



## Industrie 4.0

Digitalization in Manufacturing, Smart Devices and Data Mining on the Shop Floor

University of Sao Paulo

August 12<sup>th</sup>, 2016

Dr.-Ing. Eike Permin

Philipp von Cube, MBA

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## Joseph von Fraunhofer (1787-1826)

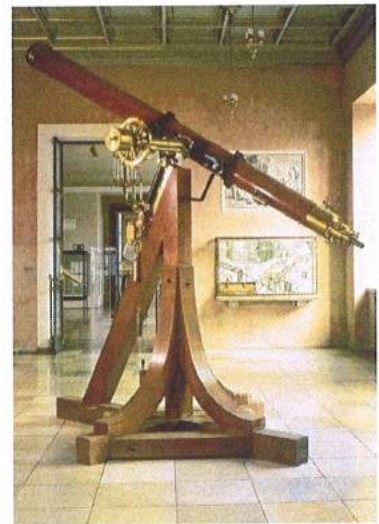
### Researcher

Discovery of the "Fraunhofer lines" in the solar spectrum



### Inventor

New methods for processing lenses



### Entrepreneur

Director and partner in a glassworks

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# The Fraunhofer-Gesellschaft



## Target

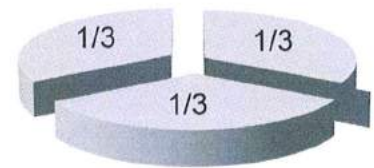
- Contract research for industry and society
- Transfer of results to industrial applications

## Organisation

- Founded in 1949
- Legal status as non-profit organisation
- Headquarters in Munich

## Budget Funding of the Fraunhofer Institutes

- Basic funding by federal state
- Funding via public projects
- Funding via industrial projects



# The Fraunhofer-Gesellschaft Institutes and Locations



## Key Figures

- 67 Institutes and research establishments
- > 23,000 employees
- ca. € 2 billion annual research budget

→ Europe's largest organization for applied research

## Activities and presence worldwide

- **Europe**  
Austria, Italy, Portugal, United-Kingdom, France, Greece, Poland, Hungary, Sweden
- **Americas**  
Canada, USA, Brazil, Chile
- **Asia**  
China, Indonesia, Japan, Korea, India, Malaysia, Singapore, Thailand
- **Australia**
- **Middle East, Africa**  
United Arab Emirates, Egypt, South-Africa

# Production Technology in Aachen



- Founded in 1870
- 42,298 students, 5,915 graduates
- 9 faculties, 260 institutes
- 4,745 researchers, 512 professors
- € 894 million Budget  
(thereof € 354 million external funding)

### Faculty of Mechanical Engineering

- 11,727 students, 2000 new immatriculations
- 1704 graduates, 169 professors
- 1,136 researchers, 63 professors
- € 311 million budget,  
thereof € 95 million external funding via  
Fraunhofer Institutes and others

### Focus Production Technology



- **Laboratory for Machine Tools and Production Engineering**      total budget € 49 million
- **Fraunhofer Institute for Production Technology IPT**      1200 employees\*

\*) thereof approx. 50% students

## Two Institutes – one Philosophy Comprehensive Solutions for Production



### Fraunhofer IPT





- Process Technology
- Production Machines
- Production Quality and Metrology
- Technology Management

### WZL of RWTH Aachen University

- Production Technology
- Gear Technology
- Machine Tools
- Assembly Systems
- Metrology and Quality Management
- Production Systems
- Production Management

# Competence Overview

## Departments at the Fraunhofer IPT

Process Technology	Production Machines	Production Quality and Metrology	Technology Management
			
<h3>Technology Development</h3> <ul style="list-style-type: none"> <li>Fine-machining and Optics</li> <li>High Performance Cutting</li> <li>Laser Material Processing</li> <li>CAX-Technologies</li> <li>Precision and Special Purpose Machines</li> <li>Fiber-reinforced Plastics and Laser System Technology</li> <li>Production Metrology</li> </ul>			
<h3>Management Methodologies</h3> <ul style="list-style-type: none"> <li>Production Quality</li> <li>Strategic and operative Technology Management</li> </ul>			

