IOT ENABLED

PREDICTIVE MAINTENANCE

Kalman Tiboldi
Chief Business Innovation Officer

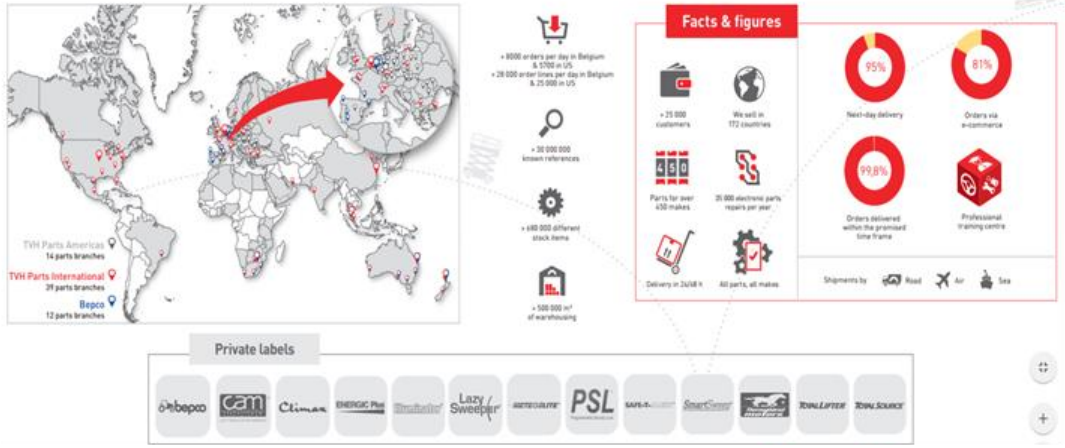
TVH GROUP

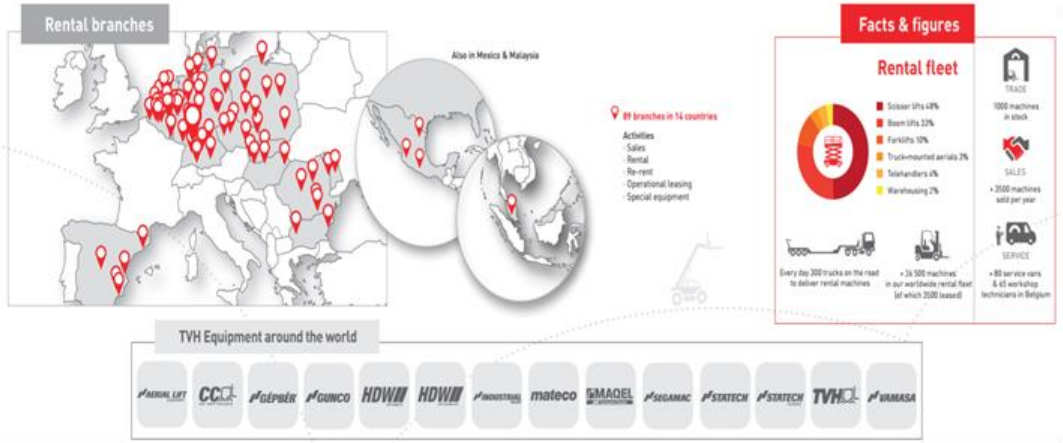
2 business units

TVH PARTS | **TVH EQUIPMENT**

6 business lines

- Material handling parts (MPA)
- Industrial equipment parts (IPA)
- Agricultural equipment parts (APA)
- Sales (trade & domestic)
- Rental
- Service & repair

