ENGINEERING TOMORROW

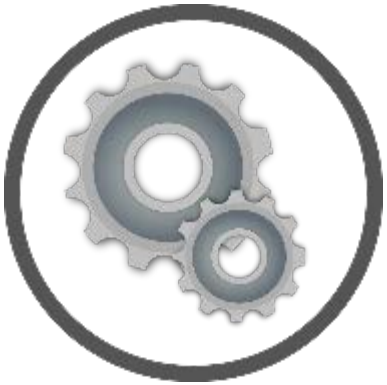
Industry 4.0

Condition monitoring & **smart sensors**

Norbert Hanigovszki

Motor Summit 2018 International
Zurich, Switzerland
15 November 2018

The fourth **industrial revolution**!



1. Mechanization

2. Electrification

3. Automation

4. Networking

Definition of Industry 4.0

- There is **no universal definition** of Industry 4.0!

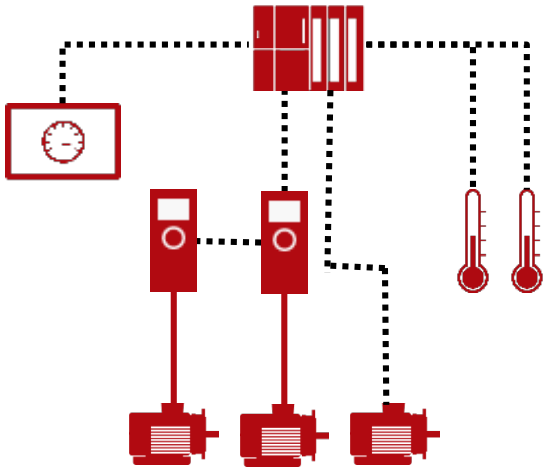
- Related terms:
  IoT: Internet of Things
  IIoT: Industrial Internet of Things

- Common **key elements**: Production, networking, digitalization

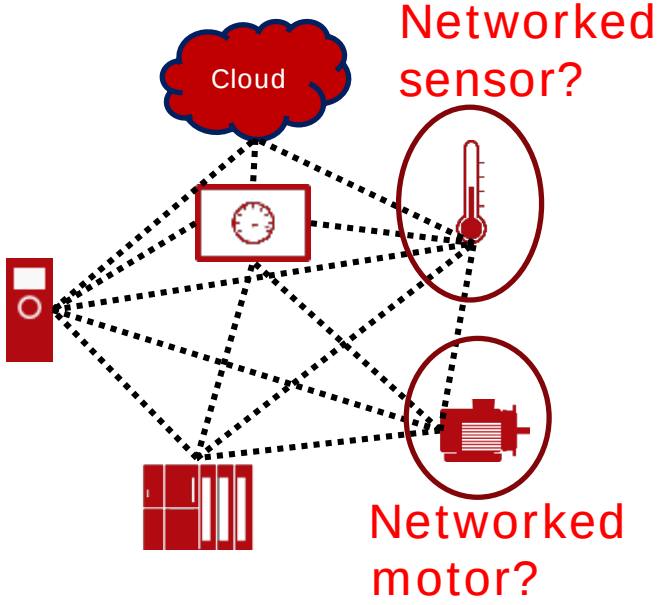
- **One of many definitions**:

  *"Industry 4.0 describes the intelligent **networking** of people, things and systems by utilizing all of the possibilities of **digitalization** across the entire **value chain**."*

What's new in I4.0 with motor systems?



