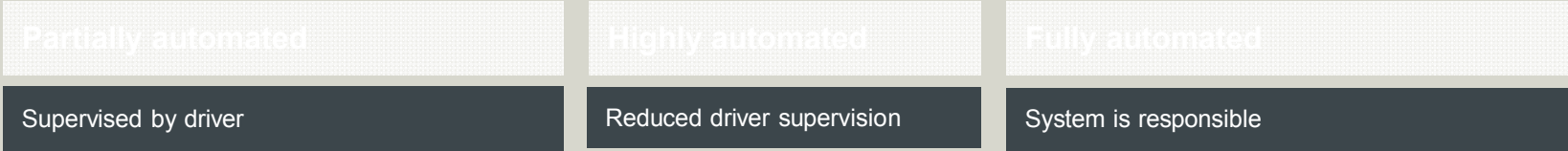
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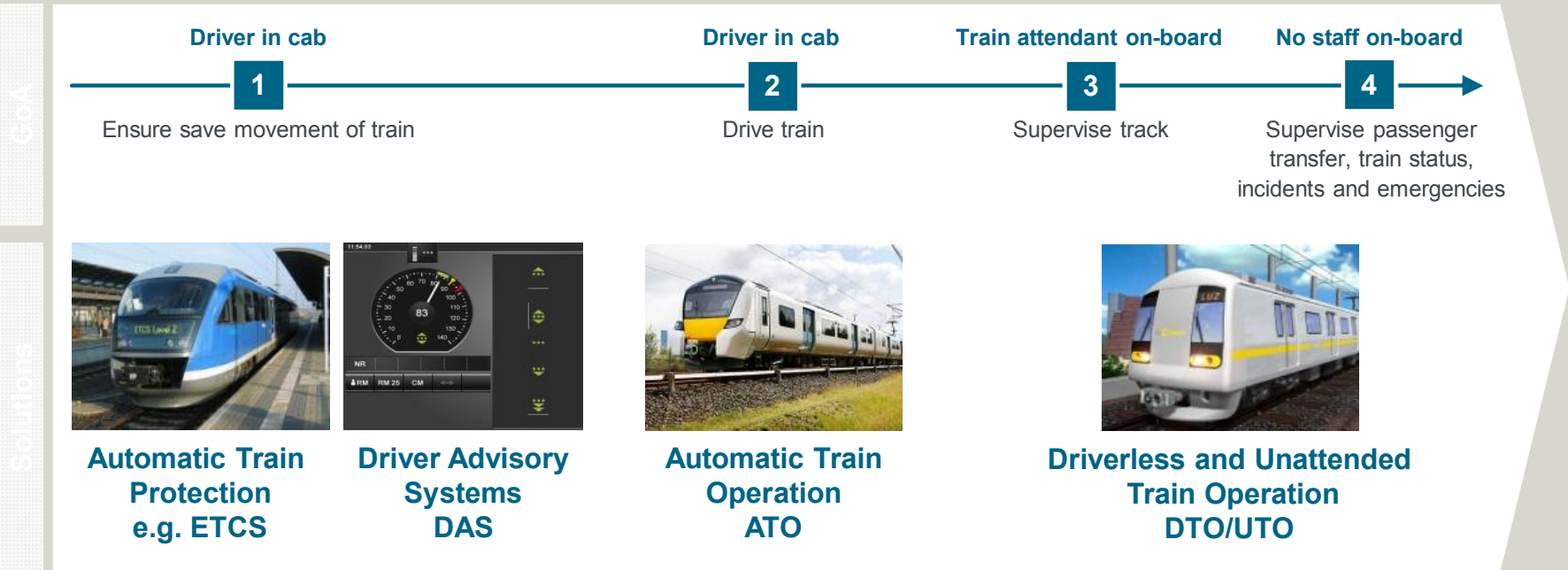
Outlook



