



# connect@rail - Infrastructure and Driveline Monitoring

Rail Drive Systems | Industrial Technology



# Agenda

1. Overview
2. Scope of System & Technical Data
3. Features
4. Progress & Evolution
5. Highlights & Benefits

# 01

## Overview



# ZF in Railway Technology

ZF Friedrichshafen AG is a reliable partner for the journey into the future on rails. It is a global technology company that supplies systems for passenger cars, commercial vehicles and industrial technology, enabling the next generation of mobility. The products and solutions make rail vehicles ready for the complex requirements of modern mobility.



# Digital Solutions for Rail

## Infrastructure and Driveline Monitoring

Condition Monitoring System for Infrastructure and Driveline Components

Features:

- Flat Spot Monitoring
- Wheel-Tread Wear
- Infrastructure Monitoring
- Condition Monitoring Driveline Components



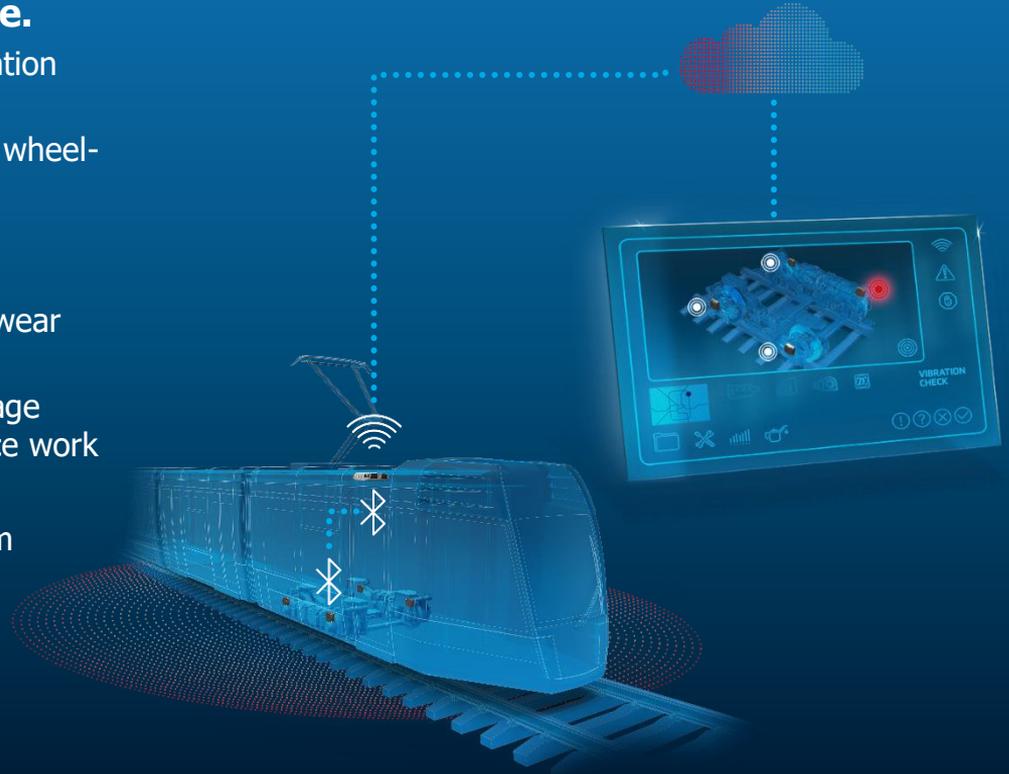
## Smart Identification

Smart Fleet and Maintenance Management

# Infrastructure and Driveline Monitoring

## Keep an Eye on Everything. At any Time.

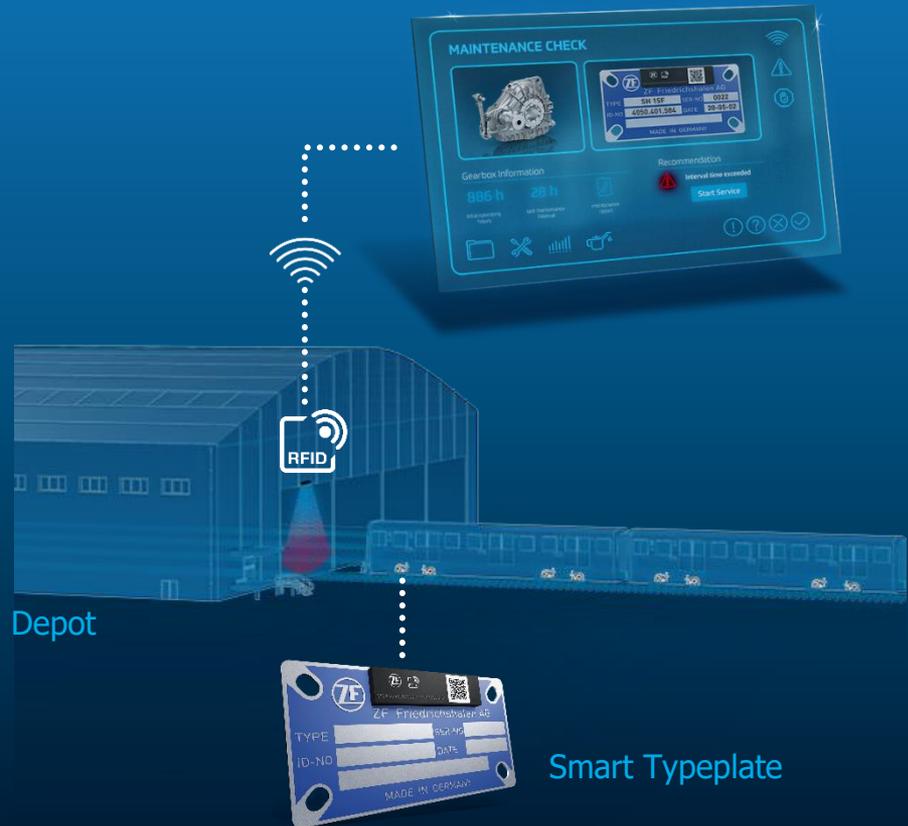
- Wireless sensor technology enables easy integration into rail vehicles
- Monitoring wheel tires to detect wheel flats and wheel-tread wear
