KNORR-BREMSE

Evolution of Braking

The Electro-Mechanical Brake: Electric braking by Brake-by-wire

Josef Baier
Director Brake Domain Systems
Knorr-Bremse Systeme für Schienenfahrzeuge GmbH

AGENDA

1. Introduction – Our motivation
2. System architecture and functions
3. Benefits for future operations
4. Knorr-Bremse development status

Your Requirement – Our Motivation

dynamize your
TRAFFIC FLOW

- Flexible transport capacity
- Higher vehicle availability
- Reduced train headways
- Automated driving

sustain enhance accelerate your
TRAIN OPERATIONS MAINTENANCE

- Reduction of life-cycle costs
- Reduction of total cost of ownership
- Low-maintenance / optimized systems

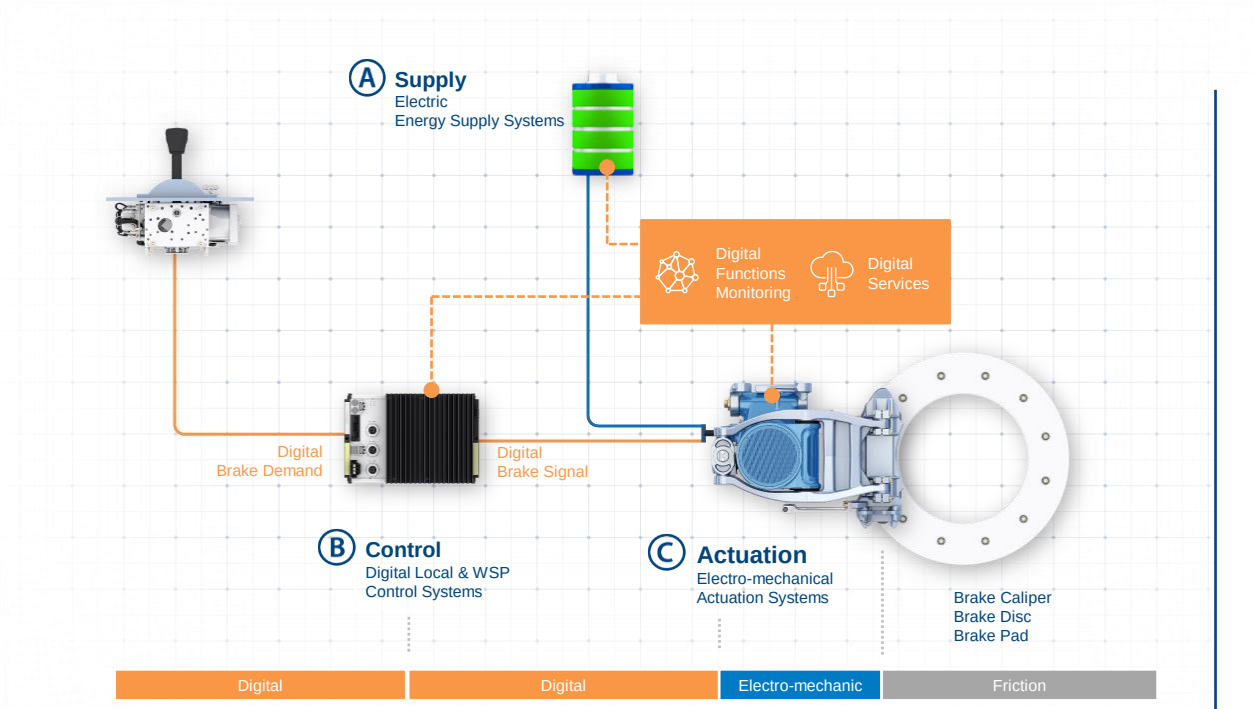
build your
DIGITAL SOLUTIONS

- Increased diagnostic capability
- Condition Monitoring
- Cybersecurity

optimize your
ECOLOGICAL FOOTPRINT

- More efficient and energy-saving vehicles
- Weight reduction
- Optimization / saving of installation space

Basic System Architecture – Electro-mechanical braking system (EM brake)



