



# Predictive Maintenance: From Signal to Business Case

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# Agenda

1. **Intro to ZF**
2. **Predictive Maintenance: Use Cases & Business Cases**
3. **Technical Essentials**



# 01

## Intro to ZF



# ZF Corporation Facts and Figures 2017



**146,148**  
**Employees**



**230**  
**Locations Worldwide**



**€36.4 bn**  
**Sales**



**€2.3 bn**  
**Adjusted EBIT**



**€2.2 bn**  
**Research & Development  
Expenses**



**€1.4 bn**  
**Investment in Property,  
Plant and Equipment**





# Intelligent Mechanical Systems Megatrends

## EFFICIENCY



### **Zero Emissions, zero unplanned Downtime**

- Increasing efficiency thanks to electrification and networking
- Increasing system reliability with monitoring and maintenance services
- New ZF division E-Mobility

## SAFETY



### **Operational Safety**

- Protection for passengers and pedestrians
- Intelligent systems independently identify hazardous situations and react by performing autonomous braking and evasive maneuvers

## AUTOMATED DRIVING



### **Autonomous Operation**

- ZF as pacemaker and system supplier for automated driving
- Development of innovative assistance systems

# ZF, Division Industrial Technology



# 02

## Predictive Maintenance: Use Cases & Business Cases





# The general Use Case of Predictive Maintenance



**Collect, analyze and compare field and product related data for:**

- Automated detection of anomalies
- Remaining lifetime calculations
- Coordinate demand oriented service



**OEM and operator benefits:**  
**-> Reduction of operational costs:**

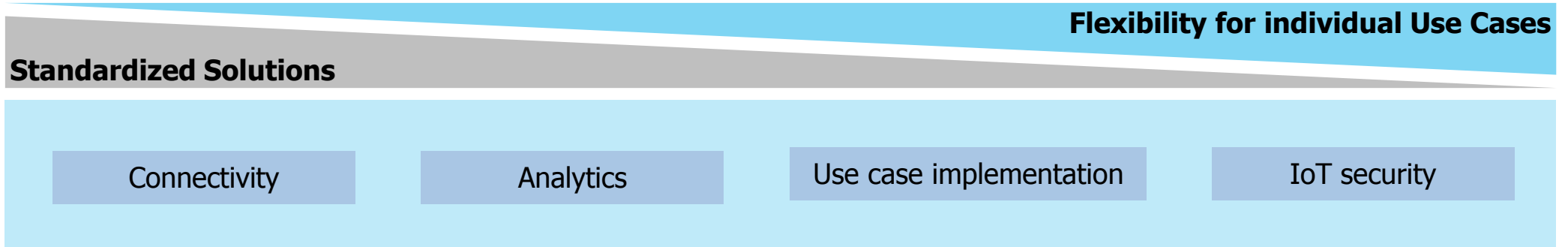
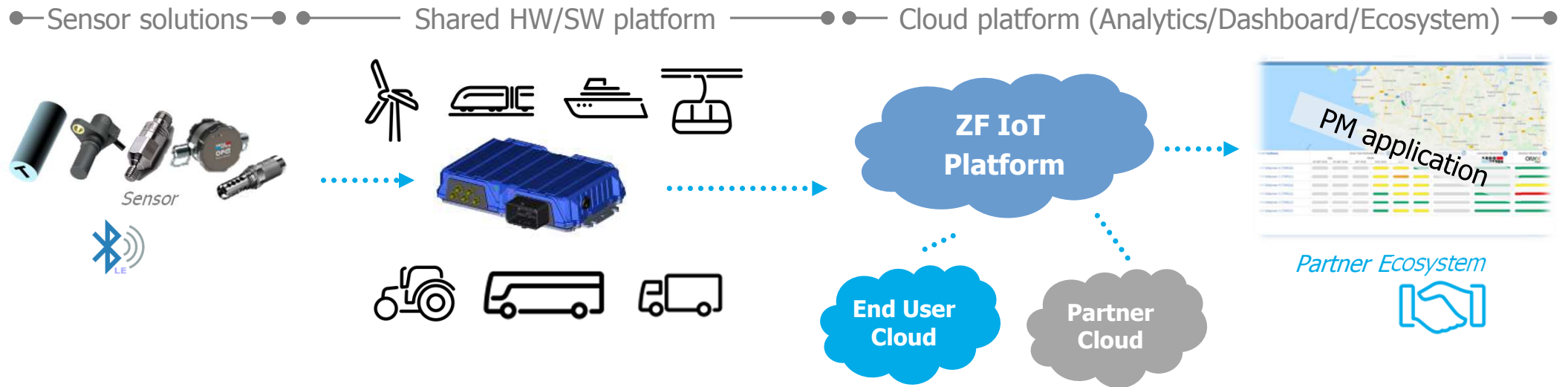
- Enhancing operations
  - reduced stress and wear
  - extended life cycles
- Optimizing the system performance
- Increase system reliability





# The technical Scope of Predictive Maintenance

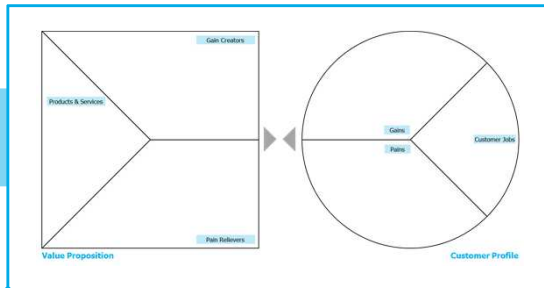
## A broad Field



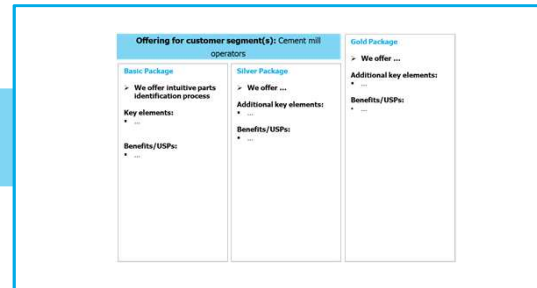
# Business Development PM for Industrial Products

