The Flexx Family: Pushing boundaries with integrated solutions

This article is the first instalment in The Flexx Family, our five-part series of white papers on our Metroflexx and Regioflexx brake control solutions.

- **Pushing boundaries with integrated solutions**
- Achieving more through unrivaled modularity
- A maintenance breakthrough
- New functionalities thanks to SIL4 architecture
- Converging on the future of brake architecture

Wabtec

To begin "The Flexx Family" series, we will share the design philosophy that led to the creation of Metroflexx and Regioflexx brake control systems. Once we've elucidated the innovative approach at work in these systems, we will show how integrated solutions are key to push the boundaries of conventional systems' performance

Designing future-proof brake systems

In 2014, we started our journey to create what would eventually become the Flexx Family of brake control systems to meet several strategic objectives:

- drastically improving performance and reliability
- offering the most versatile equipment for a wide range of architectures
- reducing installation and maintenance costs
- improving diagnostic capability to enable CBM capability
- improving competitiveness
- future-proofing systems in preparation for S2R, ERJU (virtual coupling,…)

We tackled these goals by following a new design concept based on three priorities :

Simplify

Designing the functions using electronic control and SW modules ensuring same or better SIL level (up to SIL4) instead of traditional approach leads to simplification of the pneumatic part.

Streamline

We redesigned the remaining pneumatic components, using improved materials to boost reliability, performance, and service life.

Innovate

We developed a new generation of adaptive algorithms to improve system performance.

Flexx : a new generation of high performance, reliable and flexible brake control systems

These guiding principles resulted in the standout features the Flexx Family of brake control systems boasts today in two distinct products: Metroflexx for single-pipe brake systems, and Regioflexx for dual-pipe brake systems :

- an integrated LRU weighing less than 15 kg
- wired or fully networked interfacing capabilities
- independant axle control to ensure single failures cannot compromise more than 50% of local braking effort
- a standard hardware platform with modular, scalable software
- safety and interoperability certifications

How it works: the unique architecture at the heart of the Flexx Family, explained

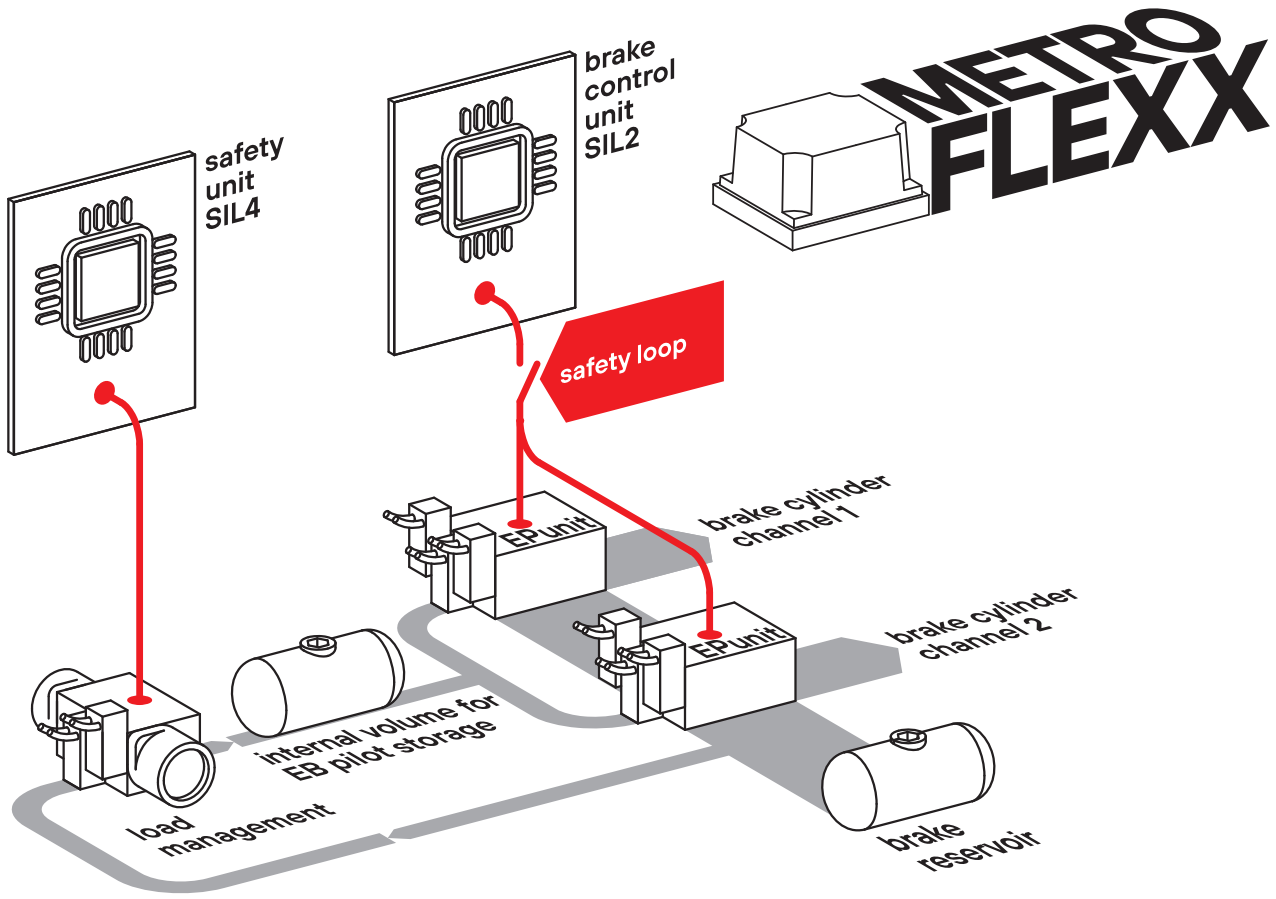
The key innovation at the heart of the Flexx Family is the transfer of safety functions from pneumatic components to software modules. Not only does this ensure an equal or higher safety level than conventional systems, it also enables new capabilities. Each Flexx system features two independent yet fully integrated electronic units driving the electro-pneumatic (EP) equipment:

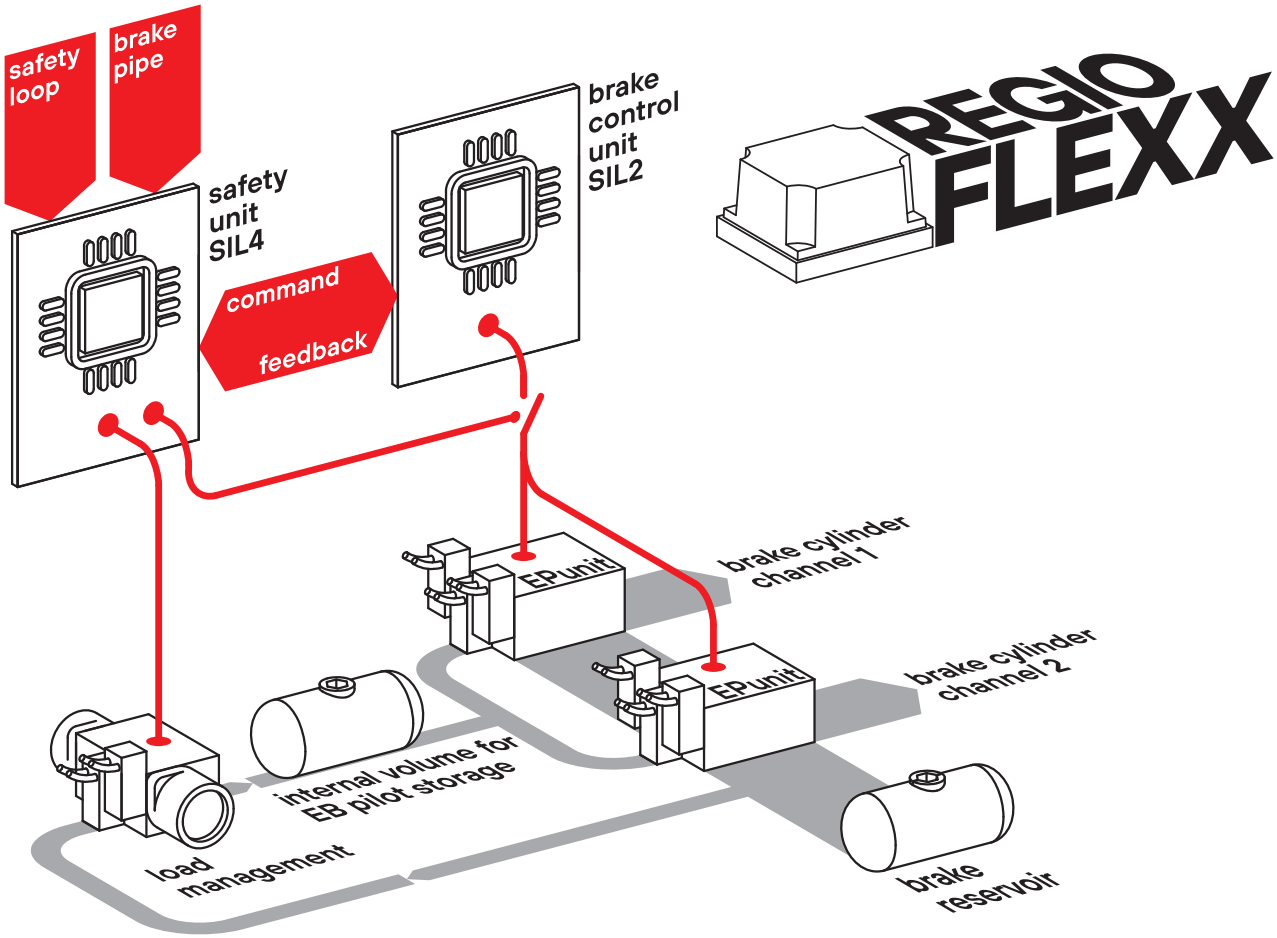
- a brake control unit (BCU) performing all functions rated up to SIL 2 (i.e., non safety critical)
- an independent, SIL 4 safety unit executing and monitoring all safety-related functions