- Monitoring and visualization of changes in rail infrastructure
- Latest algorithms for analysis and prediction of wear and damage
- Automated notification in case of detected damage and recommendations on necessary maintenance work
- Presentation in customer-specific user interface
- Standardized interface solutions with Eco-System partners



# Smart Identification

## Keep an Eye on Everything. Digitally.

- Type plate supplemented with RFID transponder
- Reliable, contactless detection of components, for example when entering the depot
- Automated, faultless identification without direct visual contact
- Paperless online documentation accessible from anywhere
- Indication of pending maintenance
- Guided service activities according to product-specific documentation and checklists
- Direct documentation of completed maintenance work (maintenance history)
- Spare parts catalog and web store application
- Simple communication between operator, customer and service



# 02

## Scope of System & Technical Data

# Infrastructure and Driveline Monitoring

## Connectivity Solutions Portfolio

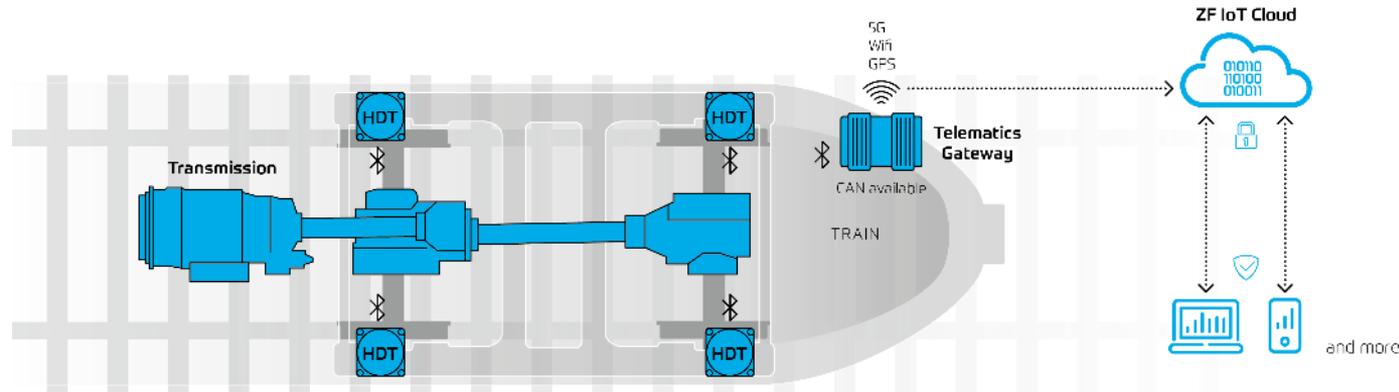
Please find also more information about the hardware on our website.  
Heavy Duty TAG: [www.zf.com/hd-tag](http://www.zf.com/hd-tag)  
VCU Pro Onboard Unit: [www.zf.com/vcu](http://www.zf.com/vcu)