System Architecture

Electro-pneumatic/-hydraulic braking system

- Stable and proven system
- Will continue to be used for the next decades

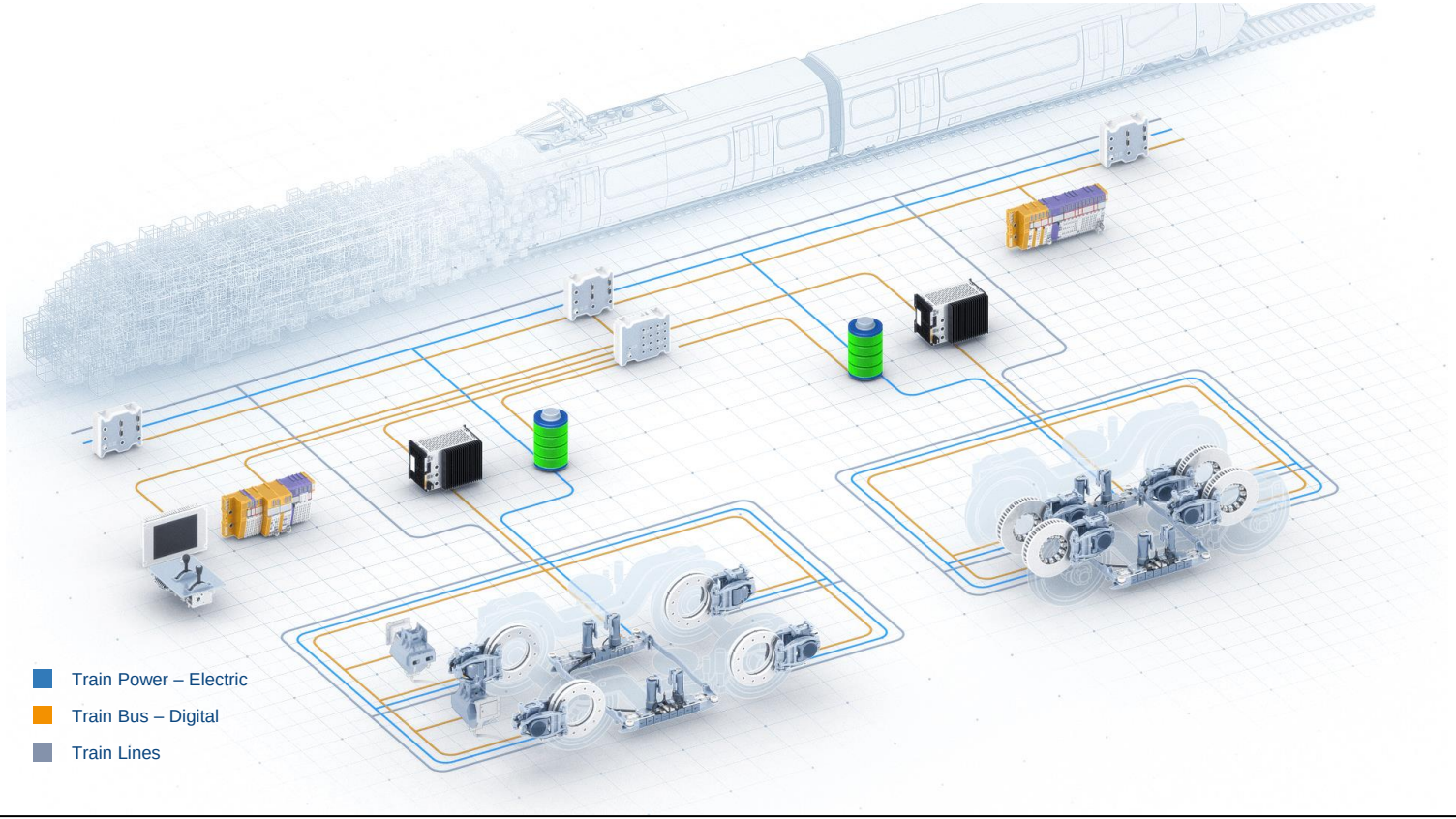
Physical limits reached in further technological development

Customer need to optimize the traffic flow

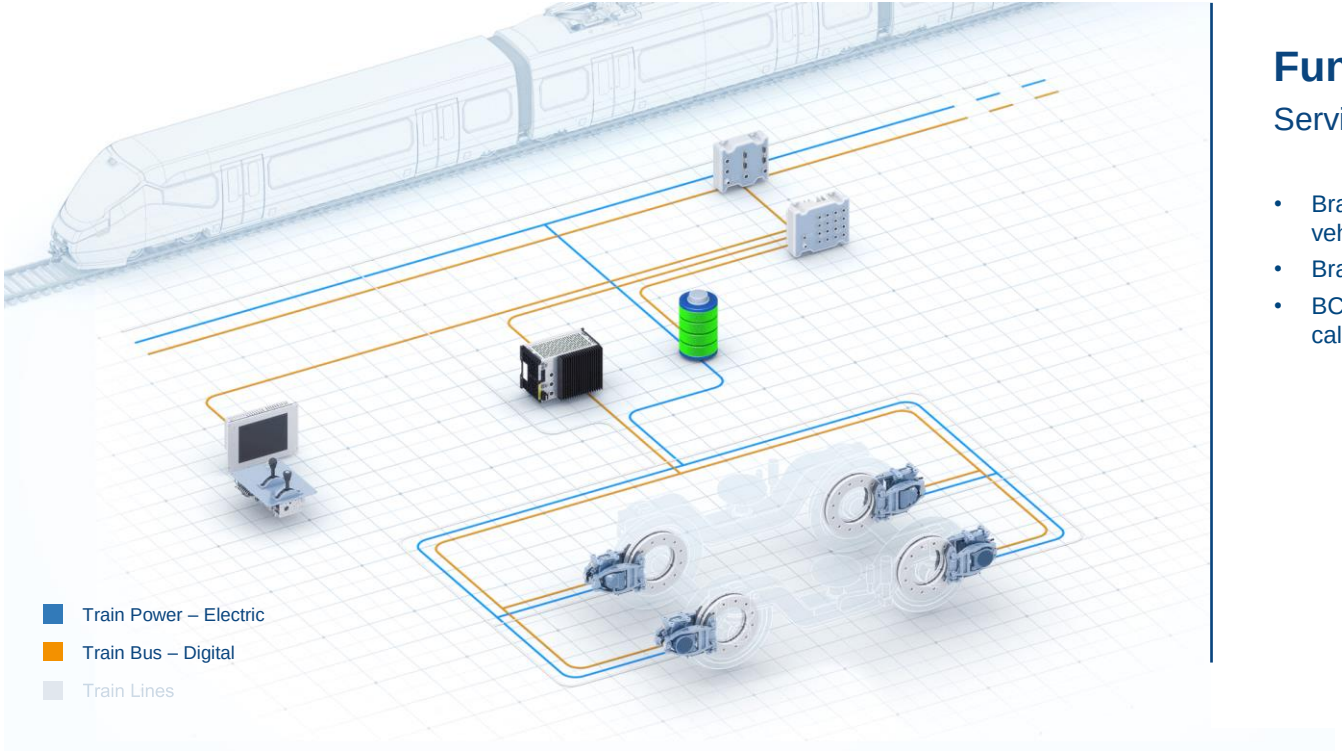
- Lighter trains
- Higher train frequencies
- Electrification
- Airless train
- Higher efficiency