## Classical Approach

### Value Proposition Canvas



### Offerings overview



### Most common product attributes:

Tasks: Sustainably generate a revenue

Gain: Low invest & operating costs

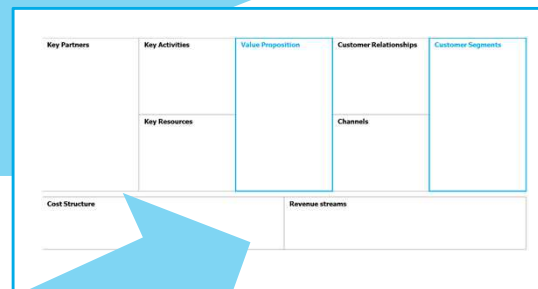
Pains: Unplanned downtime

Pain Relievers: High reliability and performance

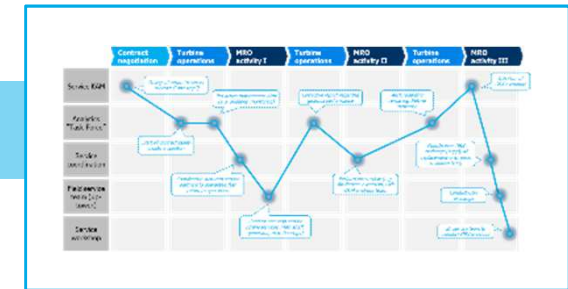
Gain Creators: Risk sharing (\$)

=> **Services & optimized products**

### Business Model Canvas



### Customer Journey



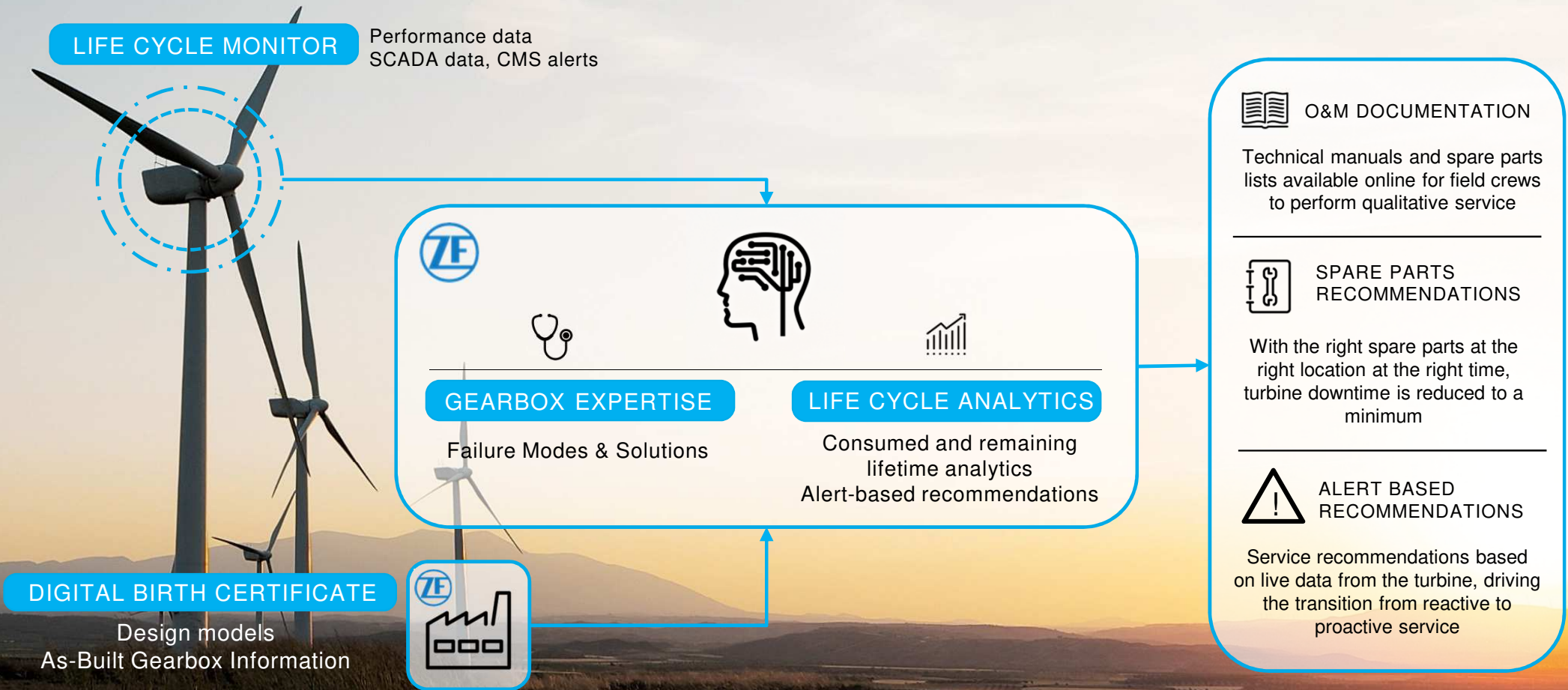
# Paradigm Shifts

- From single units to fleet operation
- Autonomous operation requires self diagnostics
- Seamless mobility need reliable communication
- System partnerships with risk sharing



