TECHNOLOGY ENABLED
PREDICTIVE MAINTENANCE

Kalman Tiboldi
Chief Business Innovation Officer
TYPES OF MAINTENANCE

Corrective 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

- Cracked Housing
- Loose Bolts
- Loose Bearing Housing
- Seal Problem
- Leaking Lubrication
PERIODICAL vs. CONTINUOUS OBSERVATION

40.000.000 heartbeats / year

100 heartbeats / observation

1 observation / 4 years

Probability of 1: 1.600.000 to detect a failure for the first time

Continuous monitoring
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.

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.

Remote monitoring and self optimizing

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%

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

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

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

Source: IBM – Published on Oct 27, 2016
Source: Gartner – Published on Oct 17, 2016
Source: Volvo Construction Equipment 2016
SUPPORTING TECHNOLOGIES

1st: Mechanization, water power, steam power
2nd: Mass production, assembly line, electricity
3rd: Computer and automation
4th: Cyber Physical Systems

- Augmented reality
- Mobile
- Autonomous robots
- Cloud Computing
- 3D Printing
- Internet Of Things
- Artificial intelligence
- Big & Fast data
- Big Data
- IoT
- Analytics

- Cloud Computing
- 3D Printing

1st, 2nd, 3rd, 4th Industrial Revolutions
SMART PRODUCTS

Physical Components
Mechanical and Electrical Parts

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

Connectivity Components
Ports, antennae, protocols, wired or wireless connections
CYBER-PHYSICAL WORLD

Internet of things

MERGING THE REAL AND VIRTUAL WORLDS
DESIGN – BUILD - OPERATE

Design
3D CAD twin

Simulate
First born digital twin

Monitor
Physical asset twin
CONTINUOUS ASSET MONITORING

In past 6 months, my number of cold starts is 4, my number of warm starts is 8, my number of hot starts is 39. The number of start/stop cycles has increased by 27.5%.
IMMERSION INTO THE VIRTUAL WORLD

AR / Mixed Reality Headset
- Physical world is augmented with some “virtual items”
- Real controls etc.

Traditional Simulator:
- Virtual world etc.
- Real controls etc.

VR Headset & Camera
- Virtual mach. & env.
- Real controls etc.
- Virtual world is augmented with some “physical items”

VR Headset
- Virtual mach. & env.
- Real controls (not visible) or virtual controls.

? The future?

Source: Mevea Ltd.
MAJOR BENEFITS OF THE DIGITAL TWIN

Physical Asset

Digital Twin

Ecosystems
Collaborative product development

Asset performance
Analytics-based performance optimization

New digital business model
Based on the data produced by the Twin
### How to Build Digital Twins?

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<th><strong>Integrate smart components</strong></th>
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<td>such as sensors, software, computing power, or data storage into new or existing products</td>
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<th><strong>Connect the product</strong></th>
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<td>to a central location where you can capture sensor data and enrich that sensor data with business and contextual data</td>
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<th><strong>Analyze that data</strong></th>
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<td>on an ongoing basis to identify opportunities for product improvements, new products, or even new business models.</td>
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<th><strong>Leverage these digital insights</strong></th>
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<td>to transform your company — for example, by reducing costs through proactive avoidance of business interruptions, or by creating new business opportunities</td>
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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

**Geospatial Services**
- Location Geo-fencing

**Events from the local environment**

**Customer User profile**

**Social Media**
- Customer experience

**Connected Equipment Ecosystem**

**Equipment Sensor based information**

**Service Company**
- Service and Asset Management
SMART LIFT TRUCKS

- GPS
- Engine data
- Fuel
- Temperature
- Speed & Accelerometer
- Heavy load position
- Mast & steering sensor
- Load presence
- Proximity sensor
- Mast Tilt Angle
- Tyre pressure
- Oil condition
- Battery
MAKING THE LIFT TRUCK SMARTER

Safety & Security

Weight-sensing fork blade assembly for engaging pallets in different alternative directions of approach

Usage Monitoring
Impact sensing

Sensors for Lift Trucks

Putting more intelligence on existing machines
CONNECTED TVH EQUIPMENT

IoT Endpoints

IoT Edge Gateways

Data Ingestion & Analytics

Device Control

Service Engineer

IoT Platform

Data Streaming

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 6000 connected machines
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

Data aggregation and processing **at the Edge**. Relevant data is forwarded to central site for additional processing

The **massive scale** and **highly dynamic** nature of the IoT, the huge amounts of data streamed from the physical world, and new communication patterns demand novel programming, content delivery, and network management.

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

 cải tiến thông tin

 FIX MARKET DATA

 SENSORS

 MOBILE

 REAL-TIME NEWS

 TWITTER

 BIG DATA

 TRADING

 EVENT SERVER

 2:00 PM: BUY 10K IBM

 2:01 PM: SELL 10K IBM

 POTENTIAL FRAUD

 INTERNAL EVENTS

 STREAMING ANALYTICS

 HADOOP

 ENTERPRISE

 Business Innovation through Information Technology

 TVHOL
MOVING TOWARDS ADVANCED ANALYTICS

**BI & Reporting**
- Descriptive
  - What is happening?
    - Business Reporting
    - Dashboards
    - Metrics
    - Scorecards
    - Mobile BI

**Business Analytics**
- Diagnostic
  - Why did it happen?
    - Data discovery
    - OLAP
    - Ad-hoc query
    - Location analytics
    - Basic predicative modelling

- Predictive
  - What will happen?
    - Predictive analytics
    - Support for BigData
    - Advanced data access
    - Experimentation

**Advanced Analytics**
- Prescriptive
  - What should we do?
    - Decision modelling
    - Expert systems
    - Simulation
    - Optimization
    - Innovation

**Information Portal**
- BI Specialist

**Analytics Workbench**
- Information Analyst

**Data Science Laboratory**
- Data Scientist
IoT & PREDICTIVE ANALYTICS

- Signal Analysis
  - Sensor value distribution analysis
  - Linear regression

- Event Analysis
  - Event Tracking & Filtering
  - Event Correlation
  - Event Aggregations

- Edge Data Filtering

- Real-Time Data Analysis

- Exploratory Data Analysis

- Predictive Modelling

- Integrate into Operations

- Root Cause Analysis

- Iterate
NEXT GENERATION SERVICE ENGINEERING

AUGMENTED REALITY

NATURAL LANGUAGE PROCESSING

CHAT BOTS

ADVANCED TECHNICAL SUPPORT

ARTIFICIAL INTELLIGENCE

IMAGE RECOGNITION

SMART GLOVES

COMBINING HUMAN AND ARTIFICIAL INTELLIGENCE
MAJOR BENEFITS FOR TVH

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

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
The Internet of Things is about the transformation of physical objects into 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.
Thank You