### Scope of system: Hardware

- **Heavy Duty TAG:** Battery-operated Bluetooth sensor for detecting vibrations and the location
- **Secure Gateway:** Gateway to bundle the individual sensor data, data pre-evaluation and data transfer into the ZF Cloud

### Scope of system: Software

- **ZF IoT Cloud:** Data storage and processing in the ZF IoT Cloud
- **Dashboard visualization:** Platform for a comprehensive infrastructure and driveline monitoring



1 IDT = 1 Heavy Duty TAG    Bluetooth connection

# Infrastructure and Driveline Monitoring

## Technical Data

### Bluetooth sensor: Heavy Duty TAG

#### Features

- Comprehensive recording of condition data, Bluetooth Low Energy 5.0 ensure trouble-free and energy-saving data connection between TAG and Gateway
- Designed for industrial use – optimized for use in rail vehicles
- Different, intelligent modes enable optimal measurement results, as well as maximum energy efficiency (service life: Up to five years)
- Optimally protected thanks to robust housing and IP65

#### Benefits

- Modular system of HD TAGs, Gateway and specific software packages, enables customized solutions for every application
- Wireless Bluetooth sensor for easy integration into existing systems
- Early insights regarding wear and damage

→ More information on our website: [www.zf.com/hd-tag](http://www.zf.com/hd-tag)



**Heavy Duty TAG:**  
the wireless sensor

# Infrastructure and Technical Data

## Bluetooth sensor: Heavy Duty

### Features

- Comprehensive recording of conditions for trouble-free and energy-saving operation
- Designed for industrial use – optimized for long service life
- Different, intelligent modes enable maximum energy efficiency (see table)
- Optimally protected thanks to rugged design

### Benefits

- Modular system of HD TAGs, GHD TAGs and customized solutions for every application
- Wireless Bluetooth sensor for early wear and tear detection
- Early insights regarding wear and tear

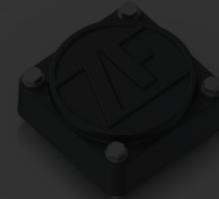
→ More information on our website

### Technical information

Data transfer	<b>Bluetooth Low Energy (2.4 GHz)</b> <ul style="list-style-type: none"> <li>▪ Standard protocol</li> <li>▪ Sub1GHz ready (868 MHz)</li> </ul>
Scope of functions	<b>RTC (Real Time Clock)</b> <ul style="list-style-type: none"> <li>▪ Parameterizable RTC, accuracy of + 1 s per day</li> </ul> <b>Energy management for optimized efficiency</b> <ul style="list-style-type: none"> <li>▪ Min. energy consumption (Deep Sleep Mode) until use on site.</li> <li>▪ Power Saving Mode saves energy when the sensor is not needed. In case of vibrations the sensor is reactivated.</li> <li>▪ Customized Action Modes</li> </ul> <b>3-axis accelerometer</b> <ul style="list-style-type: none"> <li>▪ ±16 g, 1.6 Hz – 6.6 kHz</li> </ul> <b>OTA (Over the Air) capable</b>
Data memory	External Flash Memory 128 MBit (16 MB)
Battery	3x Lithium polymer batteries, 4 Ah each, not interchangeable
Compliance	CE WEEE
User interface	Web Portal of ZF

### Environmental Conditions

Protection class	IP65 acc. DIN EN 60529
Fire protection	DIN EN 45545
Vibrations and shocks	DIN EN 61373, category 3
Environmental conditions	DIN EN 50155 (class TX column 2) <ul style="list-style-type: none"> <li>▪ Humid heat (25°C - 55°C at 80% - 100% humidity)</li> <li>▪ Dry heat (25°C - 85°C)</li> <li>▪ Cold during operation (-40°C for 2h)</li> <li>▪ Cold without operation (-40°C for 16h)</li> <li>▪ Salt spray at 35°C for 48h</li> <li>▪ Stone chipping</li> </ul>
Operating temperature	-40°C to +85°C acc. DIN EN 60068
EMC	DIN EN 50121-3-2