Electro-mechanical braking system as a real alternative

Electro-mechanical braking system – Fundamental design



Electro-mechanical braking system – Service Brake

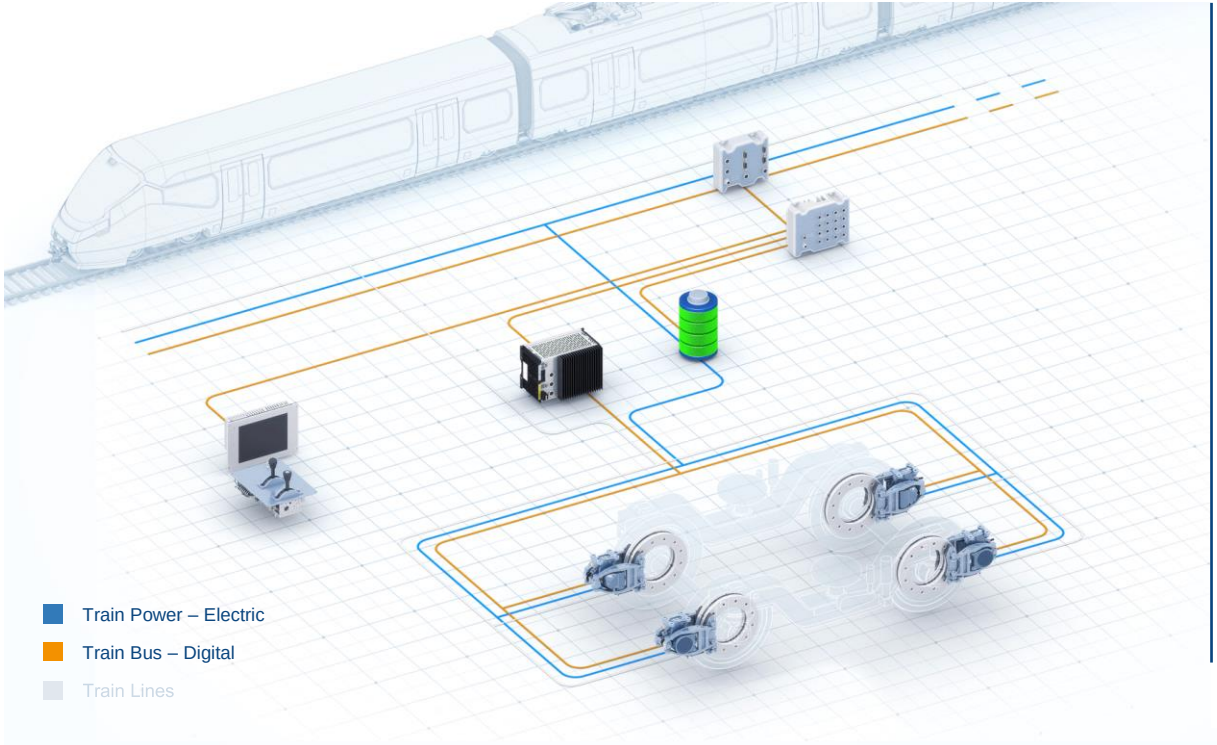


Functional Principle

Service Brake (SB)

- Brake Control Unit (BCU) as gateway to the vehicle
- Brake signal from ATO, brake lever, etc. to BCU
- BCU calculates and transmits set value to brake caliper (load corrected, WSP, etc.)

Electro-mechanical braking system – Service Brake



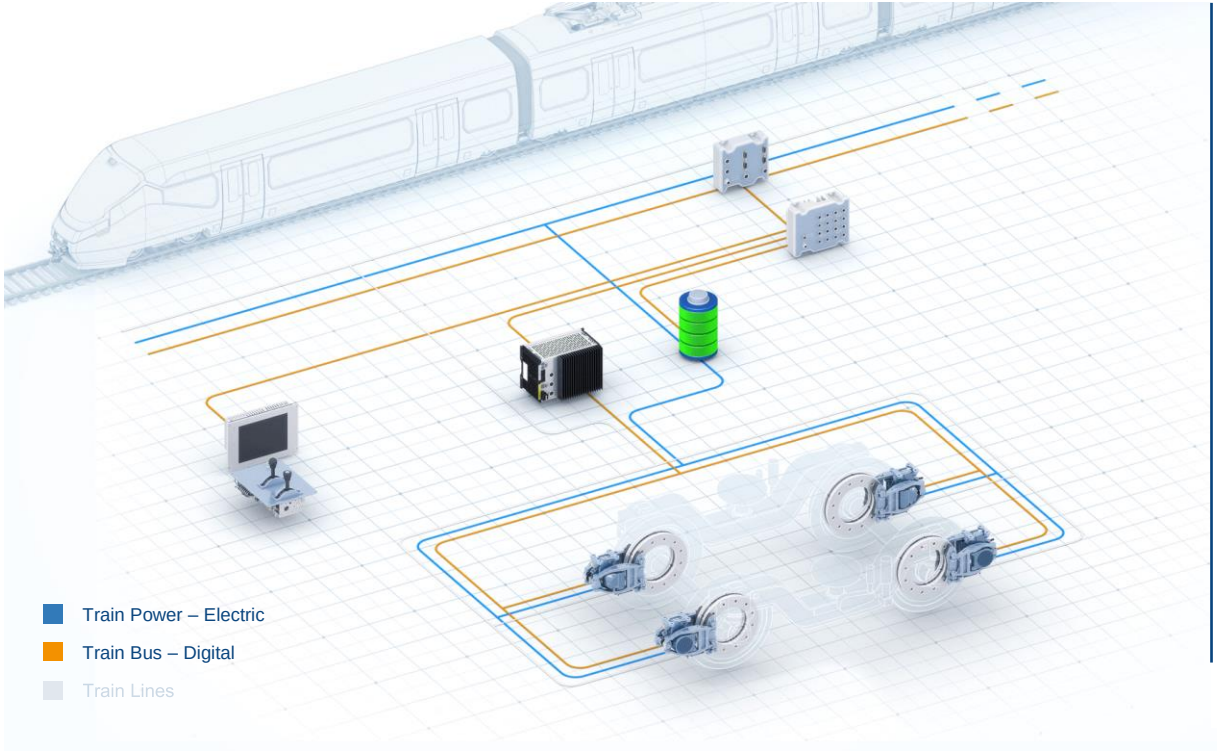
Functional Principle

Service Brake (SB)

- Brake Control Unit (BCU) as gateway to the vehicle
- Brake signal from ATO, brake lever, etc. to BCU
- BCU calculates and transmits set value to brake caliper (load corrected, WSP, etc.)