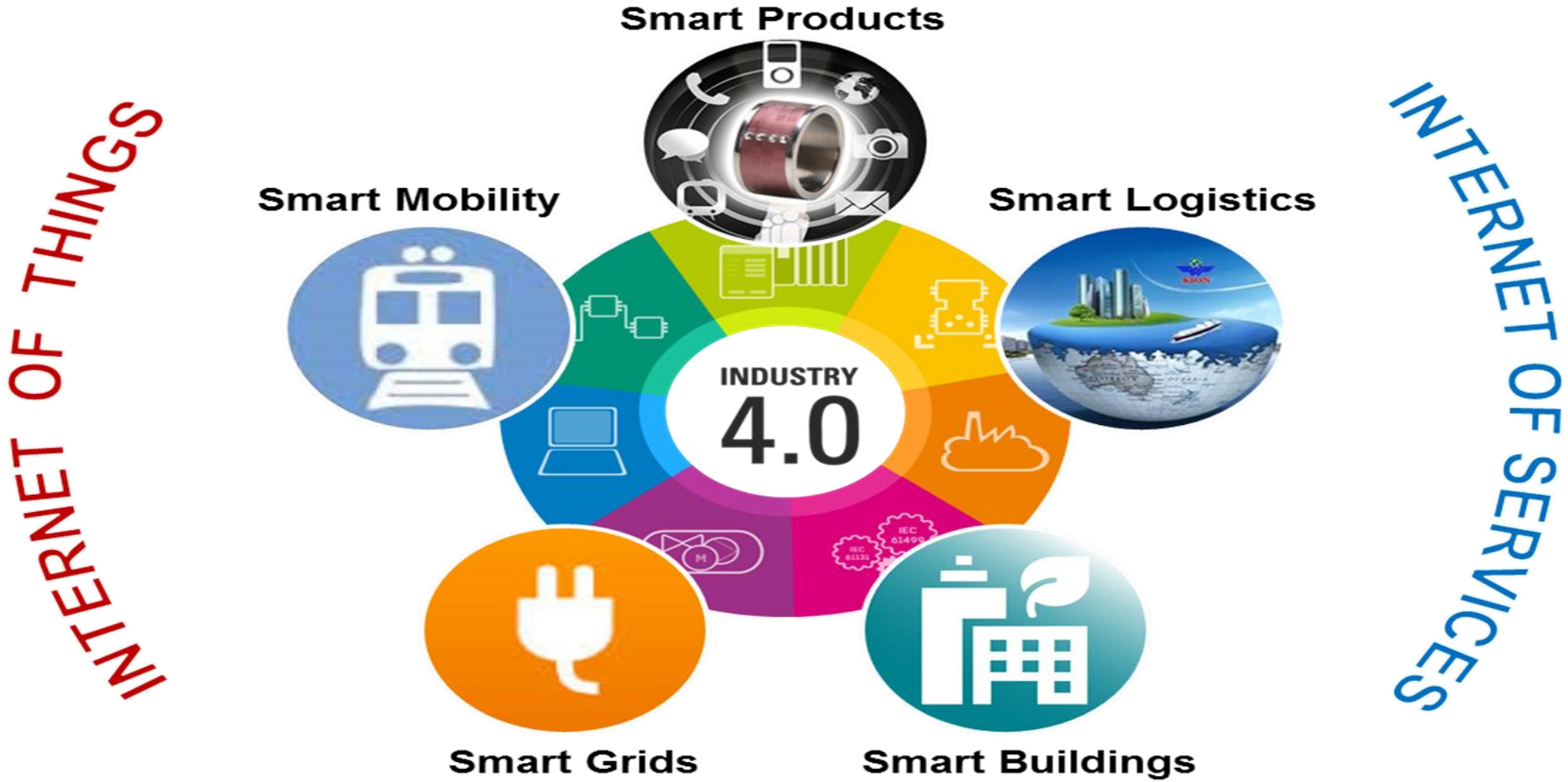




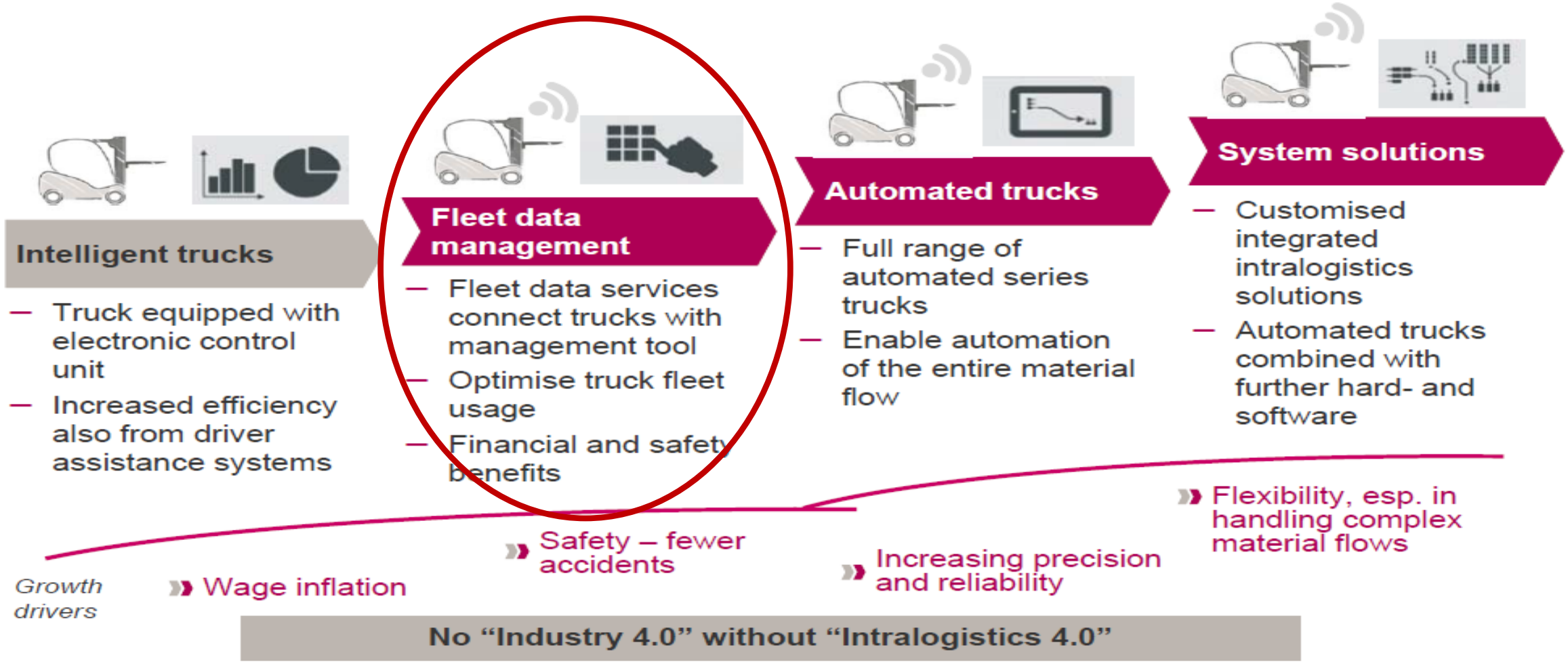
> 6000 colleagues worldwide

Consolidated turnover € 1,34 billion

SMART LOGISTICS – PART OF INDUSTRY 4.0

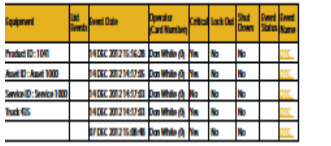


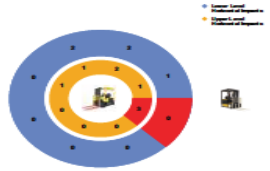
LOGISTICS 4.0 FOR LIFT TRUCK INDUSTRY



Source: KION Group AG - 2015

TECHNOLOGY ENABLED FLEET MANAGEMENT





Operational Fleet Monitoring and Management
Real-time equipment tracking, KPI management per truck, fleet and location