Automation functions from mass transit can be adapted successfully for mainline



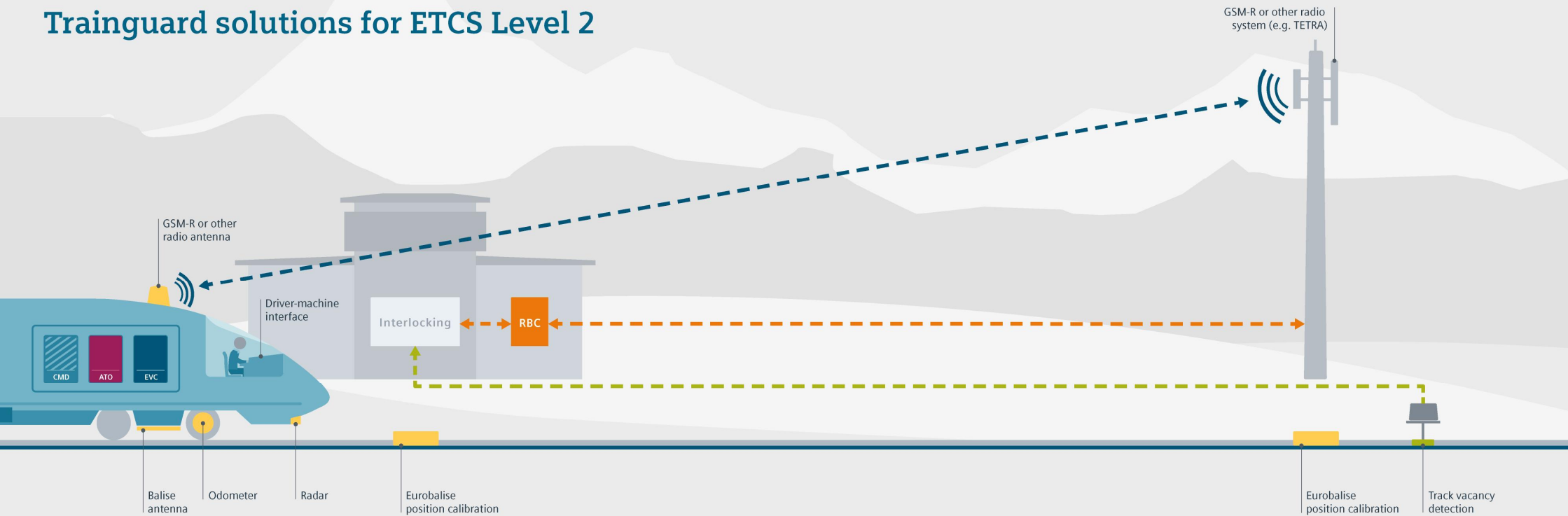
GoA – Grades of Automation according to IEC/EN 62290-1



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



EVC = European vital computer CMD = Cold movement detection
 RBC = radio block center ATO = Automatic Train Operation