# ZF's Services powered by Analytics

## Optimized Spare Parts Supply



# Performance Management System ZF ProVID

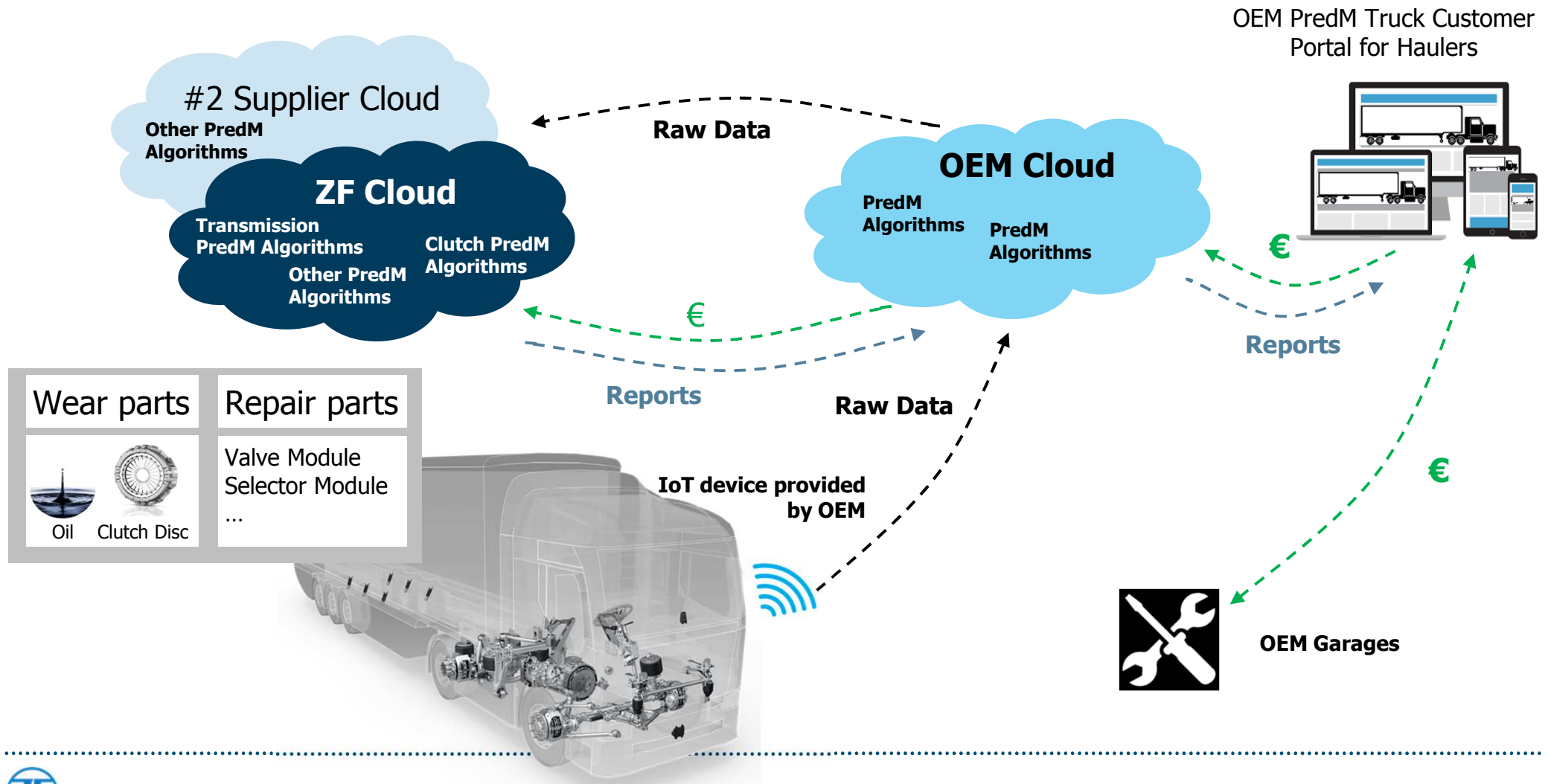
Performance management system for the entire driveline.



*ZF ProVID: monitoring of the complete drivetrain, analysis and evaluation by ZF owned algorithms, transfer via cloud solution and documentation on specific dashboard*

- **Reduced operating costs** by
  - Monitoring of bearings, teeth and oil quality
  - reduced oil analyses and changes
  - early detection of potential failures
- **Reduction of total costs of ownership (TCO)** by
  - specific preventive maintenance actions
- **Reduction of downtimes** by
  - Scheduling of maintenance works as needed
- **Prevention of secondary damages**
- **Reduction of repair costs**
- **Availability of all status reports**
  - basis for audit documentation of service history