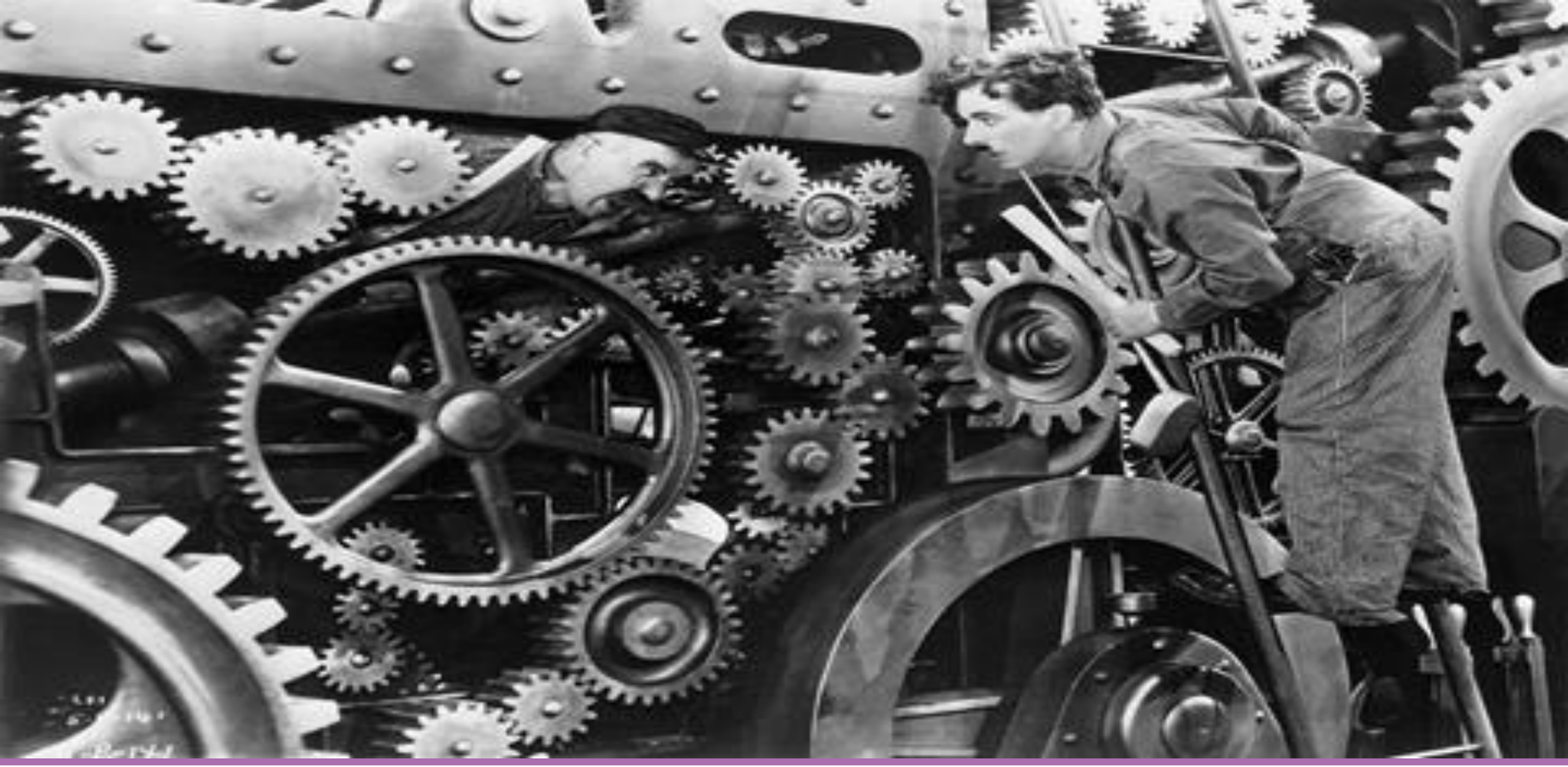
Equipment dispatching
Assigning equipment to customers

Technician scheduling
Location, skill requirement, shift of work based crew scheduling

Asset tracking
Linked to overall fleet management, allows the tracking of all goods and physical items allocated to fleet operations

Condition based, predictive maintenance
Remotely view and manage equipment servicing

Security and safety
Equipment and driver security during operation or while stopped, recovery of stolen vehicles



TYPES OF MAINTENANCE

Correctieve Maintenance

Performed to identify, isolate, and rectify a fault so that the failed equipment, machine, or system can be restored to an operational condition

Preventive Maintenance

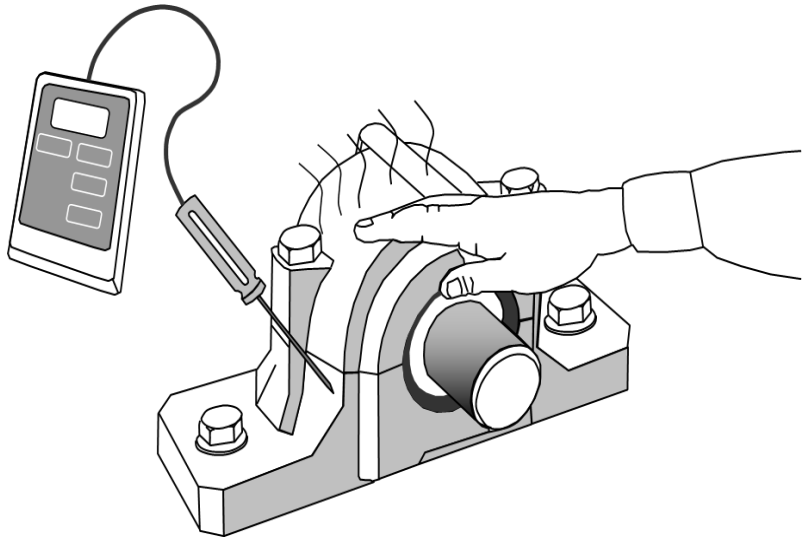
Schedule of planned maintenance actions aimed at the prevention of breakdowns and failures. Preserve and enhance equipment reliability