In a mainline train using a Regioflexx, the safety unit also commands the BCU to execute specific safety functions, such as emergency braking (EB). This operation is under permanent supervision by the safety unit, which, in case of misalignment with targets, acts to restore a safe state.

In the event of serious system failure, such as loss of power supply, Flexx ensures the availability of load-controlled emergency brake thanks to the EB pilot pressure stored under the control of the safety unit in the volume inside before the failure. An additional layer of safety comes from the Ultimate Safe State, a pneumatic component providing the guaranteed minimum emergency brake pilot pressure to the EP units.

The two EP units are independently responsible for establishing brake pressure on channels 1 and 2. Each features a high performance pneumatic relay valve and three solenoid valves (supply, vent and forced release). By including two independent EP units, Flexx can control two bogies or two axles. Each EP unit can also be connected to a dedicated brake reservoir. This patented feature of the Flexx Family offers new opportunities for brake architectures that will be explored in the next instalment of this series, “Achieving more through unrivaled modularity.”


METRO FLEXX
safety unit SIL4
brake control unit SIL2
safety loop
EP unit
EP unit
brake cylinder channel 1
brake cylinder channel 2
internal volume for EB pilot storage
load management
brake reservoir


safety loop
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REGIO FLEXX
safety unit SIL4
brake control unit SIL2
command
feedback
EP unit
EP unit
brake cylinder channel 1
brake cylinder channel 2
internal volume for EB pilot storage
load management
brake reservoir

A unique design in practice: outperforming conventional systems across the board

The Flexx Family dramatically simplifies brake system integration by removing complex pneumatic components and managing the associated functions through software emulations without impairing safety. These design concepts translate to concrete benefits for users and integrators alike over conventional systems.

Maximum train availability with the most versatile architecture

Both Metroflexx and Regioflexx feature SIL 2 service brake and remote release functions that operate independently for each EP channel, which reduces the effect of single failures on performance. Unlike conventional systems, a single Flexx brake control can, for instance, generate two distinct service brake demands on a mixed bogie with a motor axle and a trailer axle.

Simplified systems and installation

Flexx products feature two high-performance relay valves per unit, which are used to build brake cylinder pressure, including the wheel slide control.

Fast, highly accurate control.

Flexx systems eliminate hysteresis by managing pressure regulation in a closed loop, with pressure measurement downstream from the EP Units. This results in stable, very high accuracy (+/- 0,01 bar) throughout the train's lifecycle. What's more, the high-performance relay valves result in brake release times under 800 ms, enabling fast WSP control while helping ensure brake release time is not on the dwell time critical path—a particularly important feature for suburban trains.