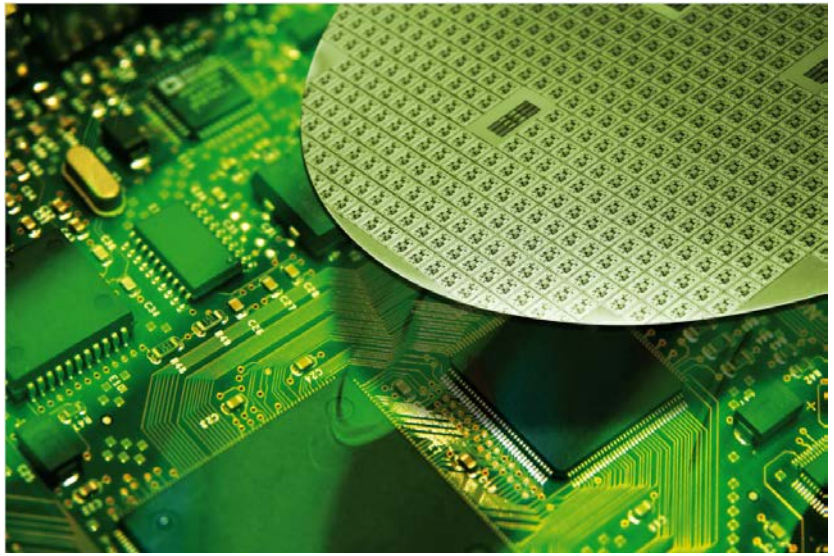
Automation pyramid



Networked systems

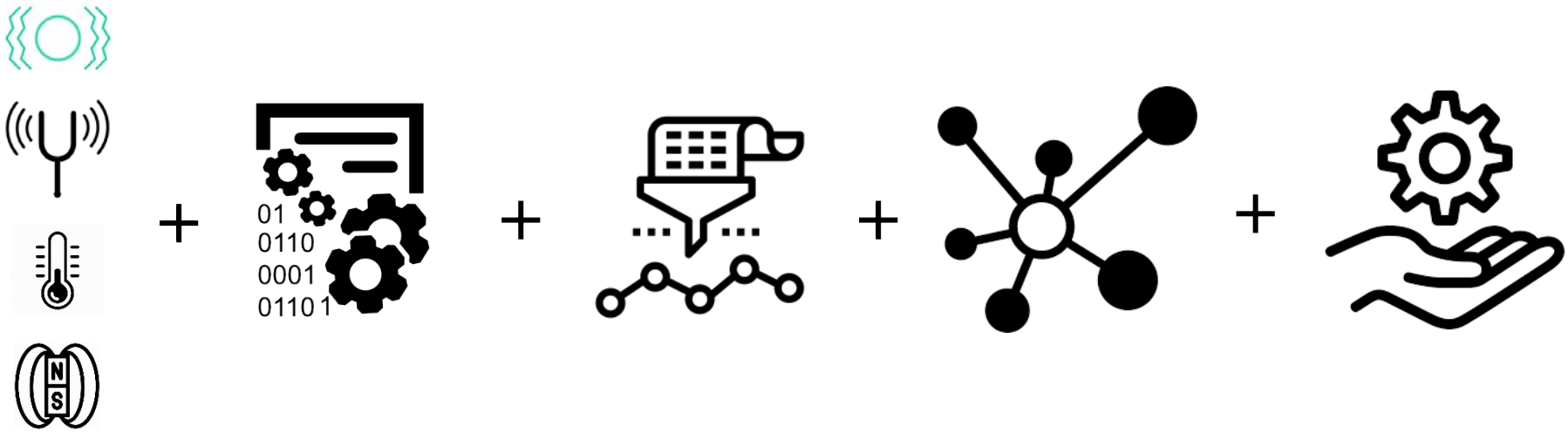
Why smart sensors?

≠



- The short explanation: motors consists of copper and steel, not silicon!
- What are smart sensors measuring?
  - Vibration (RMS or wide-band)
  - Sound
  - Temperature
  - Magnetic field
  - Pressure

What are smart sensors?



Primary sensing

Digitization and signal processing

Data analysis and representation

Connectivity (wired or wireless)

Services

- Smart sensors consist of the primary sensor (vibration, sound, temperature, magnetic field, etc.), which provides an analogue value that is digitized and processed.
- Smart sensors provide connectivity: either through wired communication (Ethernet, RS485) or wireless (Wi-Fi, Bluetooth or other)
- Smart sensors are then linked to various services

Smart sensor overview

Smart sensor	Primary sensing	Communication	Communication
 TestMotors SMS	• Vibration • Temperature • Magnetic field	• Wi-Fi	• Web based full diagnostic (electric and mechanic) dashboard • Sampling every 20 minutes
 FAG SmartCheck	• Vibration • Temperature	• Ethernet • (RS485)	• Analytics embedded in the sensor • Large database of bearings • Remote support from bearing specialits
 ABB Ability	• Vibration • Temperature • Magnetic field	• Bluetooth low energy	• Proprietary ABB Ability platform
 Siemens Simotics IQ	• Vibration • Temperature • Magnetic field	• Wi-Fi	• Connection to Mindsphere open IoT operating system
 WEG Motor Scan	• Vibration • Temperature	• Bluetooth	• WEG IoT platform
 Augury Halo	• Vibration/acoustic and ultrasonic • Magnetic field • Temperature	• Wi-Fi	• Cloud based learning system • Integration with 3rd party systems and CMMS: IBM Maximo, Fluke e-Maint, etc.