**Heavy Duty TAG:**  
The wireless sensor

# Infrastructure and Driveline Monitoring

## Technical Data

### Gateway: VCU Pro Onboard Unit

#### Features

- Secure acquisition and processing of sensor data
- Two independent processors
- Four CAN interfaces, four analog input and four digital output ports
- Supports Bluetooth, wireless network and all common GNSS
- Permanent tracking of various parameters of vehicle, rail tracks and driving behavior via ZF IoT Cloud

#### Benefits

- Easy and fast integration into existing vehicles
- Stable and secure connection to the ZF IoT Cloud
- Secure over-the-air updates
- Highly flexible data logging tool with possibility to change modes of data recording according to the current need
- Together with the Heavy Duty TAG, the VCU Pro Onboard Unit enables a individually tailored monitoring system for any application

→ More information on our website: [www.zf.com/vcu](http://www.zf.com/vcu)



**Telematics Gateway:**  
the secure connection

# VCU Pro Onboard Unit

VCU Pro is the advanced on-board unit from the Vehicle Connectivity Unit series. With 4 CAN interfaces (2 standard CAN and 2 CAN FD), 4 analog inputs and 4 digital outputs VCU Pro is a professional and robust vehicle gateway. Two independent processors ensure both a safe and secure connection to the vehicle network and also provide a universal communication capability.

**Dimensions**  
200 x 122 x 40 mm

**Temperature Range**  
-40 to +75 °C

**Power Supply**  
9 - 36 V DC



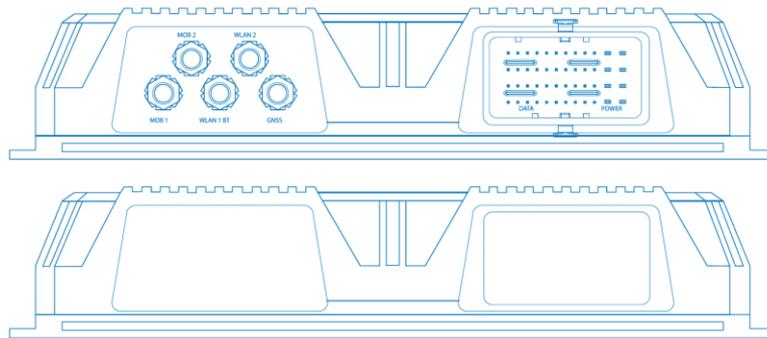
Cellular Antenna Connectors 2x  
WLAN/Bluetooth Antenna  
Connectors 2x  
GNSS

Power supply and  
signal interface

<b>CPU</b>	ARM® 1 GHz	<b>Automotive Connector</b>	MOLEX (48 pins)
<b>RAM</b>	1 GB	<b>Antenna Connectors</b>	SMA Female
<b>Memory</b>	8 GB Flash		
<b>Sensors</b>	3 Axis Accelerometer 3 Axis Gyro	<b>Mounting Option</b>	Screws
<b>GNSS</b>	GPS, Glonass, BeiDou, Galileo		

# VCU Pro Onboard Unit

<b>Communication and Interfaces</b>	<b>Processors and modules</b>	<b>Mechanical</b>
2x CAN 2.0B	ARM Cortex A8 (1GHz)	Material: Aluminum / Plastic
2x CAN FD	Infineon Aurix Microcontroller (200MHz, 472 KB RAM)	Waterproof housing
4x Analog IN	HSM (Hardware Security Module) for cloud communication secure key storage	Operating temperature from -40°C to +75°C
4x Digital OUT		Protection level: IP6K5
1x Ethernet 100 BaseT		
2x Ethernet BrdRr		
WiFi 802.11 a/b/g/n	Second HSM for diagnostic key sessions	<b>Memory</b>
Bluetooth 4.2	GTM (Generic Timer Module)	1 GB RAM
1x RS232		8 GB eMMC Flash
1x LIN		
1x K-Line	<b>Sensor Network</b>	<b>Approvals</b>
1x embedded SIM + 2x plastic SIM (accessible)	3 Axis Accelerometer	E-Mark
Cellular - LTE Cat4 (EMEA + Asia/Pacific version)	3 Axis Gyro	ISO16750
		Fire safety
	<b>Power Supply</b>	
	Nominal Voltage: 9-36 V DC	<b>Certification</b>
<b>GNSS</b>		CE
uBlox NEO-M8L with Dead Reckoning	<b>System</b>	FCC (components)
	Linux Operating System	
	Fail-safe OTA update	