- Brake caliper converts brake set value based on input signal
- Brake caliper reports diagnostic data back to BCU

Electro-mechanical braking system – Service Brake



Functional Principle

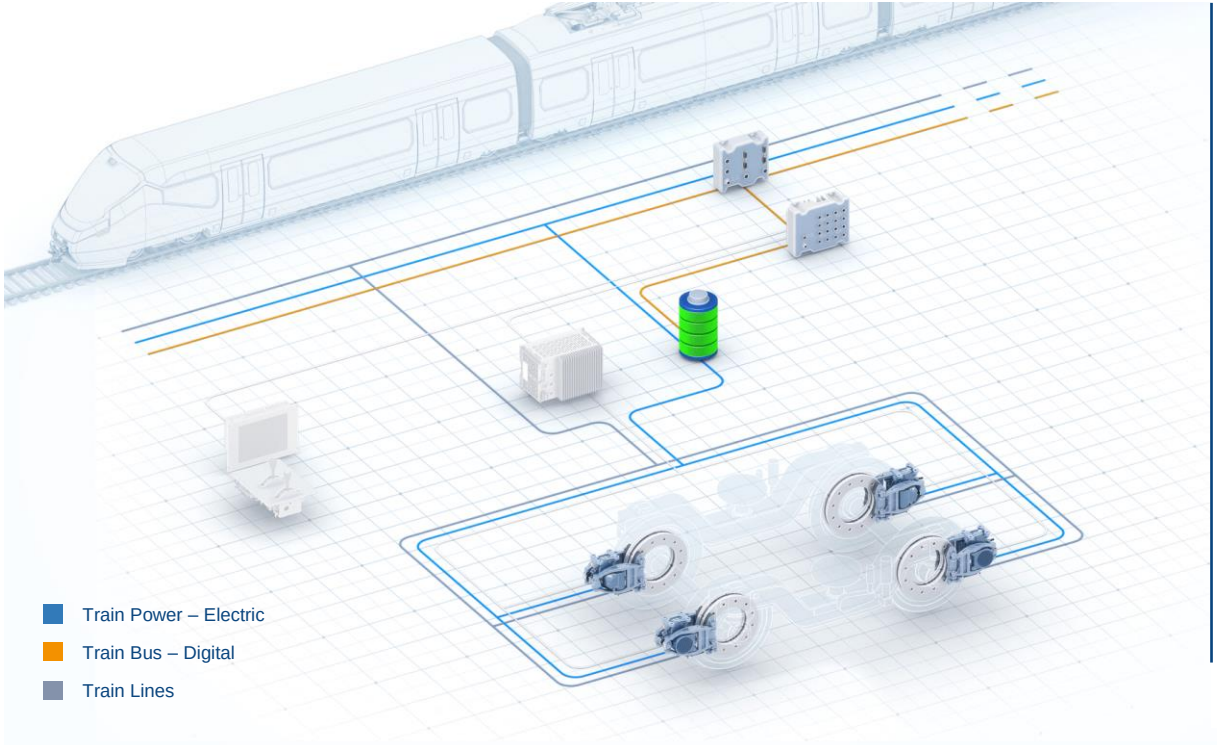
Service Brake (SB)

- Brake Control Unit (BCU) as gateway to the vehicle
- Brake signal from ATO, brake lever, etc. to BCU
- BCU calculates and transmits set value to brake caliper (load corrected, WSP, etc.)

- Brake caliper converts brake set value based on input signal
- Brake caliper reports diagnostic data back to BCU

- Power is provided by train
- Power supply module monitors and converts to system voltage

Electro-mechanical braking system – Emergency Brake

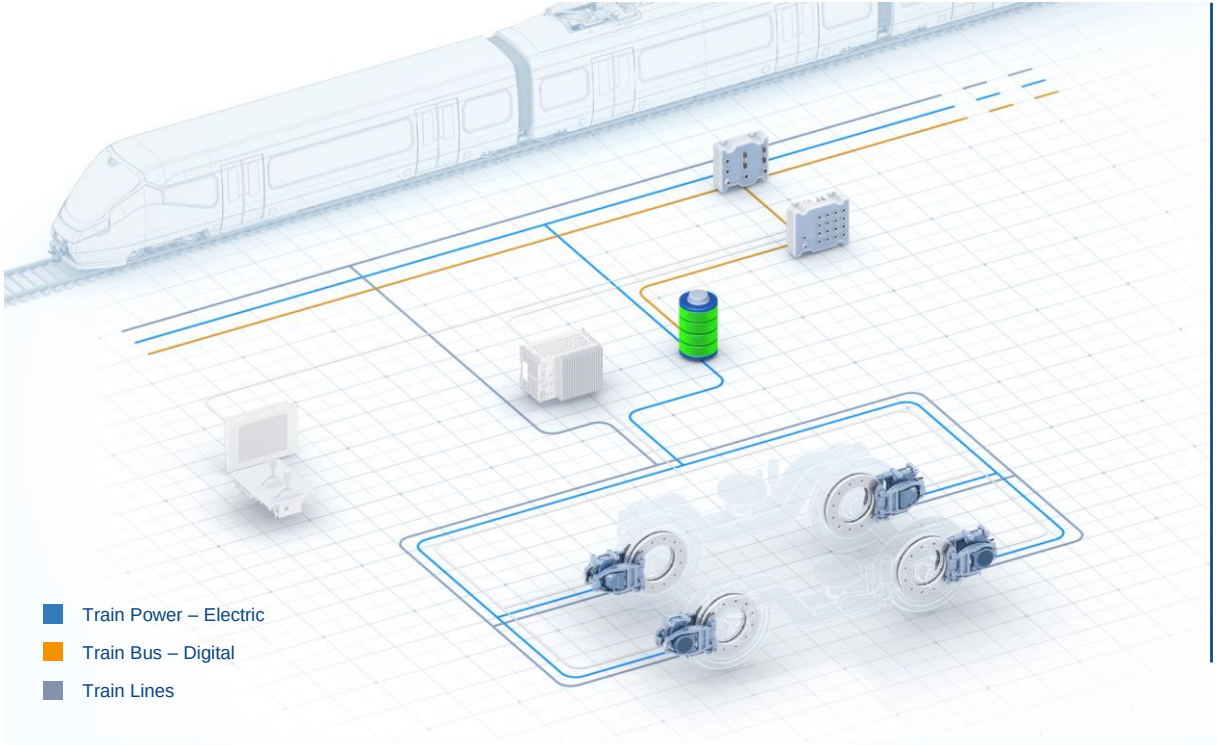


Functional Principle

Emergency Brake (EB)