# Monitoring of Truck Drive Trains for large Fleets





# 03

## Technical Essentials



# The Digital Twin

**Physical  
World**



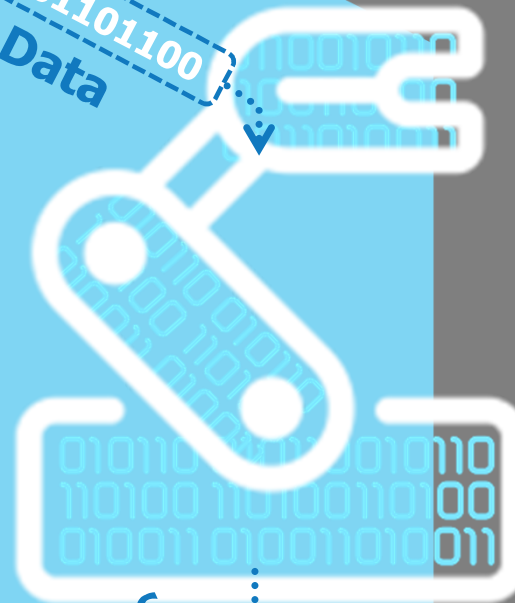
**Sensor**

**Data**  
101101100

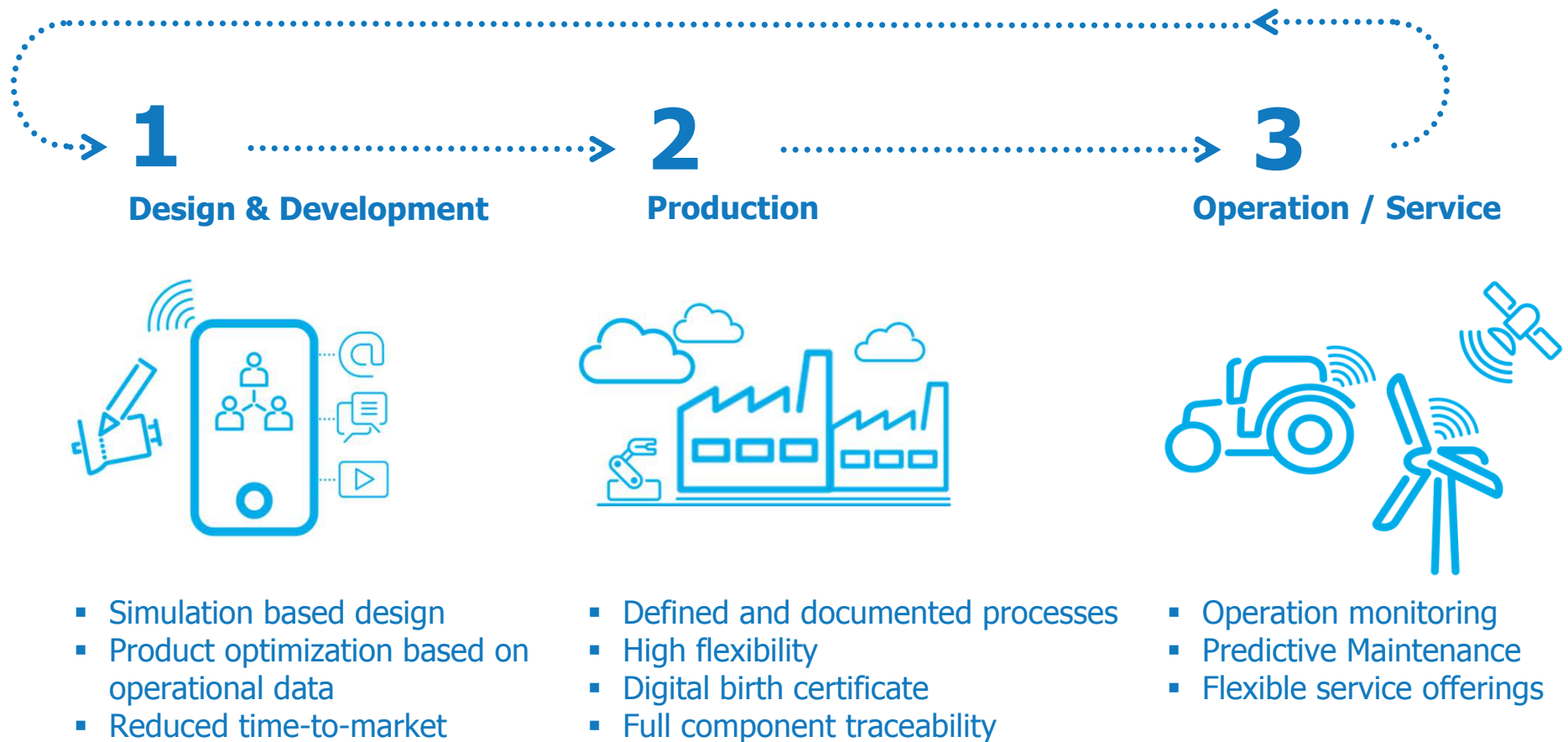
**Actuator**

**Analytics**

**Digital  
World**