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



Positive impact of rail market transformation

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Outlook



ETCS and ATO in the railway system

Operational tier

Operator

Driver

Communication/
operational rules

Interlocking
control

Vehicle
control

ATO

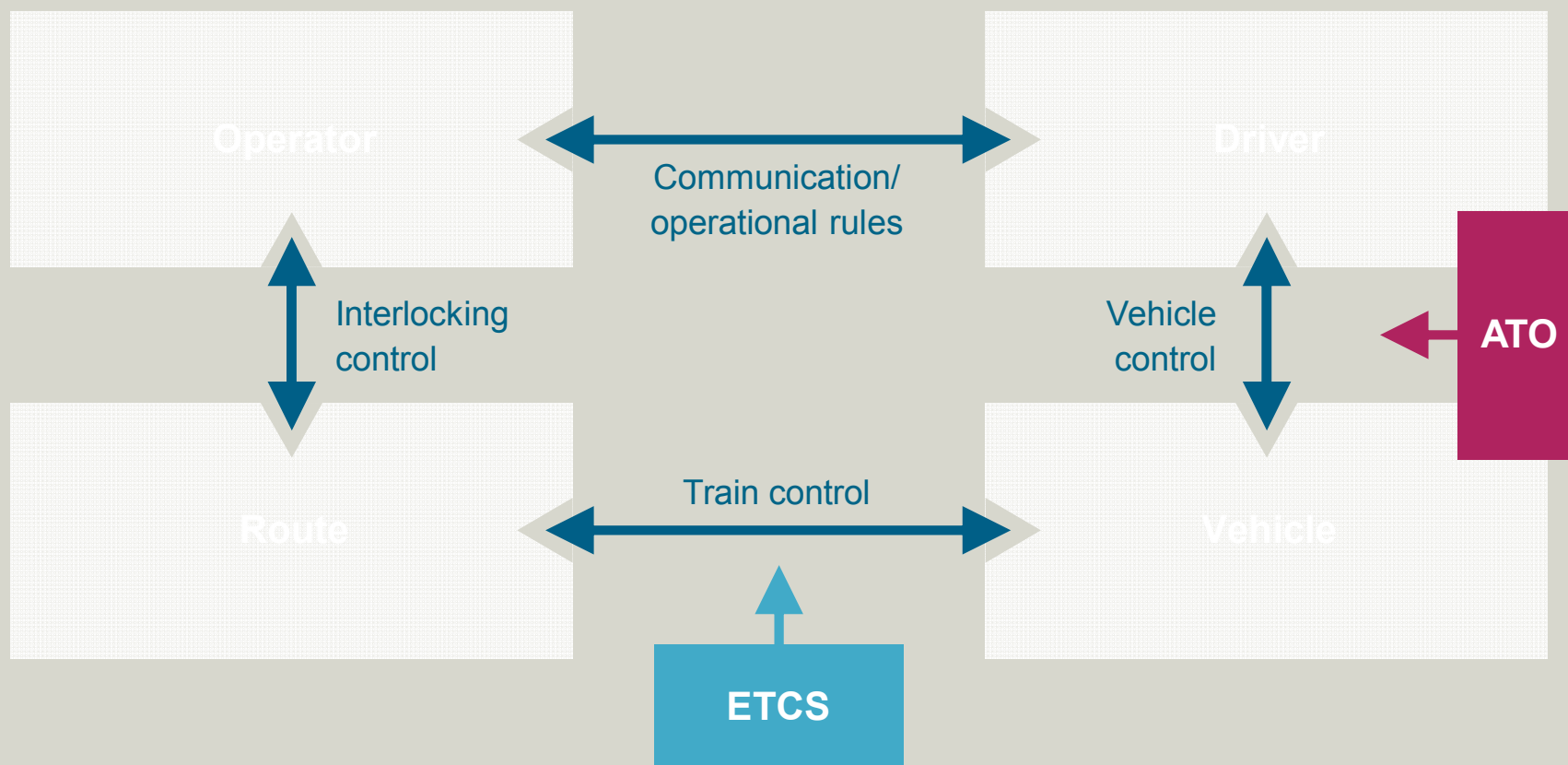
Technical tier

Route

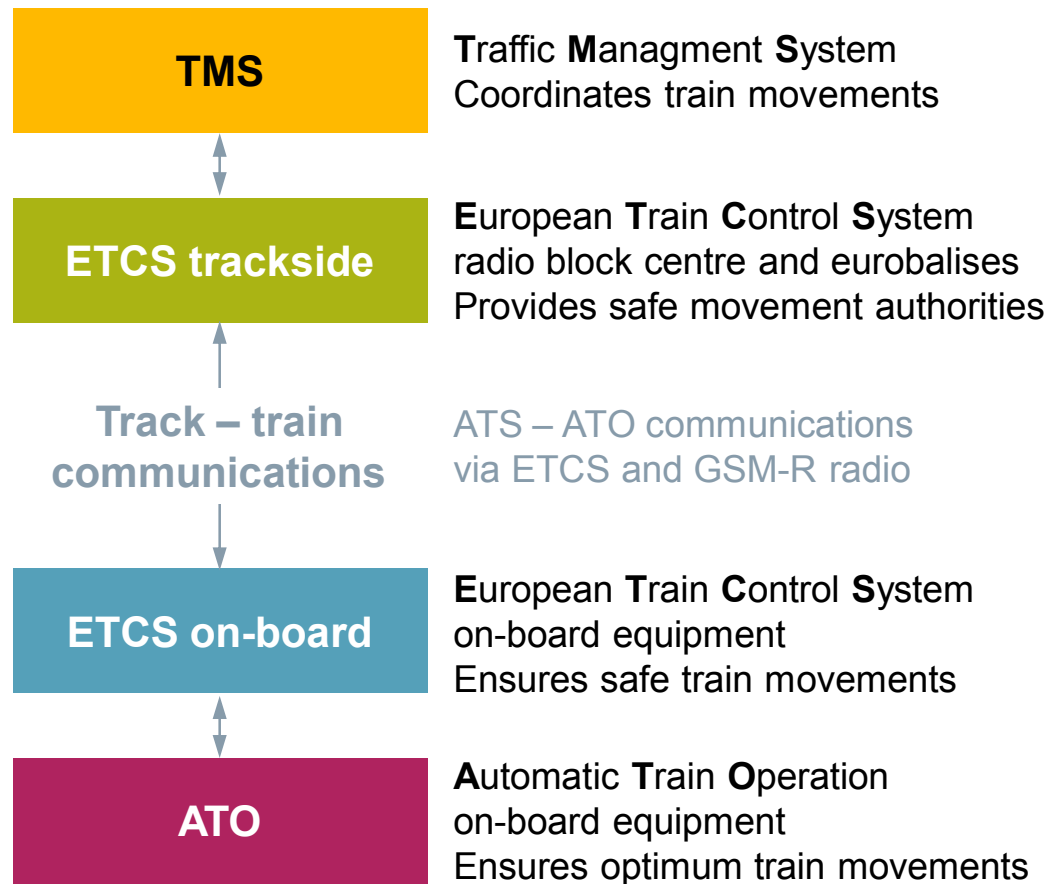
Train control

Vehicle

ETCS



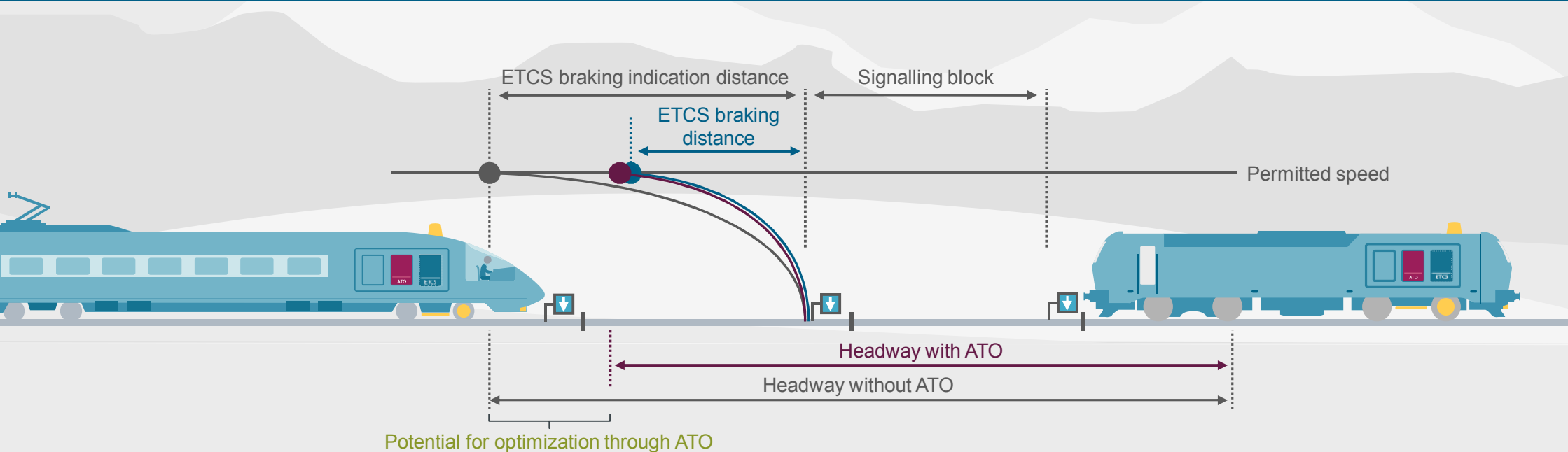
Overall system concept



ATO allows an optimal utilization of capacity through a shortened headway due to a consistent mode of operation