New **maintenance models**

CORRECTIVE MAINTENANCE
The component is changed after it fails.

PREVENTIVE MAINTENANCE
The component is changed before it fails, without any notification from the product.

CONDITION BASED MAINTENANCE
The product provides a warning if the component lifetime estimation varies from the normal lifetime and indicates possible root causes.

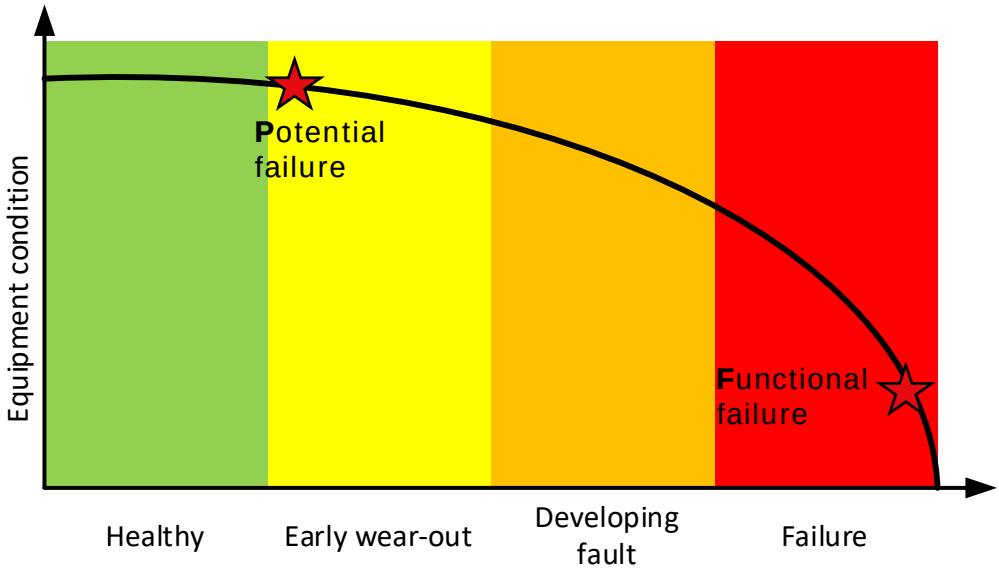
PREDICTIVE MAINTENANCE
The product provides a warning before the component's designed hours of operation are reached and this initiates the service action.