Improved train capacity and punctuality

Flexx systems help enhance the effectiveness of existing rail infrastructure thanks to their embedded DistanceMaster functions, which include adaptive WSP, deceleration compensation, and smart sanding control. These result in optimized and safe management of train adhesion, as well as more predictable and precise braking distances, even in adverse track conditions.

Flexx Family spotlight: an integrated system offering reduced weight and simplified, cost-effective installation

>80%

Over 80% weight reduction per unit

The Flexx Family combines the separate components found in conventional systems—brake control units (BCU), pneumatic panel and wheel slide protection (WSP) valves—into a single, fully integrated LRU. As a result, the additive manufacturing version of a Metroflexx or Regioflexx unit weighs only 10 kg, compared to approximately 70 kg in conventional systems on regional trains. The impact of this 60 kg weight reduction per unit is a game-changer for maintenance operations, as we will explore in the third instalment of this white paper series.

20%

20%reduction in pneumatic piping

An integrated system means pneumatic connections to a single box rather than multiple pieces of equipment, making installation that much simpler. The integration of WSP valves also removes the need for special pneumatic or electrical connections. These features result in savings on pneumatic piping of approximately 20% per vehicle.

~300m

~300 m of cable saved per vehicle from networked connections and simplified wiring

Flexx products are designed with fully networked connection to the vehicle in mind. Only the emergency brake line remains wired, with all other functions and interfaces passing through the train's IT network, without a dedicated brake network. On a regional train, this translates to approximately 300 m of cable saved per vehicle.

What's more, Regioflexx integrates all required functions for very high-speed applications, including EN 15595-compliant wheel rotation monitoring and redundant WSP electronics. The complexity of wiring two different sets of electronics disappears from the installation process.

Flexx Family spotlight: safety enshrined in a robust validation and certification process

The Flexx Family is designed to minimize risks for train manufacturers, operators, and authorities while introducing innovative technology on their trains and networks. Our products undergo rigorous assessments by various parties to ensure their compliance with the relevant standards.
Flexx products are assessed by Notified Bodies (NoBo) according to the relevant standards. This guarantees a robust design and validation process, while simplifying the recognition of train conformity and compliance with safety requirements and other standards and regulations.

Safety

TÜV SÜD has reviewed our Flexx Family products' conformity to safety targets and evaluated compliance with the safety standards listed hereafter.

Interoperability and design

DB Systemtechnik has reviewed Regioflexx conformity with relevant interoperability and product standards.

Cybersecurity

The Flexx Family also complies with the latest cybersecurity standards listed hereafter.

Safety standards

- EN 50126 (RAMS)
- EN 50128 (Software)
- EN 50129 (Hardware)
- EN 50159 (Communication)

Interoperability & product standards

- LOC & PASS TSI
- EN 16185-1 (XMU brake system)
- EN 15595 (WSP)
- EN 15734-1 (high-speed train brake system)
- EN 14198
- EN 15611 (Relay valves)
- EN 15355 (Distributor valve)

Cybersecurity standards

- IEC EN 62443-2-1:2010
- IEC EN 62443-3-2:2020
- IEC EN 62443-3-3:2013
- IEC EN 62443-4-2
- TS 50701

DB Mobility Networks Logistics
DB Systemtechnik

TÜV SÜD

Takeaway: how the Flexx Family goes beyond conventional alternatives

The Flexx Family is unique in its design concept and technical features. As integrated systems aimed at securing specific, concrete benefits for our customers, Metroflexx and Regioflexx outperform conventional systems across the board

Jean-Philippe Bouteille
Vice President Engineering
WABTEC

At a glance: the Flexx Family benefits

- Dramatic weight reduction from 70-75 kg to 10-15 kg per unit
- Unprecedented architecture flexibility
  High resilience to single failures for optimal GEBR and train availability
- A single-box concept for simplified and cost-effective installation
- Traditional wiring or fully networked interface saving up to 300 m of cabling per car
- New functions thanks to SIL4 architecture
- Highly accurate output pressure maintained over time
- DistanceMaster, our embedded wheel rail adhesion enhancement solution (including wheel rotation monitoring and electronic redundancy for VHST applications)
- Safety and interoperability certifications