Predictive Maintenance

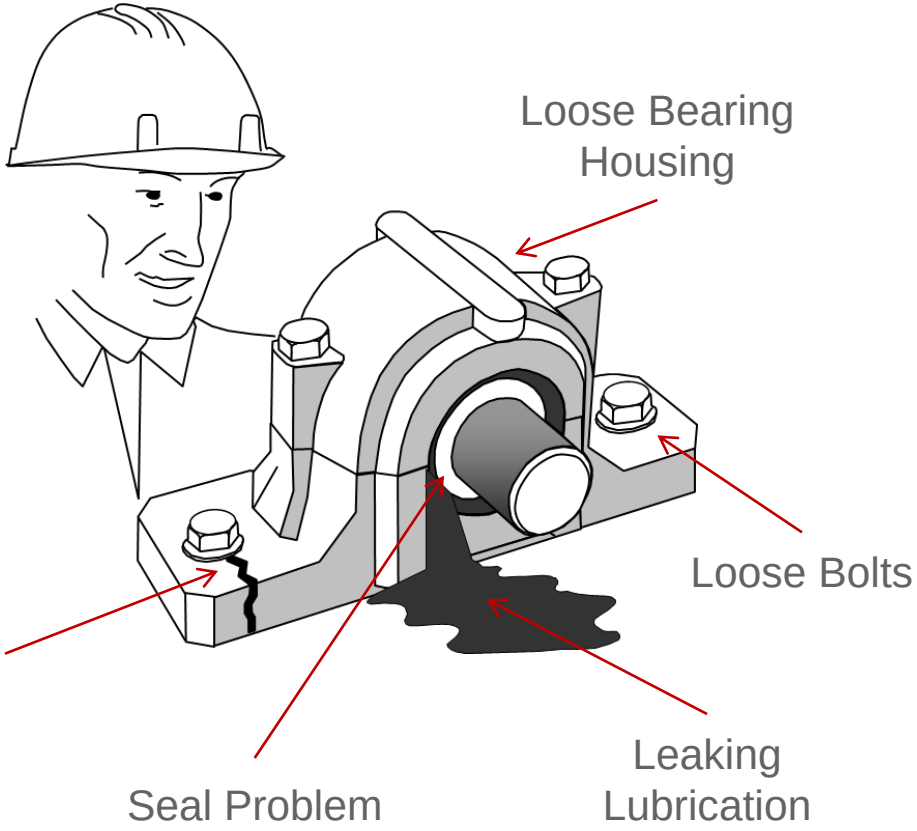
Techniques that help determine the condition of in-service equipment in order to predict when maintenance should be performed. Minimize disruption of normal operations, while allowing right time repairs.

CONDITION MONITORING

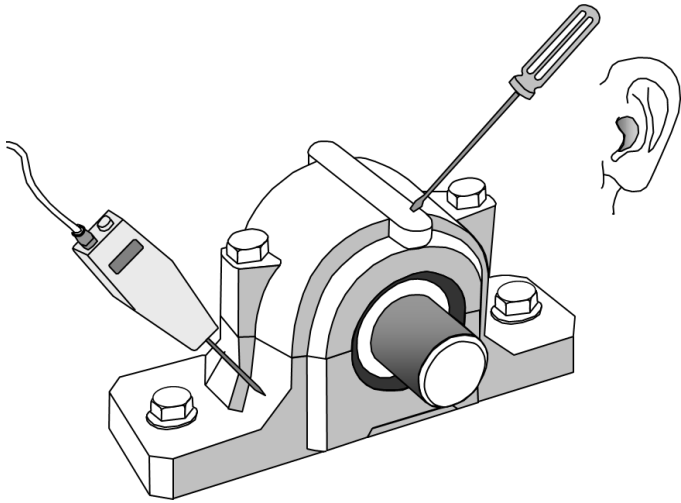
Temperature



Sight



Vibration



PREDICTIVE MAINTENANCE

Your equipment tells you precisely what kind of service it needs, where, why, and what its estimated life time will be without that service

Remote monitoring and self optimizing

Sense	Raw data is collected from hundred or thousands of sensors, locally processed or transmitted wireless to remote monitoring
Decide	Analyse the data, take decisions locally or through remote analytical services. Private and public data are combined using cloud –based services
Act	Adapt and optimize the performance of the process locally or take actions to replace the part causing problems

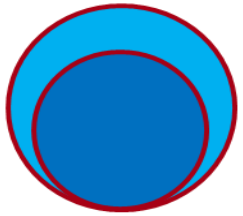
Predictive, condition-based Maintenance

Allocate and plan maintenance tasks according to the anticipated, measured or calculated condition of a component, device or system

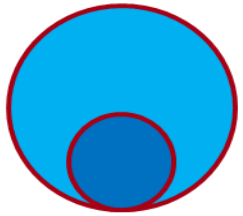
BUSINESS OPPORTUNITY

IBM

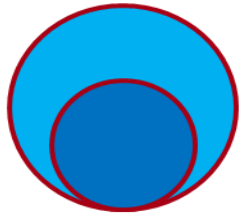
Reduction in maintenance costs
25-30%



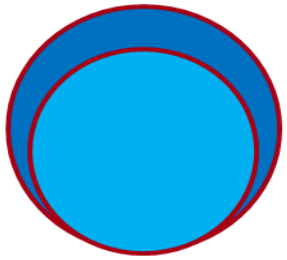
Elimination of breakdown
70-35%



Reduction of downtime
35-45%



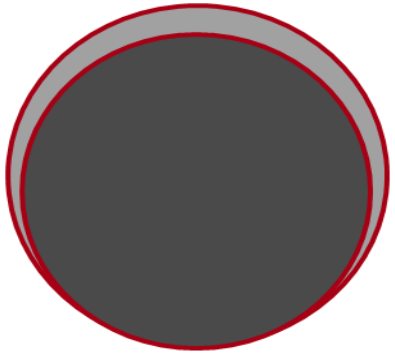
Increase in production
35-45%



Source: IBM – Published on Oct 27, 2016

Gartner

Average cost reduction moving from preventive to predictive maintenance
10-20%

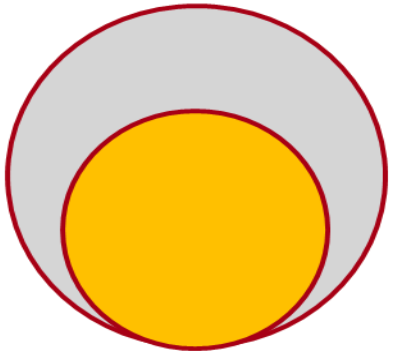


By 2022, IoT will save consumers and businesses $1 trillion a year in maintenance, services and consumables.