3. Automation

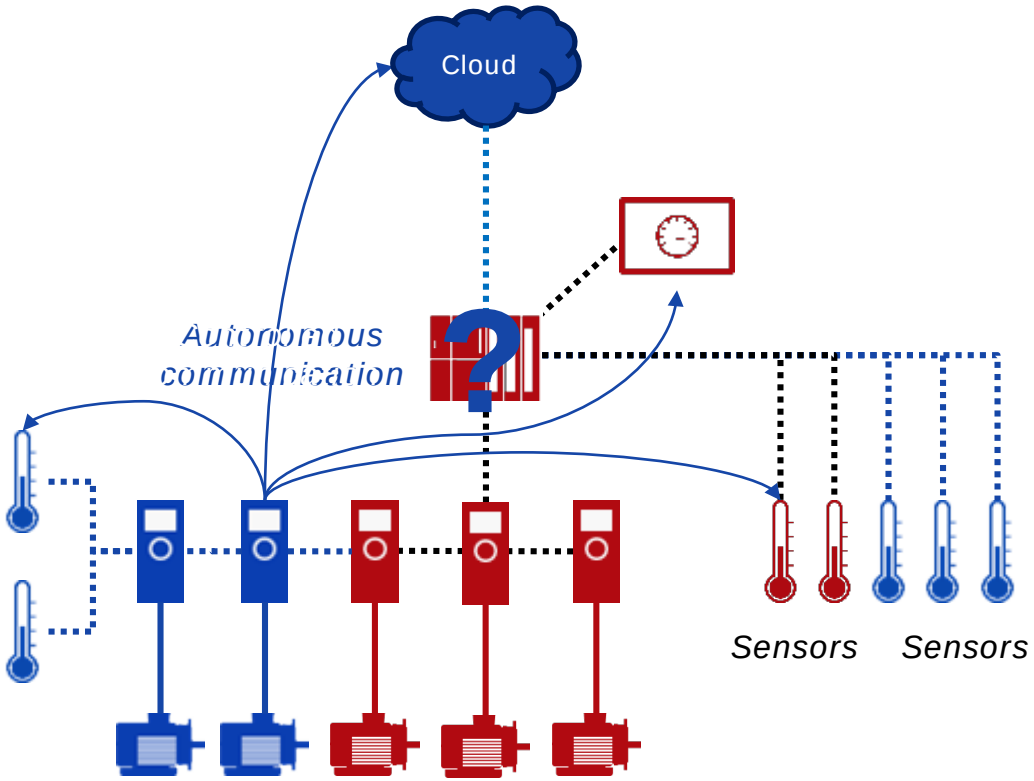
4. Networking

Condition monitoring - the right information at the right time

- Condition monitoring detects faults at an early stage
- Optimize use of resources and enables advance planning
- Reduce cost of unexpected downtime
- Reduce total cost of ownership
- Reduce stock of spare parts

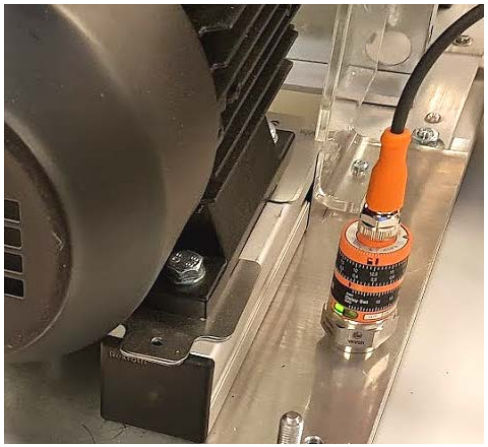


What's new in I4.0 with drives?



- More computational power in
  - Clouds,
  - local control systems
  - and field devices.
- More extensive data analyses
  - in a shorter time
  - for more devices.
- More intense communication
  - at all levels,
  - including between each other without control.

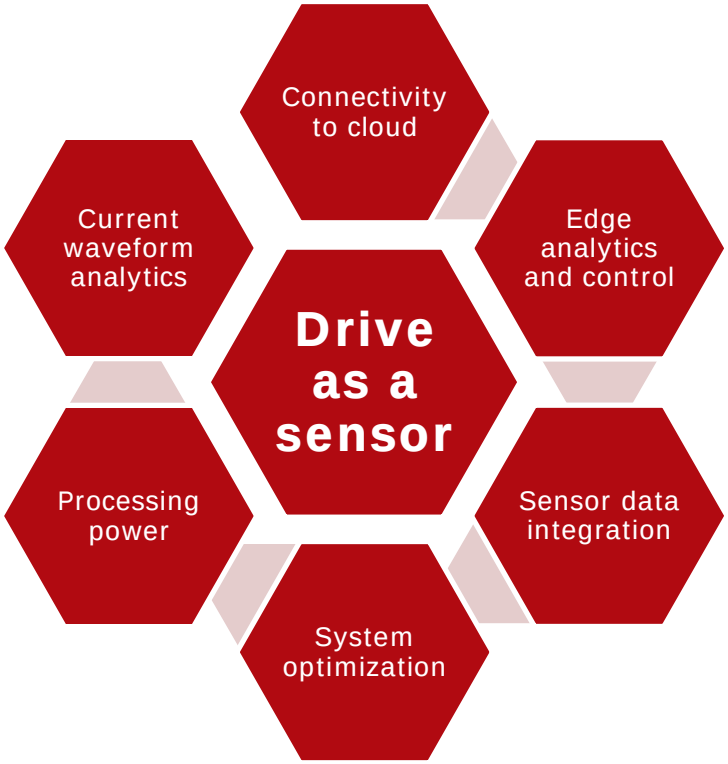
Integration of external sensors with the drive



- Vibration sensor
- Air pressure sensor/ water pressure sensor
- Temperature sensor

- Why connect sensors to the drive?
  - Correlation of measurement data with speed and load
  - Use drive as a “already available” gateway
  - Use drive for signal processing and analytics

The drive is the best single sensor into industrial processes



- The current and voltage sensors in a drive give huge amount of highly real time data
- Due to the amont of data it must be filtered and processed locally
- Data gives insight into the behavior of the industrial process and enables system wide optimization
- This can be exposed as services and analytics data
- These functionalities is continuosly being added to our products