- EB request via hard-wired safety loop to actuators (is read in at each actuator)
- EB setpoint is adjusted according to the project-specific config. (load corrected, WSP, etc.) independently at each brake caliper
- Diagnosis is done via bus as well as hardwired lines

Electro-mechanical braking system – Emergency Brake



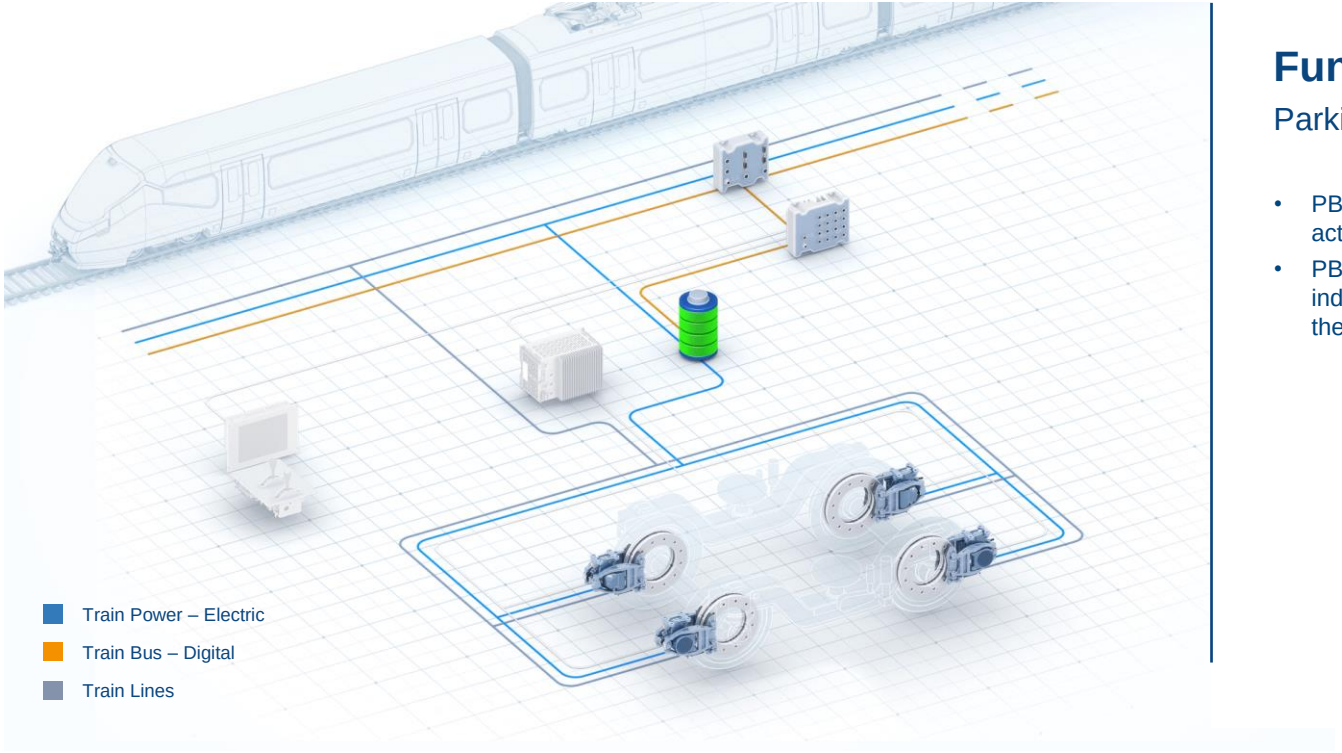
Functional Principle

Emergency Brake (EB)

- EB request via hard-wired safety loop to actuators (is read in at each actuator)
- EB setpoint is adjusted according to the project-specific config. (load corrected, WSP, etc.) independently at each brake caliper
- Diagnosis is done via bus as well as hardwired lines

- Power is provided by train
- Power supply module monitors and converts to system voltage