# Infrastructure and Driveline Monitoring

## Technical Data

### Data processing: ZF IoT Cloud

The TAGs continuously measure and record the accelerations resulting from the wheel tread and the tracks



The measurements of the TAGs are collected via the Gateway and automatically stored in a cloud storage



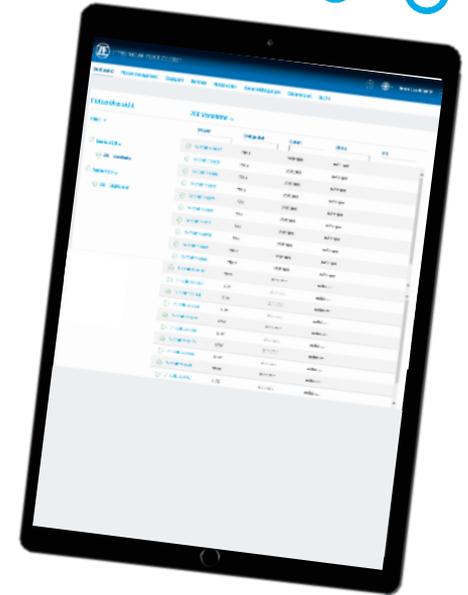
Data processing and evaluation for subsequent visualization takes place in the **ZF IoT Cloud** or in a specific customer cloud



Integrable into existing systems



Desktop and mobile version available



# Infrastructure and Driveline Monitoring

## Technical Data

### Dashboard visualization: User Interface

#### Features

- IoT end-to-end solution including connectivity and report creation
- Operators obtain real-time analyses via a digital dashboard
- Accessible via various devices
- Customized user dashboard

#### Benefits

- Permanent condition status of the assets
- Predictive maintenance planning
- Avoiding unscheduled service interruptions
- Modular dashboard of all ZF rail applications (Features) and Eco-System partner products



**Dashboard:**  
the user interface

# 03

## Features

# Infrastructure and Driveline Monitoring – Use Cases

## Wheel Flats

### Challenges:

- Flat spot causes abnormal vibrations
- Vibration causes further damages to bogie components
- High maintenance costs
- Noise impact for passengers and residents

**Wheel Flats**  
= Flat spots occur when exceeding the friction limit between wheel and rail.

### Solution:

The Infrastructure and Driveline Monitoring System from ZF provides an efficient basis for the early detection of flat spots

# Flat Spot Monitoring

## Detect Wheel Flats.

### MAIN CHARACTERISTICS

-  Determination of damage to wheel tires using acceleration data
-  Automated notification in case of detected damage
-  Simple and fast implementation by the use of wireless sensors (Bluetooth communication)
-  Storage and analysis of the measured acceleration data in the ZF IoT Cloud
-  Transfer of the measured raw data to the customer via cloud-to-cloud communication possible
-  Overview of the current fleet & component status via user interface/dashboard



### APPLICATION AREAS



# Infrastructure and Driveline Monitoring – Use Cases

## Wheel-Tread Wear

### Challenges:

- Difficult detection of wheel-tread wear of train wheels
- Resulting in vibrations and further damage to bogie components, replacement of wheel
- Vibrations can cause safety relevant issues

### Wheel-Tread Wear

= Wear of wheel surface, like e.g. shelling due to high stress.

### Solution:

The Infrastructure and Driveline Monitoring System from ZF provides an efficient basis for the early detection of wheel-tread wear.