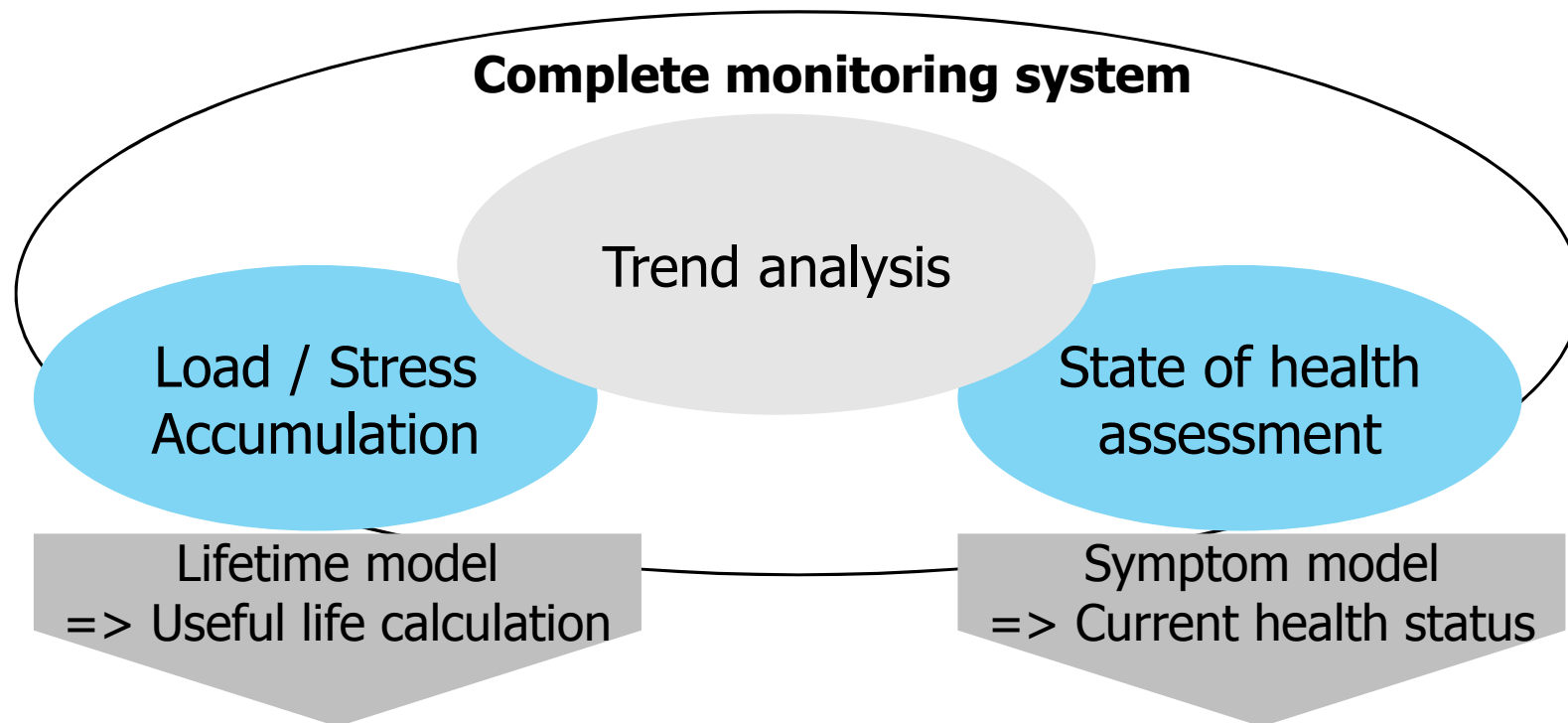


# Digital Twins in a Product Lifecycle Loop





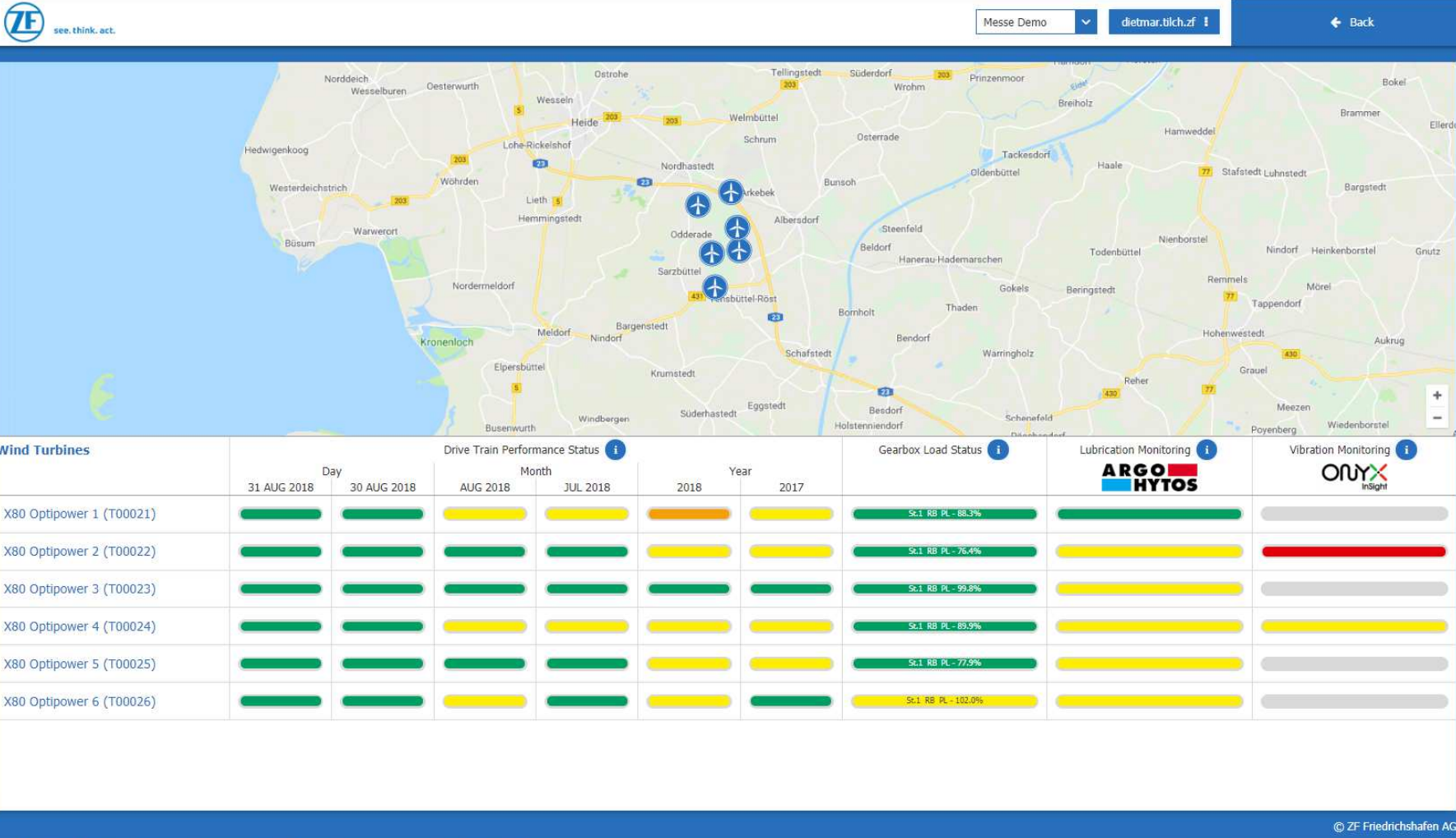
# Combining predictive and detective analytics for a complete monitoring system



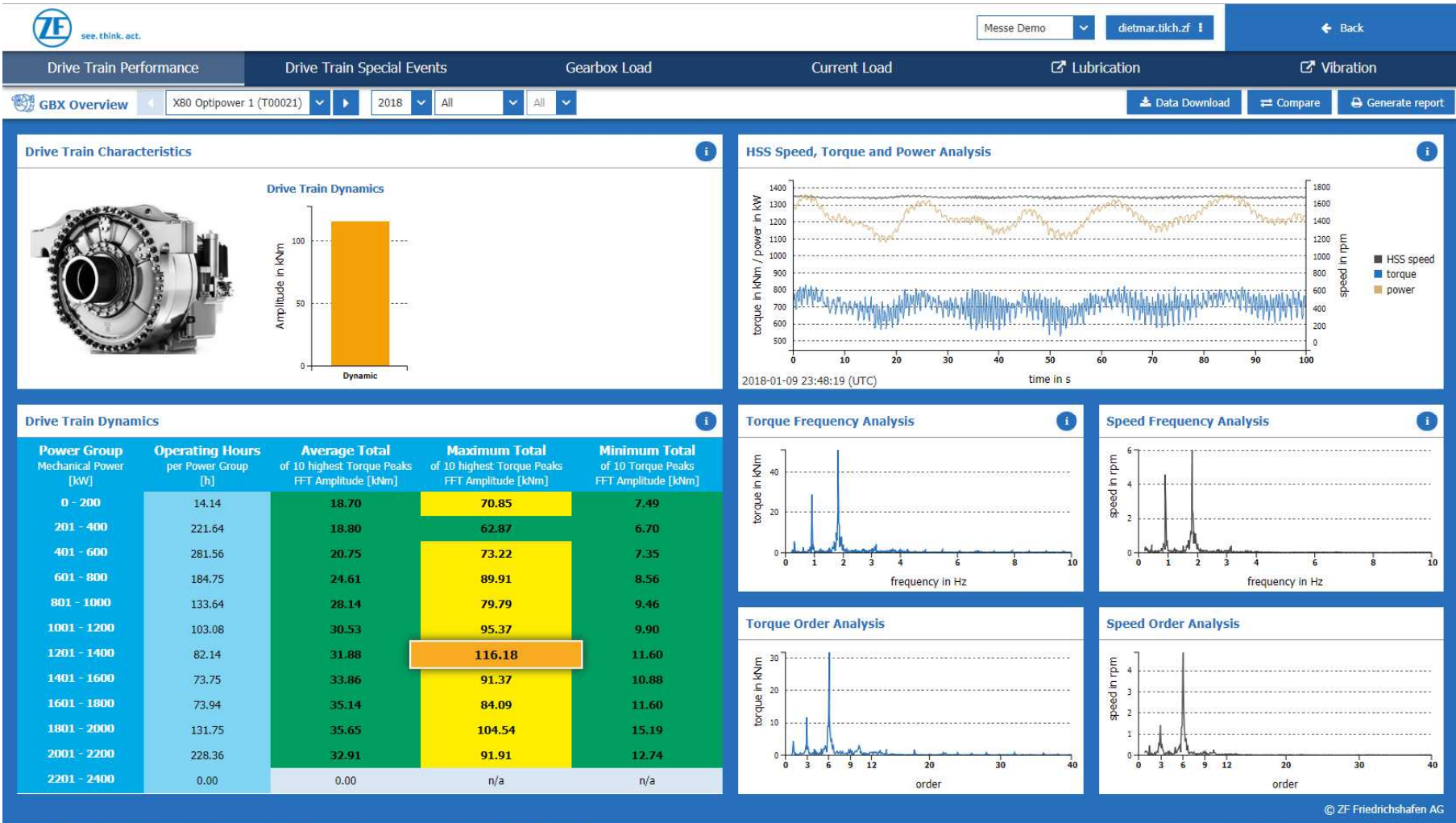
A complete monitoring concept combines symptom and lifetime based models