# Competence Overview

## Departments at the Fraunhofer IPT

Process Technology	Production Machines	Production Quality	Technology Management
			
<h3>Production Quality</h3> <div style="display: flex; justify-content: space-between;"> <div style="width: 40%;">  <p>Eike Permin Head of Department</p>  <p>Production Efficiency Laura Niendorf</p>  <p>Production Intelligence Philipp von Cube</p> </div> <div style="width: 55%;"> <ul style="list-style-type: none"> <li>Production Organization in "Industrie 4.0"</li> <li>Software Systems for Production Control and Quality Assurance</li> <li>Information Management &amp; Data Analytics</li> <li>Workplace of the Future</li> </ul> </div> </div>			

# Why is all of Germany speaking about “Industrie 4.0”?

## 2005 – Election of Pope Benedikt XVI.



Quelle: [KAGE11] Bildquellen: spiegel.de, AP, DPA

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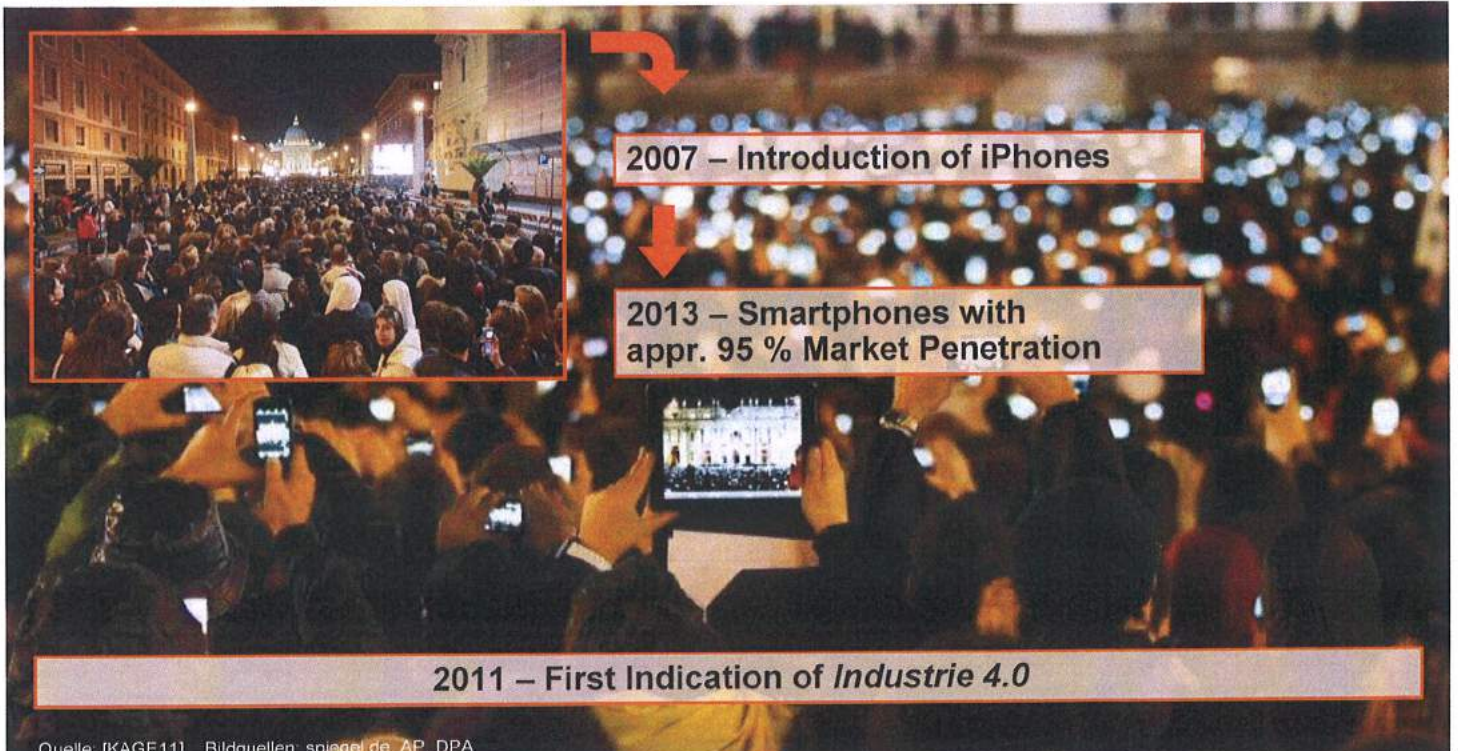
## 2013 – Election of the Pope Franziskus



Quelle: [KAGE11] Bildquellen: spiegel.de, AP, DPA

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## 2013 – Election of the Pope Franziskus