Drive as a sensor

Instant signals

- Raw signals: current, voltage, drive temperature
- Estimated signals: power, torque, speed, …
- Controller signals: speed reference, current reference, …

Processed signals and features

- Frequency spectrum
- Amplitude of specific frequency components
- Statistical characteristic: min, max, mean, standard deviation, …
- Mission profile values, cycle counting

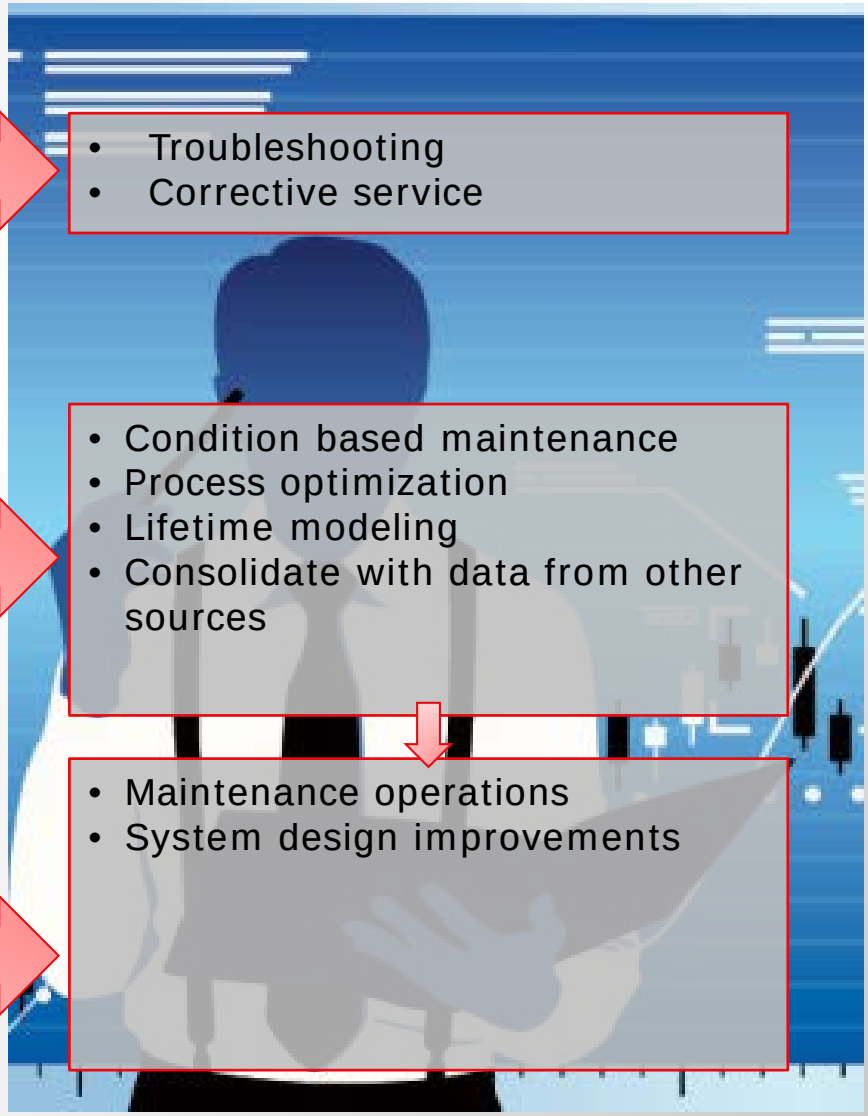
Analytics

- Predictive & preventive maintenance (component lifetime, fault information)
- Condition-based maintenance
- Baseline information
- Machine-learning algorithms

Flight recorder data

Continuous compressed data

Fault/ maintenance data



Use case example

- Condition monitoring has an impact on energy efficiency
- Deterioration of the performance of motor driven equipment means often an increase of losses
- Examples of conditions that lead to increased losses: insufficient lubrication, clogged air filters, fouled pumps and pipes, wear-out of gears, etc.
- What sense does it make to buy the most efficient components if maintenance is neglected?

Increase of motor torque due to bearing damage during an accelerated motor lifetime test

ENGINEERING
TOMORROW

Norbert Hanigovszki, project director
Danfoss Drives
Ulsnaes 1, Graasten DK-6300,
Denmark
norbert@danfoss.com