# Wheel-Tread Wear

## Keeping the wheels round.

### MAIN CHARACTERISTICS



Determination of damage to wheel tires using acceleration data



Automated notification in case of detected damage



Simple and fast implementation by the use of wireless sensors (Bluetooth communication)



Storage and analysis of the measured acceleration data in the ZF Cloud



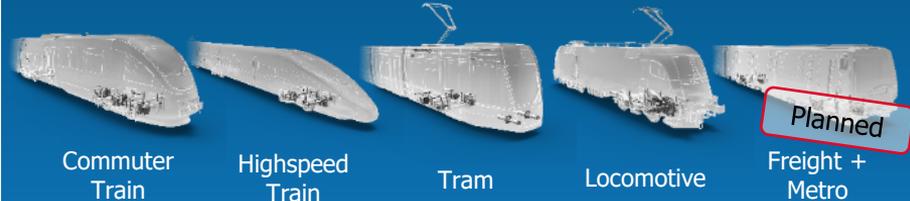
Data transfer via cloud-to-cloud communication possible



Overview of the current fleet & component status via user interface/dashboard



### APPLICATION AREAS



# Future Features



# Infrastructure Monitoring

## Detect impacts on rail tracks.

### MAIN CHARACTERISTICS



Continuous monitoring of the rail track on damage or changes by recording statistical acceleration data



Exact localization via GPS



Measuring equipment in regular vehicles  
→ No special, expensive measuring vehicle required



Simple and fast implementation and retrofitting of existing vehicles by the use of wireless sensors (Bluetooth communication)



Storage and analysis of the measured acceleration data in the ZF Cloud



Data transfer via cloud-to-cloud communication possible



Monitoring (heatmap) of the current status and changes of the tracks over time via the user interface



Planned

### APPLICATION AREAS



Commuter Train

Highspeed Train

Tram

Locomotive

Freight + Metro

Planned



# Condition Monitoring Driveline Components

Reduction of downtime.

## MAIN CHARACTERISTICS



Intelligent condition monitoring of driveline, chassis and bogie components (i.e. gearbox, dampers)



Standardized interfaces facilitate cloud-to-cloud solutions with other manufacturers (i.e. bearings, brakes)



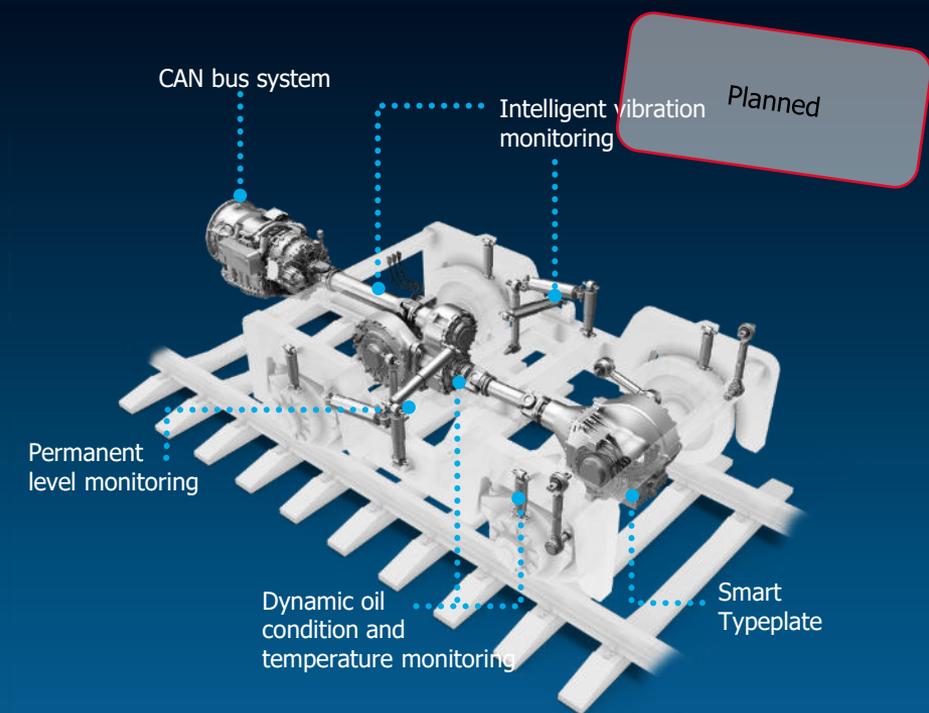
### Gearbox:

- Intelligent vibration monitoring of gears and bearings
- Dynamic oil condition and temperature monitoring