Source: Gartner – Published on Oct 17, 2016

VOLVO

Repair cost reduction vs. average 2011-2014
49-51%



Source: Volvo Construction Equipment 2016

TECHNOLOGIES DRIVING INDUSTRY 4.0

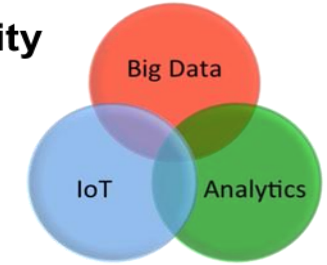
Mobile

Autonomous robots

Cloud Computing

Augmented reality

3D Printing



Big & Fast data

Internet Of Things

Artificial intelligence

SMART PRODUCTS

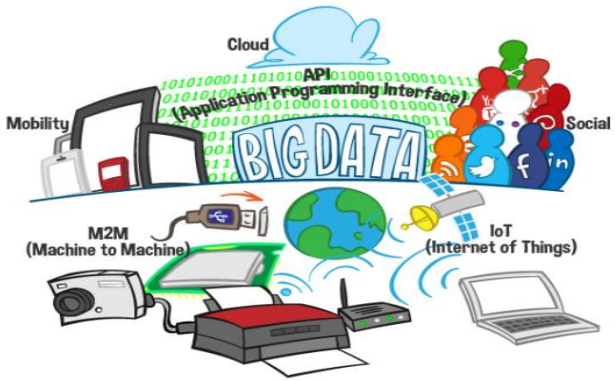
Physical Components
Mechanical and
Electrical Parts

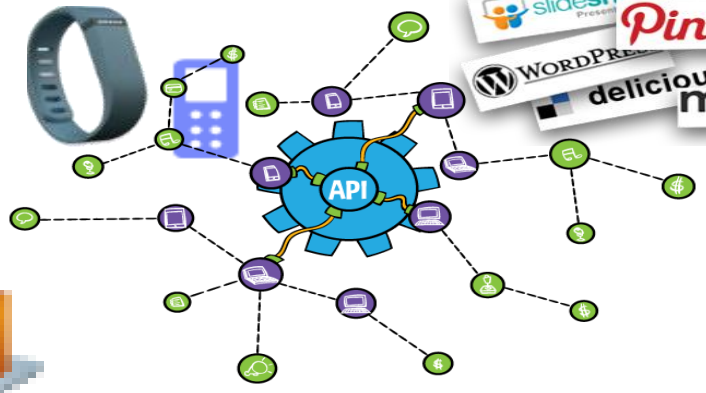
STILL CUBEXX

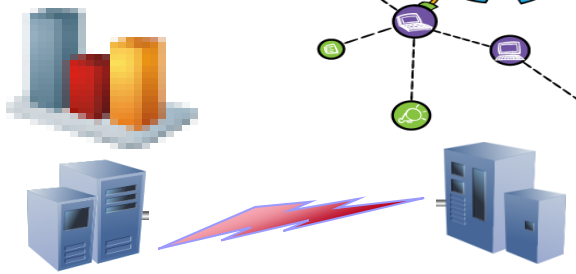
Smart Components
Sensors, chips, storage, software,
embedded operating system…

Connectivity Components
Ports, antennae, protocols,
wired or wireless connections