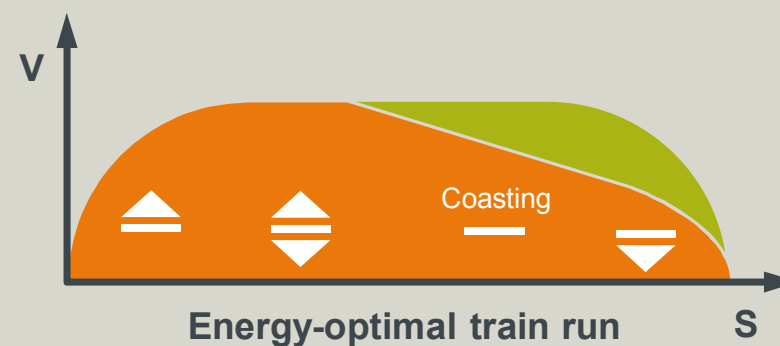
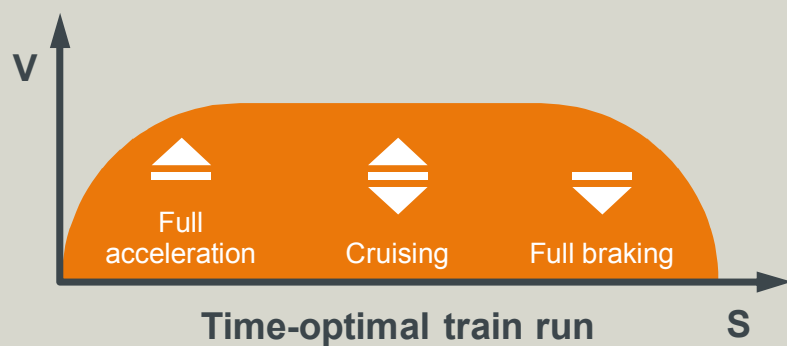
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- ATO ensures an exact realization of the speed profile at any time (minimal energy consumption at a fixed timetable)
- ATO stops more precisely
- Some notifications and warnings are suppressed by ATO to avoid confusion



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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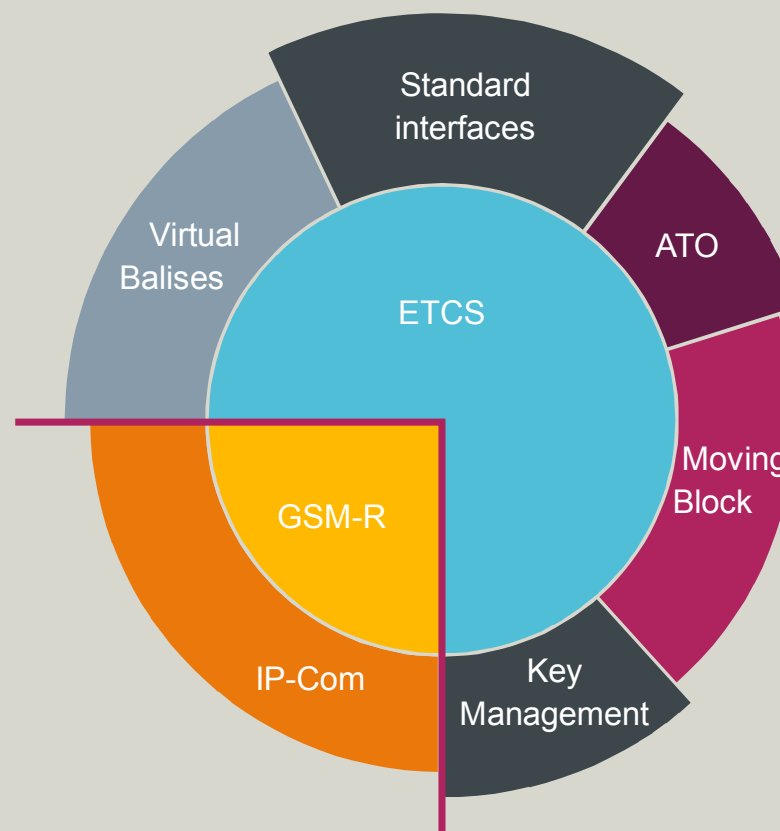


Further developments are happening on the basis of ETCS

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



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Thank you for your kind attention

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