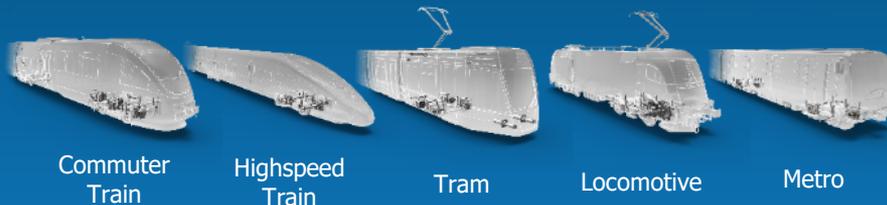


### Chassis and bogie components

- Intelligent level monitoring
- Function monitoring using pressure sensors
- Temperature range from -30°C to +100°C



## APPLICATION AREAS



# 04

## Progress & Evolution

# Infrastructure and Driveline Monitoring Evolution



## Flat Spot Monitoring & Wheel-Tread Wear

- Determination of damage to wheel tires using acceleration data
- Presentation in customer-specific user interface
- Automated notification in case of detected damage



## Infrastructure Monitoring

- Determination of damage to the track body using statistical acceleration data
- Illustrate changes in track condition over time
- Exact localization via GPS
- Presentation in customer-specific user interface



## Condition Monitoring Driveline Components

- Condition monitoring of gearbox and chassis components
- Standardized interfaces facilitate cloud-to-cloud solutions with other manufacturers (i.e. bearings, brakes)