CYBER-PHYSICAL WORLD



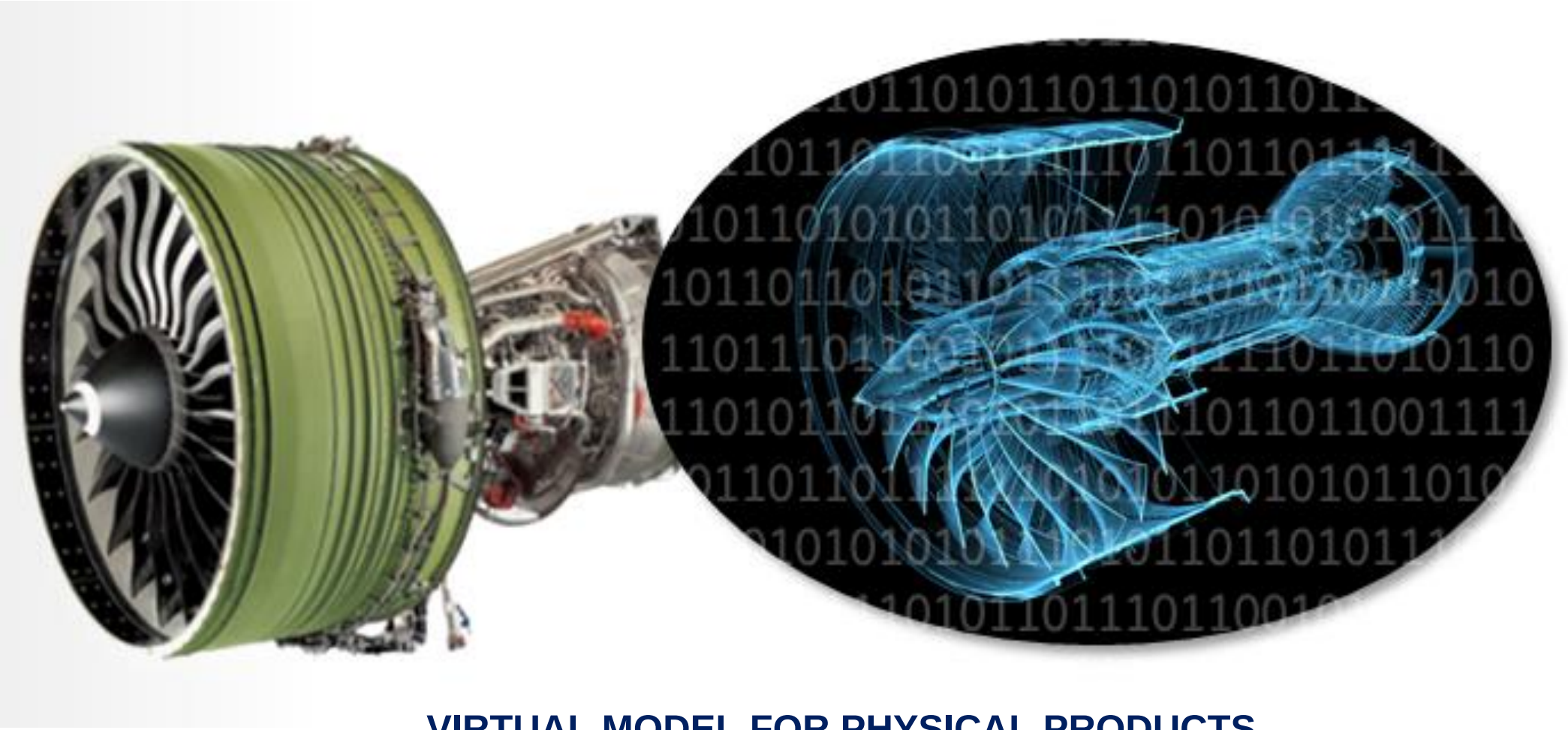




MERGING THE REAL AND VIRTUAL WORLDS

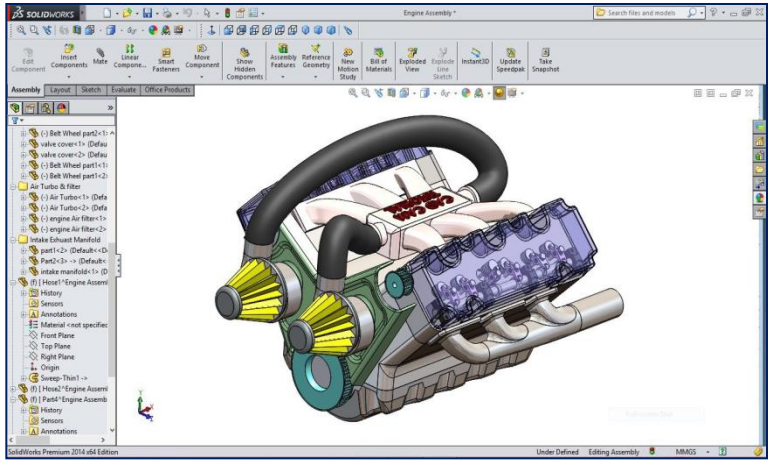
DIGITAL TWINS

SENSORS **DATA** **ANALYTICS**

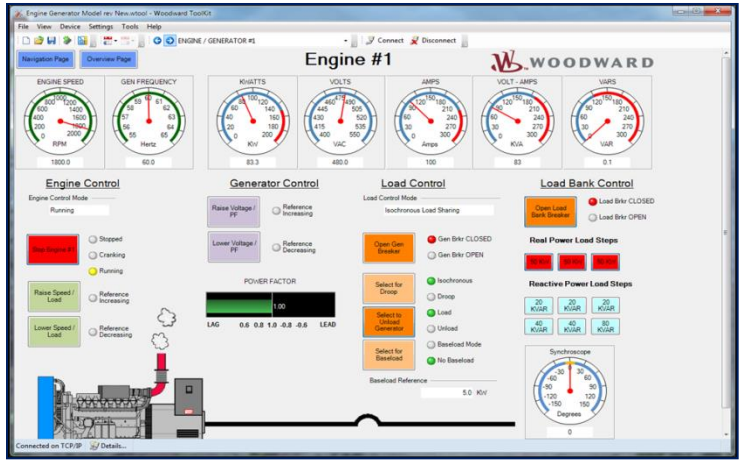


VIRTUAL MODEL FOR PHYSICAL PRODUCTS

DESIGN – BUILD - OPERATE



Design
3D CAD twin



Simulate
First born digital twin

Monitor
Physical asset twin

GENERATING VALUE FROM DATA

Physical Asset

Real-time data

Digital Twin

Ecosystems
Collaborative product development

Asset performance
Analytics-based performance optimization

New digital business model
Based on the data produced by the Twin

IMMERSION INTO THE VIRTUAL WORLD

SERVITIZATION

EQUIPMENT-AS-A-SERVICE

Lifting capacity as a service

Reducing downtime
Extending asset life

Measuring the residual value

Pay-per-usage

Detecting and avoiding overloading

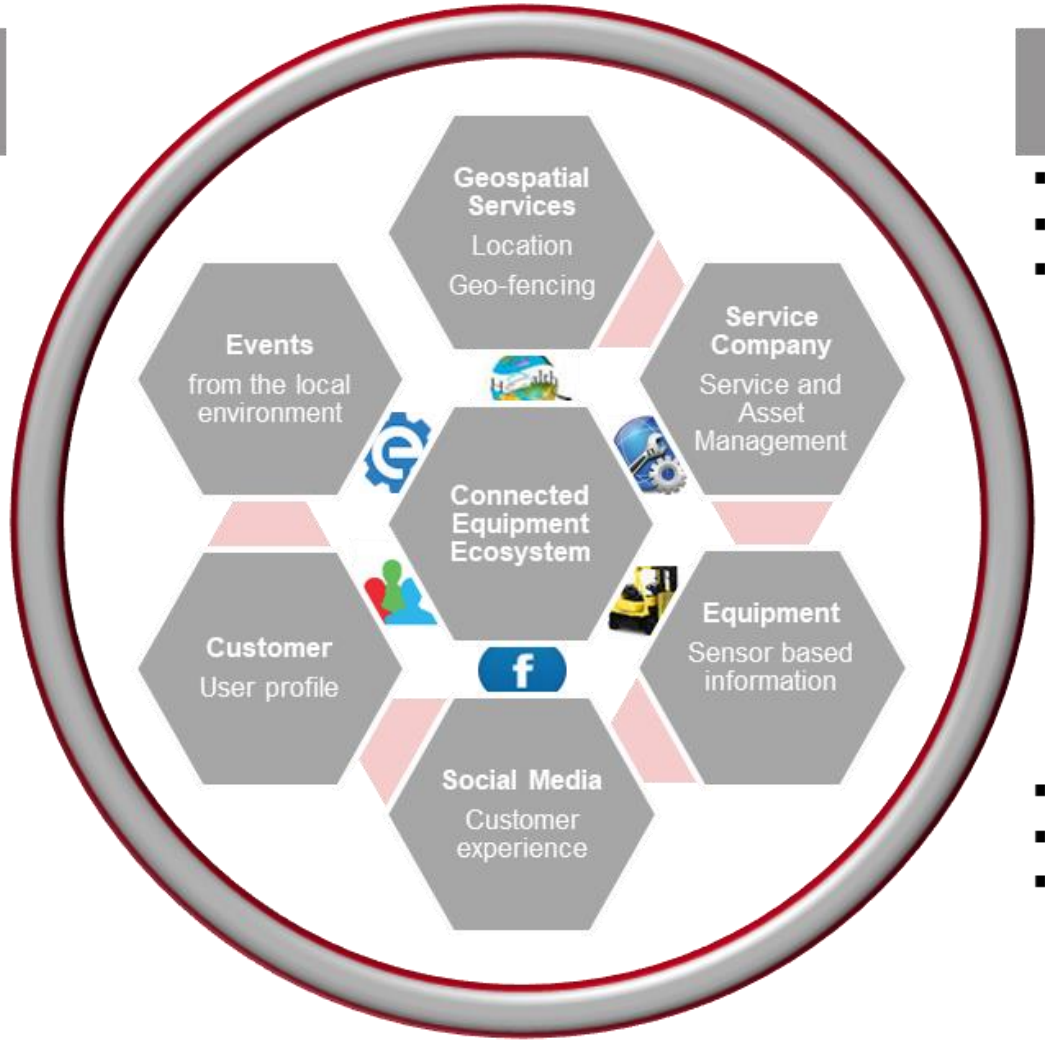
MOVING FROM PRODUCT TO SERVICE

CONNECTED EQUIPMENT ECOSYSTEM

ORIGINAL EQUIPMENT MANUFACTURER (OEM)