- The symptom model checks for existing damages in an early stage
- The lifetime model provide predictive analysis and enables damage prevention

# Cloud-based Performance Management, Park Overview



# Critical Drive Train Dynamics





# Load based Lifetime Calculation



Messe Demo

dietmar.tilch.zf

Back

Drive Train Performance

Drive Train Special Events

Gearbox Load

Current Load

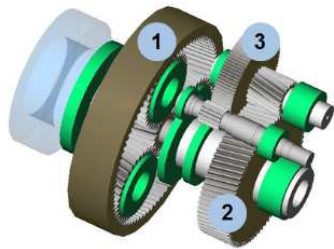
Lubrication

Vibration

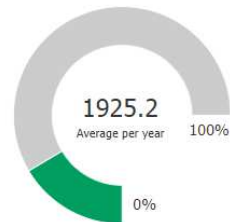
GBX Overview

X80 Optipower 1 (T00021)

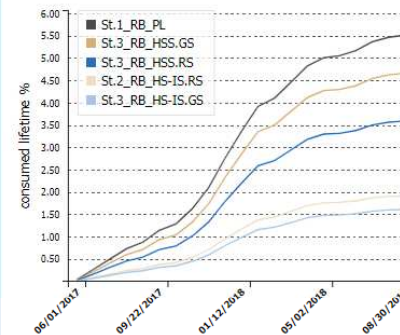
Gearbox Configuration



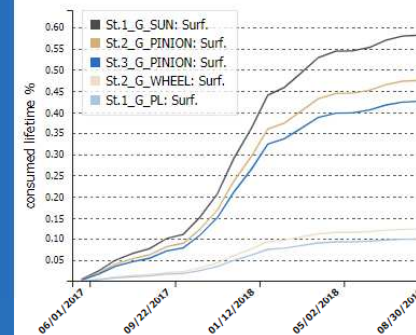
Full Load Hours



Consumed Lifetime of Bearings



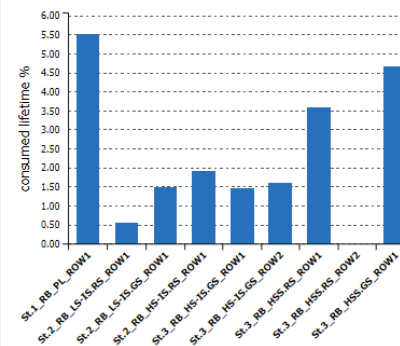
Consumed Lifetime of Gears



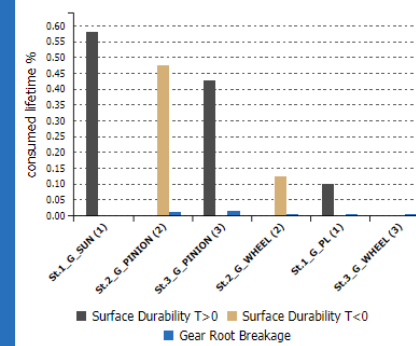
Details

Bearing	Consumed Lifetime %	Gear Comp.	Failure Mechanism	Consumed Lifetime %
St.1_RB_PL_ROW1	5.5	St.1_G_SUN	Surface Durability	0.6
St.2_RB_LS-IS,RS_ROW1	0.6	St.2_G_PINION	Surface Durability	0.5
St.2_RB_LS-IS,GS_ROW1	1.5	St.3_G_PINION	Surface Durability	0.4
St.2_RB_HS-IS,RS_ROW1	1.9	St.2_G_WHEEL	Surface Durability	0.1
St.3_RB_HS-IS,GS_ROW1	1.5	St.1_G_PL	Surface Durability	0.1
St.3_RB_HS-IS,GS_ROW2	1.6	St.3_G_PINION	Breakage	< 0.1
St.3_RB_HSS,RS_ROW1	3.6	St.2_G_PINION	Breakage	< 0.1
St.3_RB_HSS,RS_ROW2	< 0.1	St.3_G_WHEEL	Breakage	< 0.1
St.3_RB_HSS,GS_ROW1	4.7	St.2_G_WHEEL	Breakage	< 0.1
		St.1_G_PL	Breakage	< 0.1
		St.3_G_WHEEL	Surface Durability	< 0.1