Electro-mechanical braking system – Parking Brake

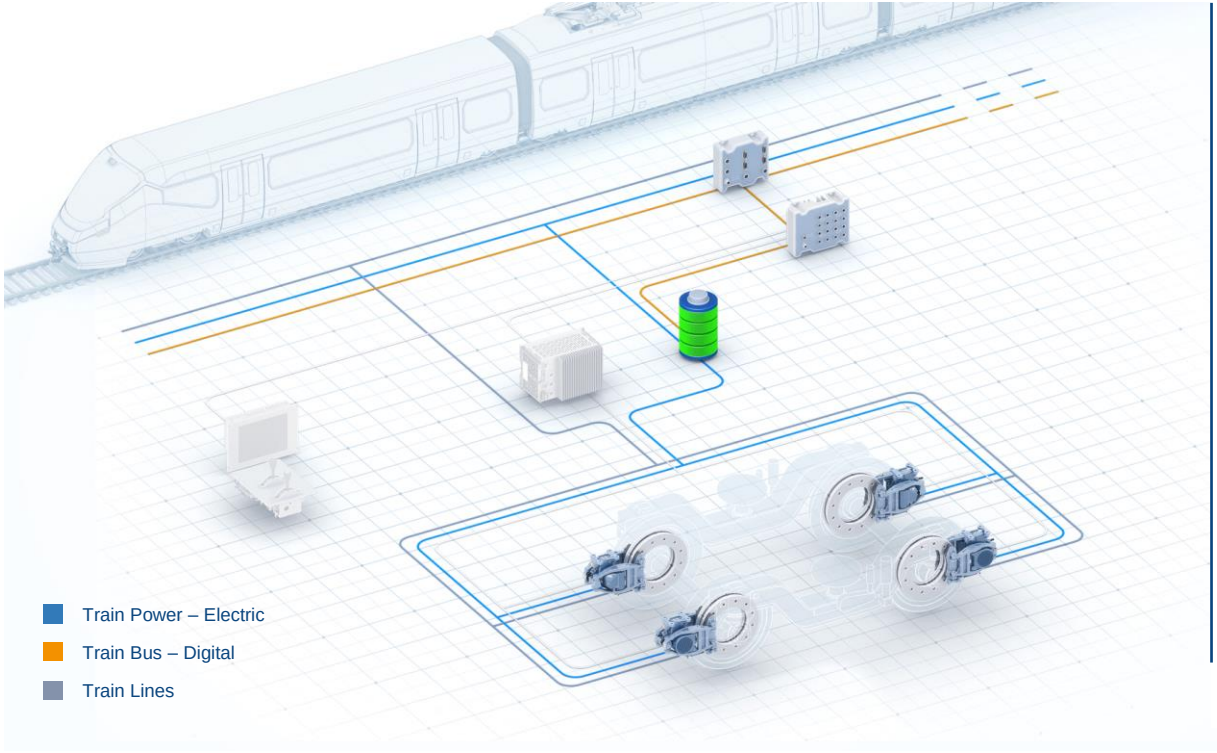


Functional Principle

Parking Brake (PB)

- PB request via trainlines (apply/release) to actuators (read in at each actuator)
- PB setpoint is adjusted and mechanically locked independently at each brake caliper according to the project-specific config.

Electro-mechanical braking system – Parking Brake



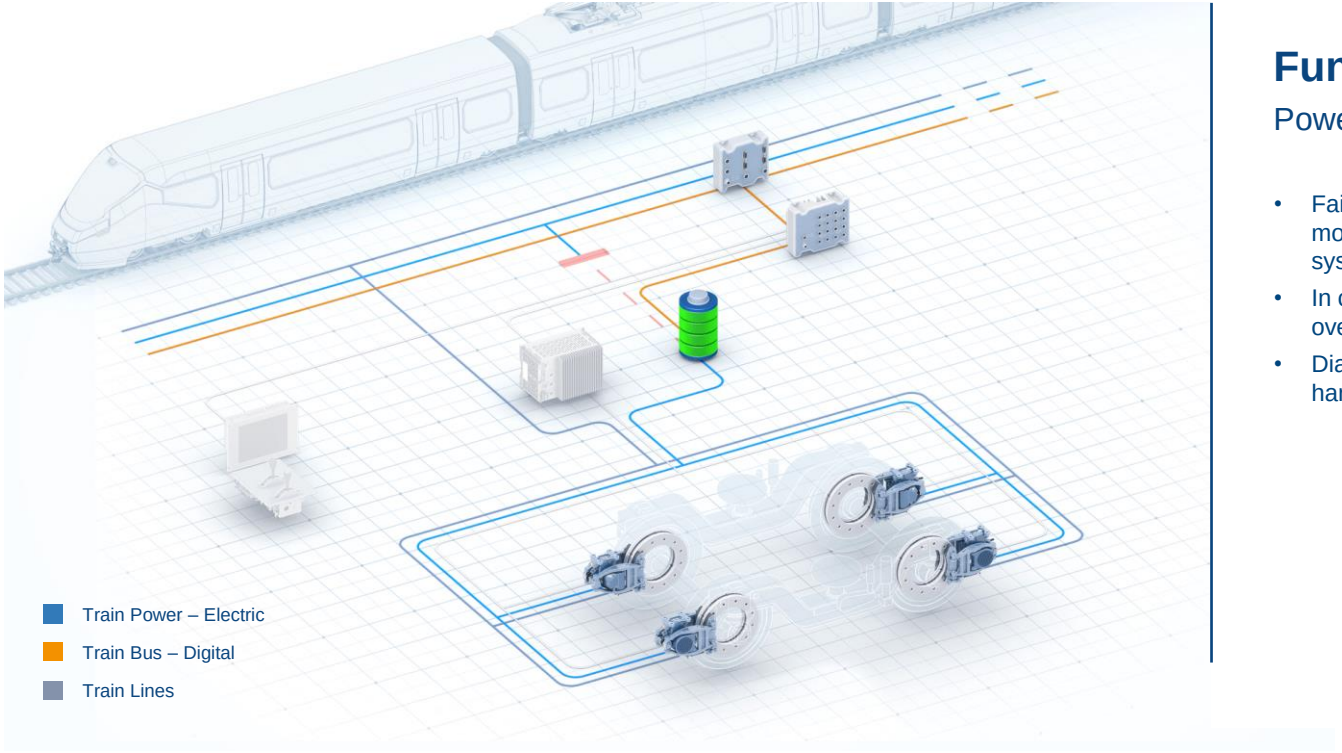
Functional Principle

Parking Brake (PB)

- PB request via trainlines (apply/release) to actuators (read in at each actuator)
- PB setpoint is adjusted and mechanically locked independently at each brake caliper according to the project-specific config.