- Real-time alerts
- Consolidated view
- Improvement proposals

- Technical specifications
- Maintenance procedures
- Digital twin API



CUSTOMER

- Real-time alerts
- Maintenance and service issues
- Data produced by equipment

- Real-time alerts & updates
- Maintenance services
- Improved user experience

SMART LIFT TRUCKS

GPS

Camera

Speed & Accelerometer

Heavy load position

Mast & steering sensor

Engine data

Load presence

Fuel

Proximity sensor

Temperature

Mast Tilt Angle

Tyre pressure

Oil condition

Battery

CONNECTED TVH EQUIPMENT

IoT Endpoints

Data Ingestion

IoT Edge Gateways

Local Filtering & Analytics

Service Engineer

Data Ingestion

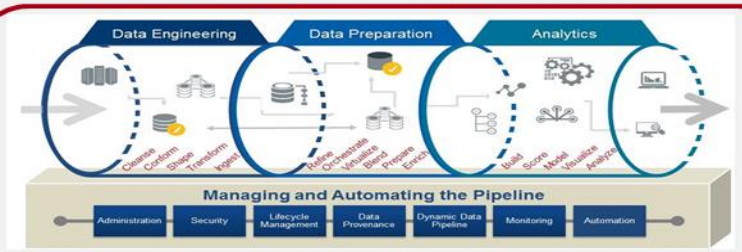
Device Control

IoT Platform

ActiveMQ, Apache Camel — Data Streaming

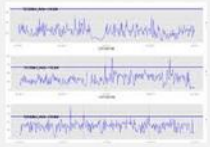
PostgreSQL — Data Repository

External data services



Data Analytics & Event Processing

Decision Management



Data Visualization

Device Management

Enterprise Applications

- Fleet Management
- Service Management
- Business Intelligence
- Predictive Model Development
- Product Engineering

More than 15000 connected machines

EDGE GATEWAYS FOR PdM

Basic

Advanced

Smartphone/Tablet

Wall-mounted

- Multi-Input/Output
  Digital, Analog, CAN-Bus, HDMI
- Communication aggregation
  RFID,Bluetooth,ZigBee,LpWan,USB,LTE,WiFi
- Data caching, buffering and streaming
- Data aggregation, transformation and filtering
- Edge Data Visualization
- Event processing
- Real-time data analytics
- Real-time decision making
- Command processing

REAL-TIME ANALYTICS AT THE EDGE

The ***Value*** comes from the ***Information*** that's hardest to manage

IoT ***generates large quantities of data*** that need to be processed and analyzed in real time

Most machine data is only valuable for a ***short period of time***

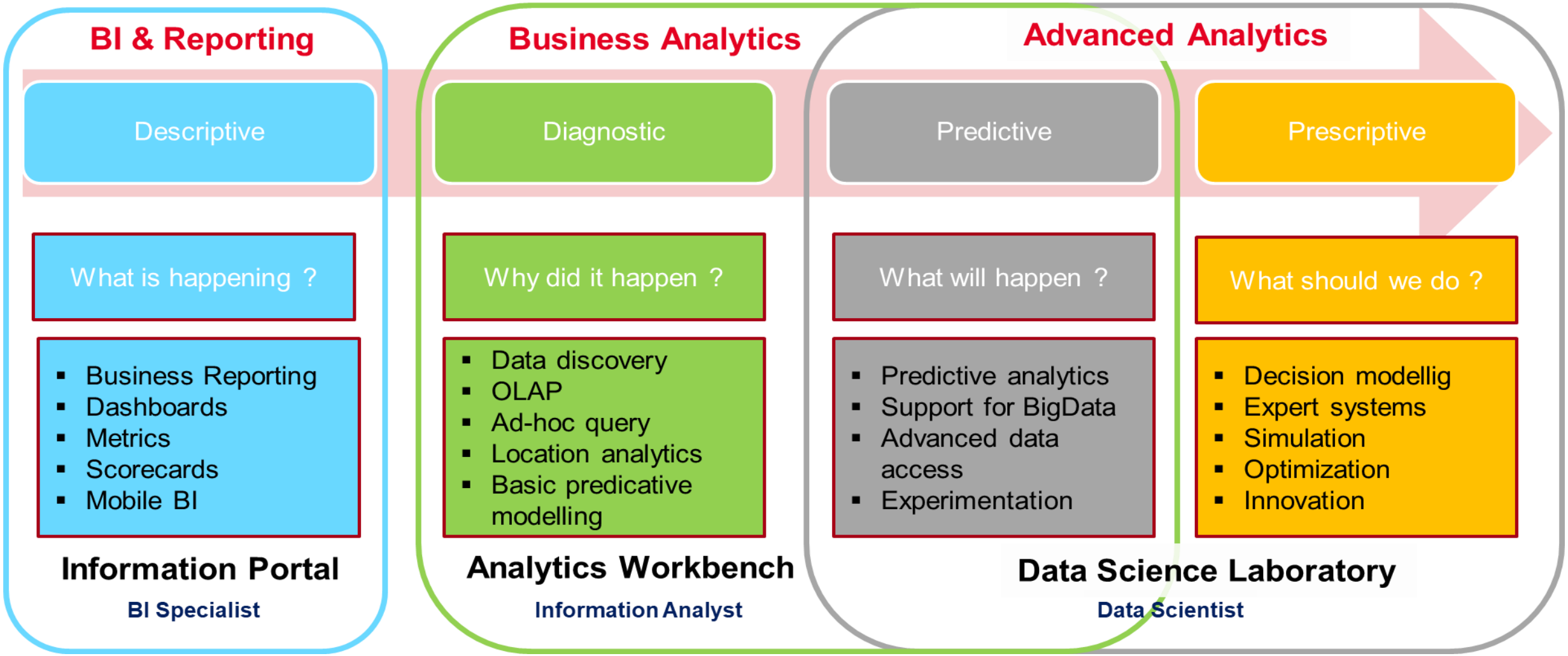
Edge Analytics ***limits the need for transporting and storing*** the high volume of IoT data and allows real-time actions