Consumed Lifetime of Bearings



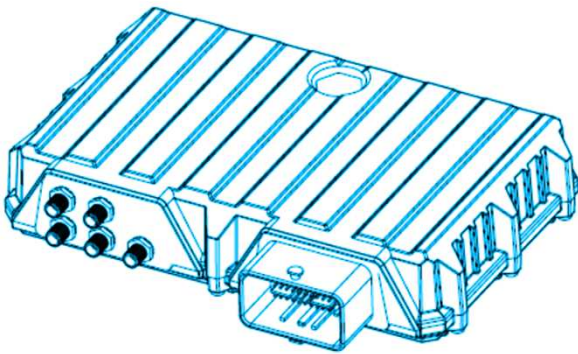
Consumed Lifetime of Gears



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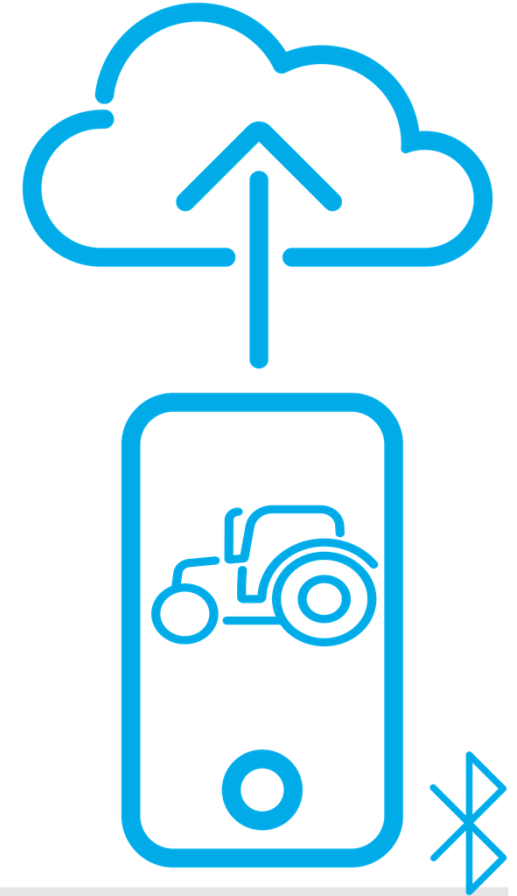
# Basic Data Communication Schemes