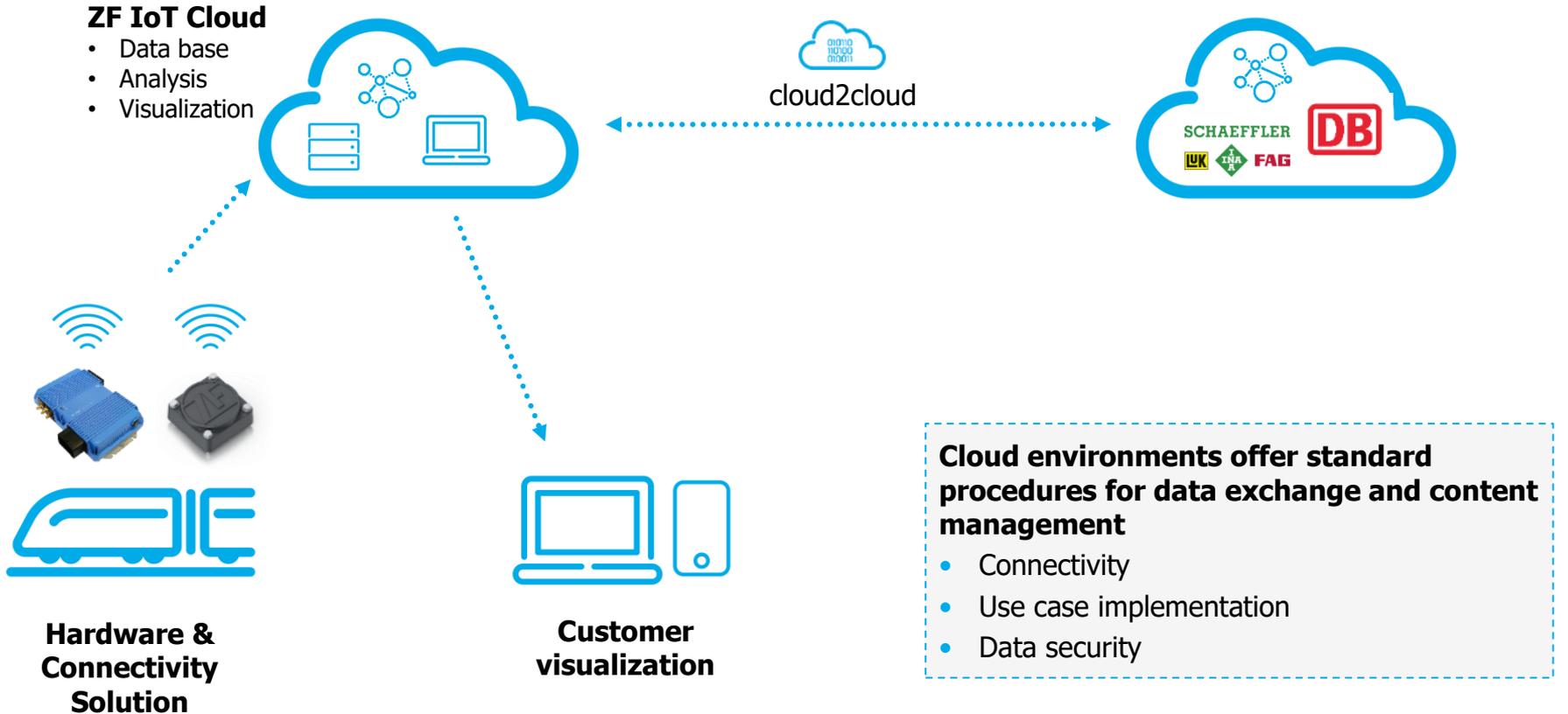
# Cloud Environments and Collaboration

## ZF Eco System

- "Eco System" network of partnerships, cooperation's, and joint ventures to reduce time-to-market
- One digital, cloud-based platform for monitoring of driveline components
- Open, customer-specific software and hardware architecture enables the integration of partners into the ZF Eco System
- Standardized interface and encrypted data traffic via VPN or Internet



# Cloud Environments and Collaboration



# 05

## Highlights & Benefits

# Highlights & Benefits

## connect@rail

### Customized solutions

Features can be added and adjusted individually.

### Eco System

Network of partnerships, cooperation's, and joint ventures to reduce time-to-market. Integration of other system/ integration of the IDM to other systems possible.

### Bluetooth communication

Latest Bluetooth connection 5.0 for a trouble-free and energy-saving data connection.

### Secure connection

Two independent processors guarantee a stable and secure connection to the ZF IoT Cloud.



### Digital Condition Monitoring

At any time and from everywhere.

### Predictive Maintenance Planning

Based on the condition to avoid unplanned down-times.

### Easy Integration and Retrofitting

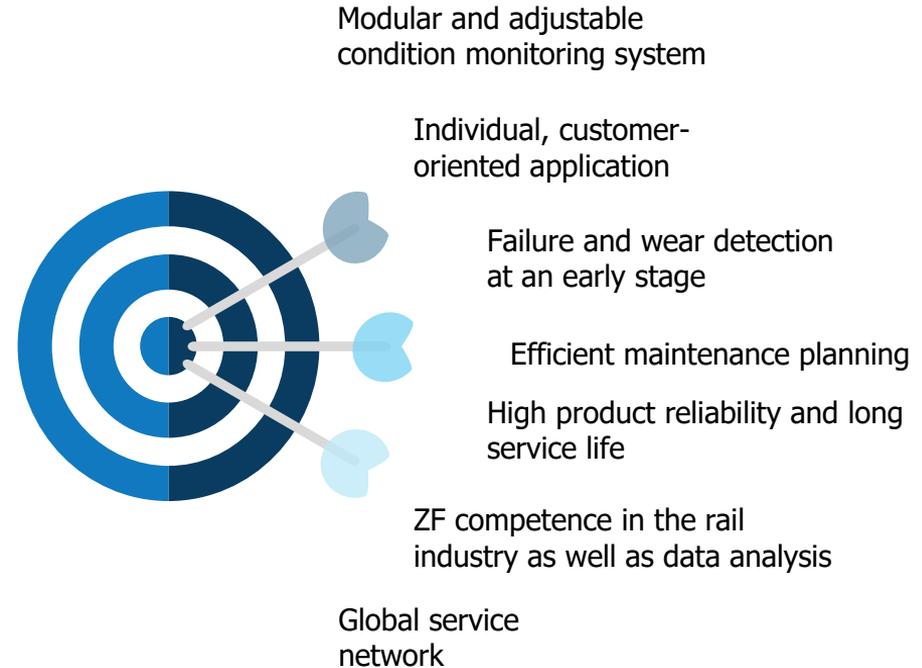
The HD TAG and VCU Secure Gateway can be easily installed in existing vehicles.

### ZF Competence

Certified series components according to railway standards.

# Service Commitment

We offer you a customized solution as an added value



# Have we aroused your interest?

## Contact us:

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[www.zf.com/connect-at-rail](http://www.zf.com/connect-at-rail)



# Let's Shape the Next Generation Mobility Together!

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