Real-time analytics ***at the Edge***. Just relevant data is forwarded to the cloud or central sites for additional processing

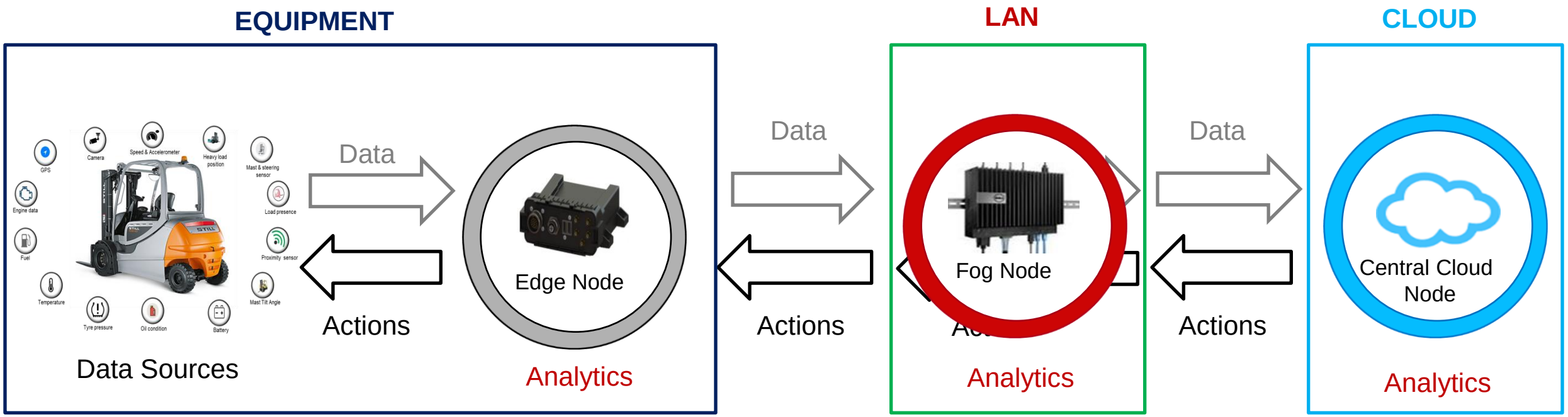
In ***Maintenance Mode*** a lift truck generates more than **3 MB / min** through CAN-bus

With Edge Computing we can do **analytics at the right place**

MOVING TOWARDS ADVANCED ANALYTICS



DISTRIBUTED ANALYTICS



Analyse the data in the RIGHT place

ML ENABLED PREDICTIVE ANALYTICS

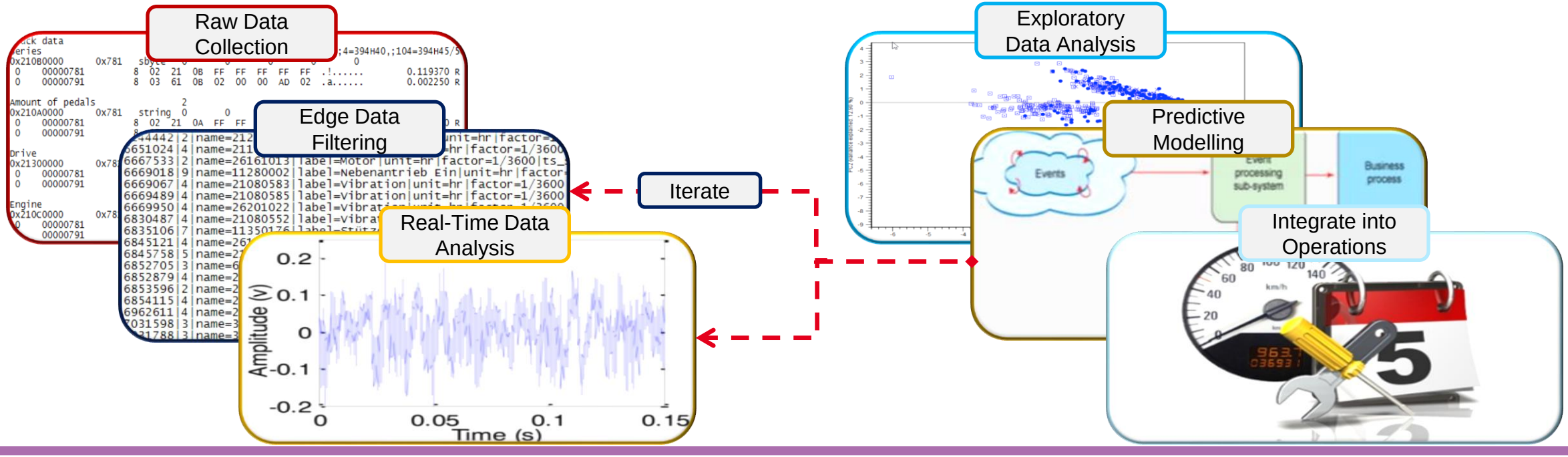
Signal Analysis

- Root Cause Analysis
- Sensor value distribution analysis
- Linear regression …

Event Analysis

- Event Tracking & Filtering
- Event Correlation
- Event Aggregations …

PREDICTIVE ENGINE



MAJOR BENEFITS FOR TVH

One-Step Maintenance
Moving from Two-Step to One-Step maintenence

Increase the availability of equipment
optimize the usage and reduce the operational cost

Improve driver safety
promote responsible driving

Empowering Equipment Maintenance
combining Human Intelligence with Machine Learning

New business model
offering Lifting Capacity as a Service

MY FINAL POINTS…

*The Internet of Things is about the transformation of physicals object into a **digital data products**. It is radically changing the way businesses operate and people interact with the physical world.*

*The benefits of Predictive Maintenance are significant. Its implementation requires more than just technological choices. It has impact on the **organizational structure and culture**.*

*New digital business models require **ecosystems** of people, businesses and technologies that must scale beyond the enterprise*

Business Innovation
through
Information Technology

Thank You

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