IoT / Edge Device

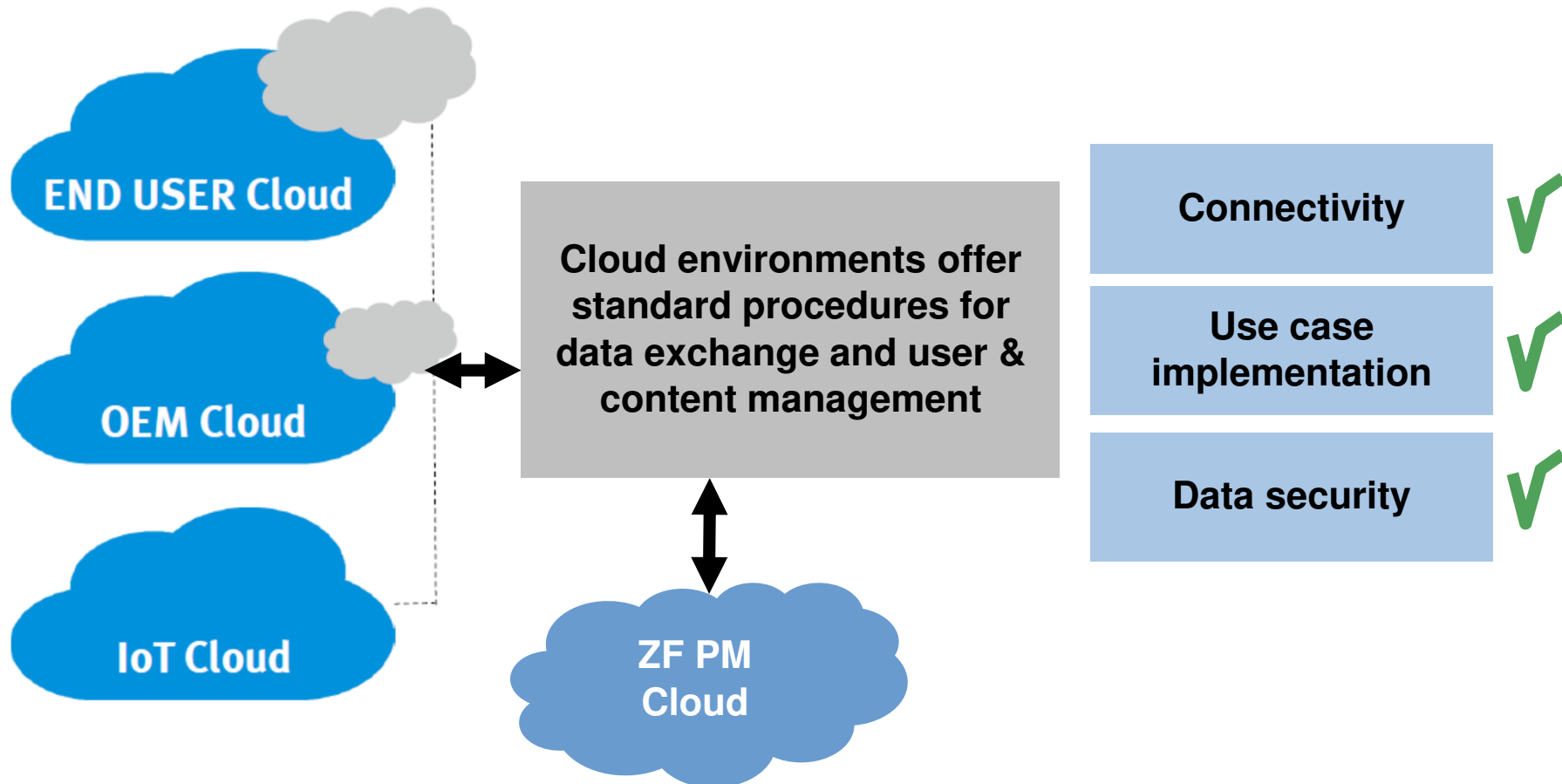


Cloud-to-Cloud



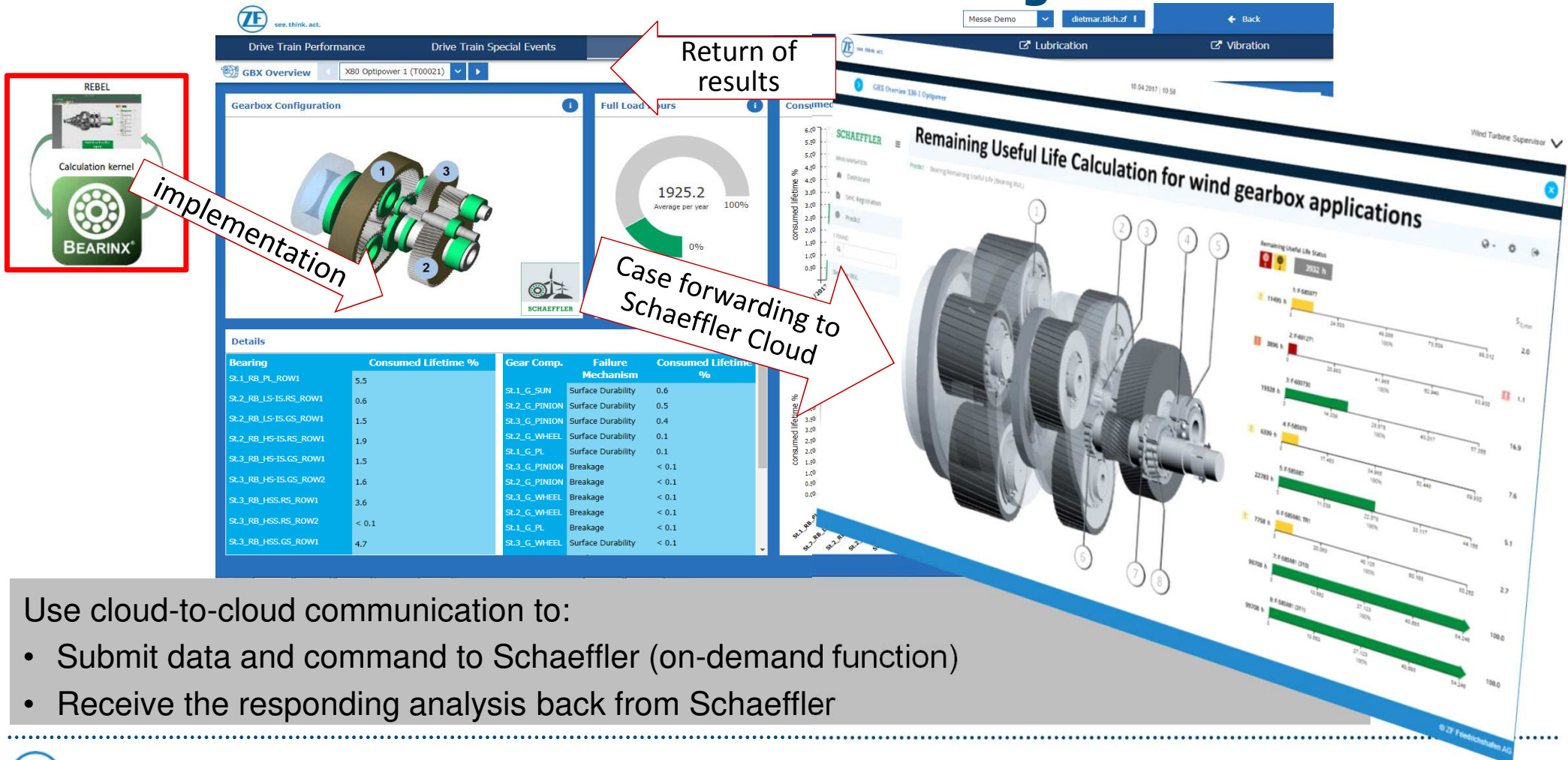
Smartphone as gateway

# Cloud environments and collaboration



# Cloud Collaboration with external Partners

## Load based lifetime calculation with bearing manuf. Schaeffler



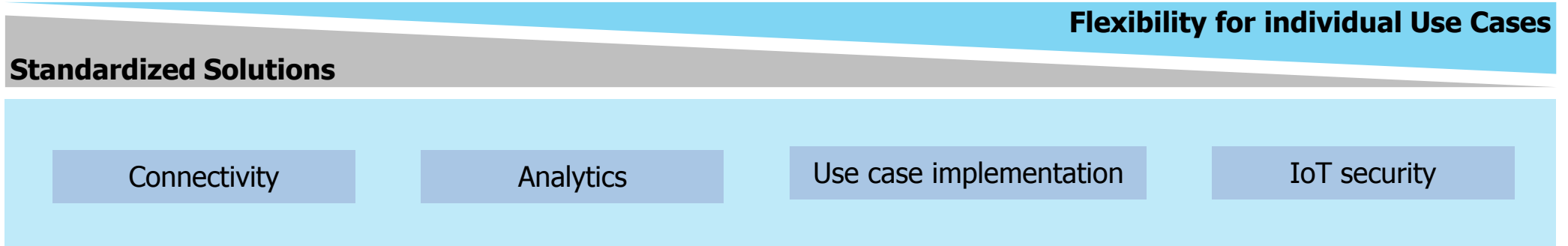
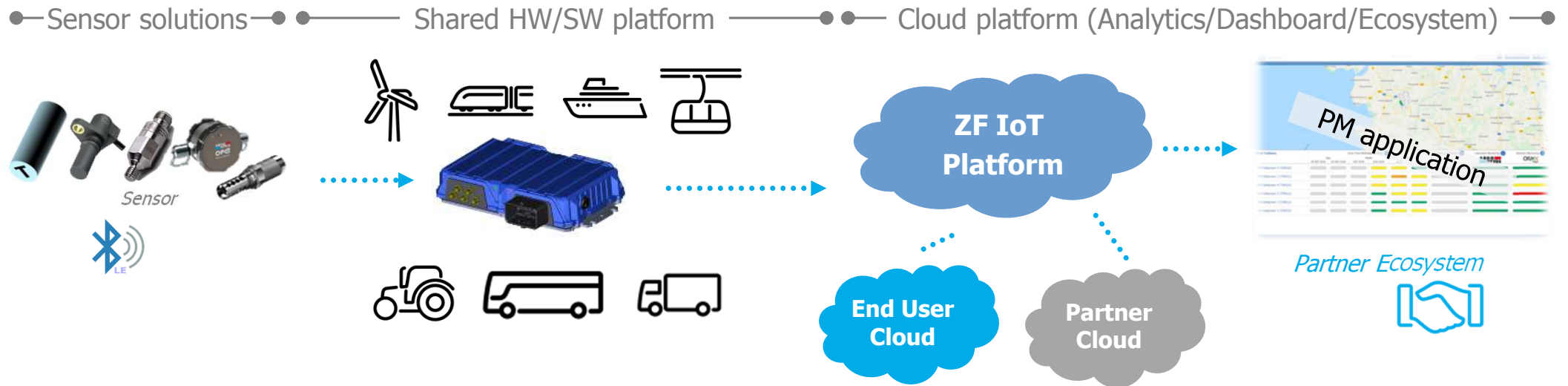
Use cloud-to-cloud communication to:

- Submit data and command to Schaeffler (on-demand function)
- Receive the responding analysis back from Schaeffler



# Predictive Maintenance

## A broad Field of Opportunities



# Thank you for your attention

## Any questions?