- Parking brake is designed without spring or hydraulic energy storage and fully complies with all normative requirements
- Diagnosis takes place via bus as well as hardwired lines
- PB is only released when a release is requested and the application signal is resolved

Electro-mechanical braking system – Power Fail

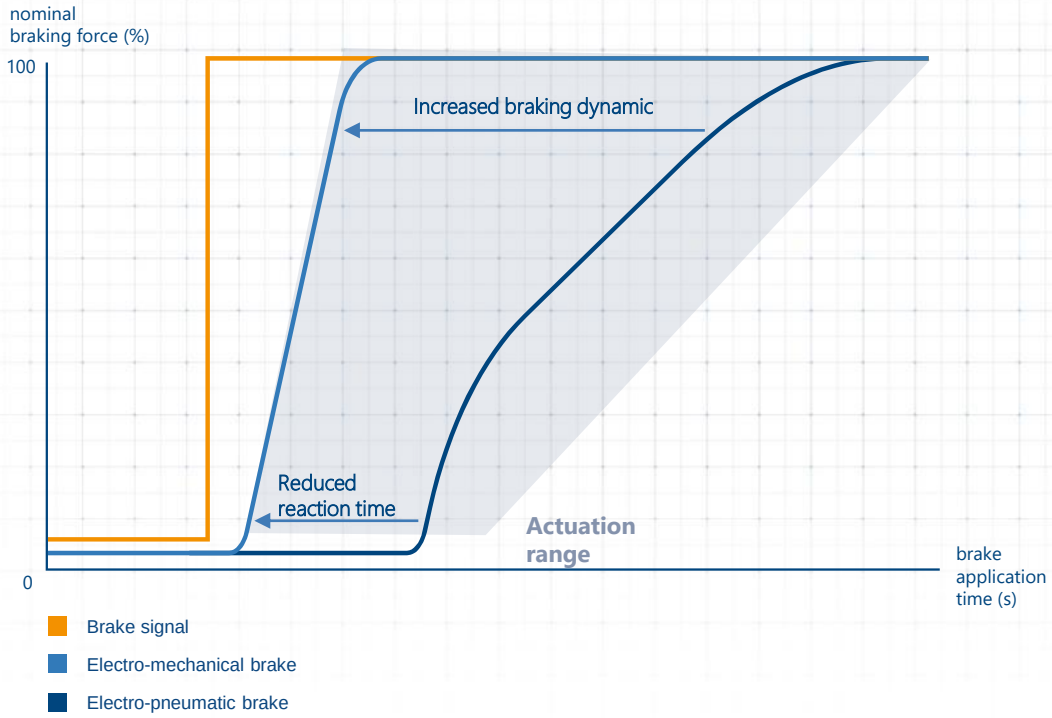


Functional Principle

Power Fail

- Failure of the vehicle energy supply is (safely) monitored by the electromechanical braking system
- In case of brake request the EM brake switches over to system-internal energy supply
- Diagnosis is done via bus as well as hardwired lines

Increase your braking dynamic – Reduce your reaction time



Customer Benefits

Optimized braking performance

- Shortened start up times – train ready for operation faster (e.g. brake test optimization possible)
- WSP optimization
- Behavior similar to electro-dynamic brake
- Increased transport capacity due to improved dynamics

Your Benefits for future operations

Reduced Installation Space

- No piping
- No/less pneumatic/hydraulic components
- Even without airless train – smaller compressor
- Brake caliper compatible with existing bogies
- Brake caliper with same installation space and mechanical interfaces

Improved Maintenance

- Significant reduction of components
- Lower life-cycle costs – reduced maintenance effort
- Brake caliper & energy accumulator – interchangeable unit
- Project-specific applications can be implemented via software
- Higher diagnostic depth
- Wear of friction pairing can be monitored – brake caliper level

Efficient Braking

- Efficient friction brake force generation
- Reduced energy consumption
- No conversion electrical energy – compressed air
- Better efficiency

Higher Availability

- EB/PB at actuator level
- Actuator failure limited to a single caliper
- Failure-tolerant, high-available safety electronics

Knorr-Bremse development status

First Field Trial

EM brake system demonstrator on a **passenger car**

synchronous braking behaviour – including **WSP**

Successfully completed.

Test scenarios

- Braking to standstill
- Permanent braking
- Braking at switch
- Force loss test of parking brake
- WSP events

over **7 days** **of testing**

more than **200 x** **braking maneuvers**

up to **36 kN** **clamping force**

up to **160 km/h** **speed**

Shift2Rail

MÁV Central Rail And Track Inspection Ltd. (MÁV KFV Kft.)

A paradigm shift in braking for railway vehicles

Active system
System control in all modes incl. backup without necessity of mechanical or hydraulic element

Complete system
Brake control, brake actuation, brake energy

Brake-by-wire
Purely electrical generation and transfer of braking signal and energy

Safety
Meets at least the requirements of today's systems
emergency brake / parking brake realized on brake caliper level

Cybersecurity
according to the state of the art

Central enabler for airless train

TSI-conformity
Technical Specifications for Interoperability

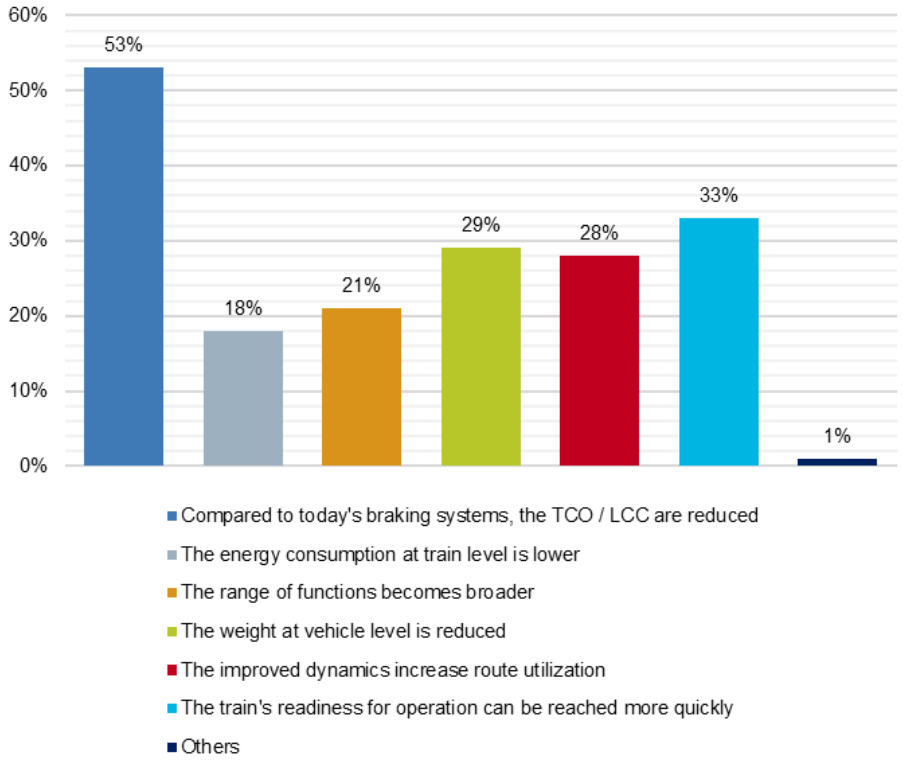
The next step for mobility of tomorrow

Evolution of Braking

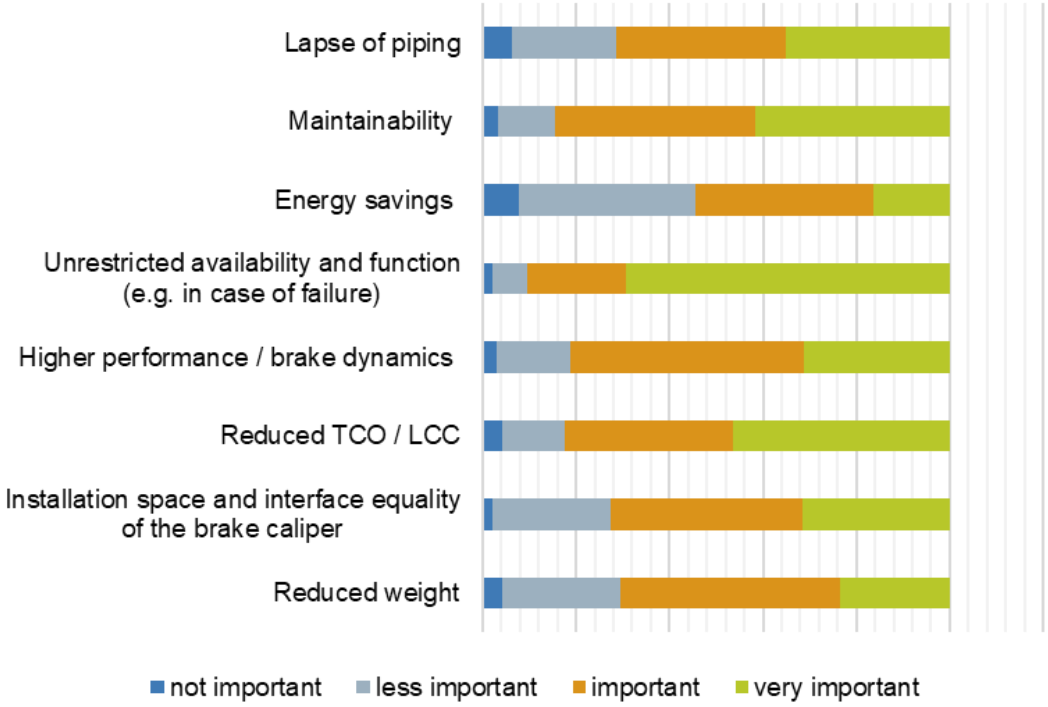
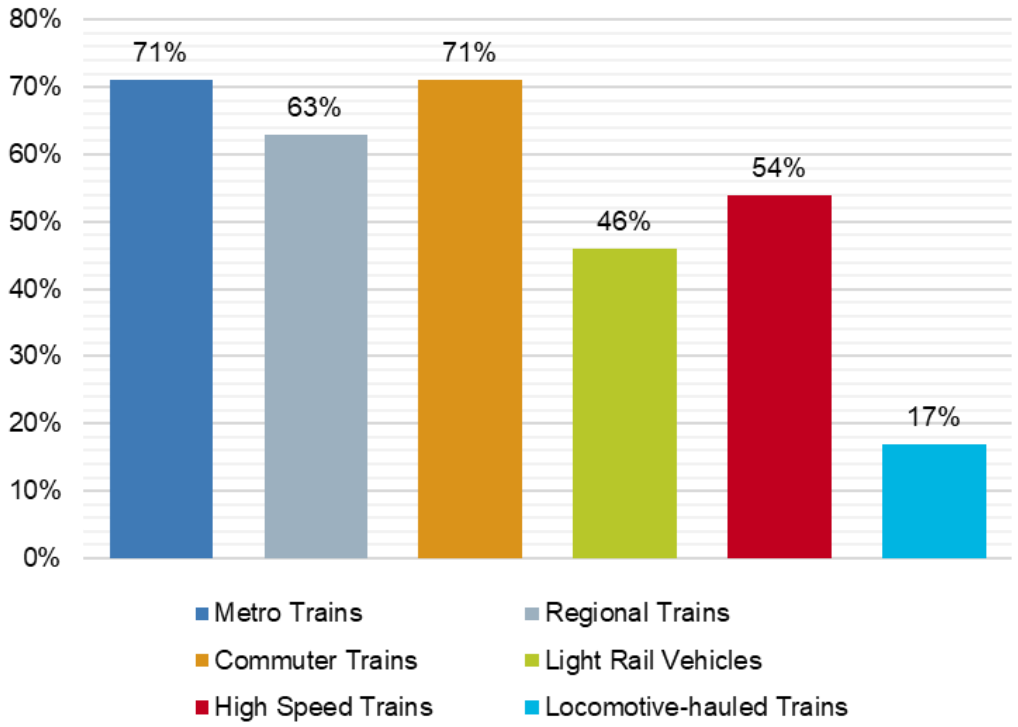
Thank you

KNORR-BREMSE

Survey results: Under which of the following conditions can you imagine installing the EM brake?



Survey results: Rate the following features of the EM brake according to your personal relevance



Survey results: For which vehicle type do you see the highest relevance in the future related to the application of the EM brake?