Quelle: [KAGE11] Bildquellen: spiegel.de, AP, DPA

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# The Internet of People



Internet of people

- 2014 appr. 3 Billion Users
- Collaborative Interaction between People
- Usually Social Networks for free!
- Turn Over 2014 of Social Networks in Germany appr. 2,2 Billion Euro

Peoples Data

Quelle: [STAT15a, STAT15b, ACAT13, LEIS10] Bildquelle: apple.com, trash-media.co.uk

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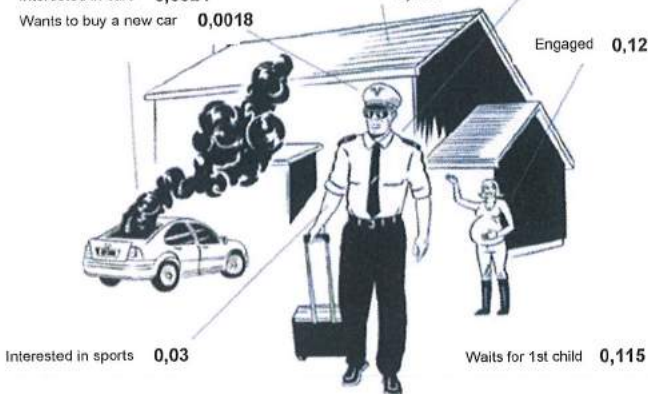


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## What is the value of data?

### Person 1: Pilot, 35

Male from Düsseldorf, 35 0,007  
 Pilot, 35 0,072  
 Interested in cars 0,0021  
 Wants to buy a new car 0,0018  
 Owns a house 0,105  
 Wants to move 0,085  
 Has back problems 0,26  
 Engaged 0,12



Value: 0,7979 Dollar

### Person 2: Overweight with 2 children

Has diabetes 0,26  
 High blood pressure 0,26  
 And overweight 0,26  
 Likes cruises 0,03

Male from Stuttgart 0,0021  
 Engineer 0,076  
 Just divorced 0,010  
 Has 2 children 0,005  
 Owns a house 0,105  
 Interested in food and finances 0,0013  
 0,001



Value: 1,1203 Dollar

Source: Brand Eins, Financial Times

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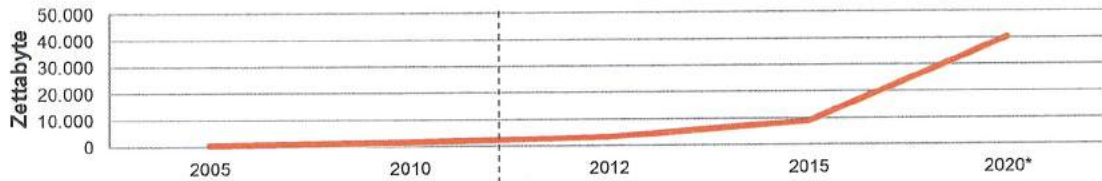


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# BIG DATA in Manufacturing?

More input by datification and digitalization

Data volume (world)



Data volume in *Manufacturing*  
→ 2 % of the data volume world wide



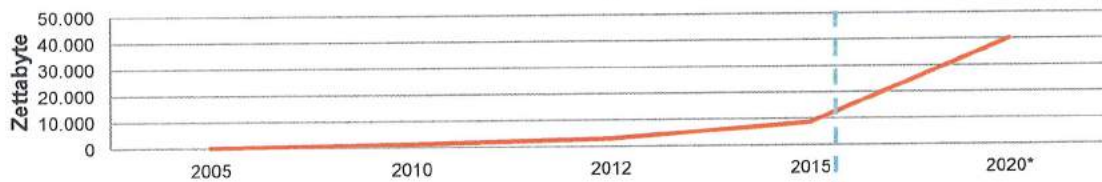
sources: Mc Kinsey 2011, Statista 2016, EMC 2014

**Informatisation and datification are increasing the amount of available data from manufacturing by large scores.**

# BIG DATA

More input by datification and digitalization

Data volume (world)



Enterprise Resource Planning		Manufacturing Execution		Computer Aided Quality	
Usage (manufacturing)	98 %	Usage	34 %	Separate system	30 %
ERP in produktion	89,1 %	Soon to be introduced	26 %	DIY-solution	26 %
Usage of a QA-module	56,6 %	QA-functionality	80 %	MS Office	24 %
Ø age (2011)	7,4 Jahre			Paper	20 %

sources: Konradin 2011, Gottwald 2015, statista 2015, Sontow 2013, Linß 2008, Stiller 2015

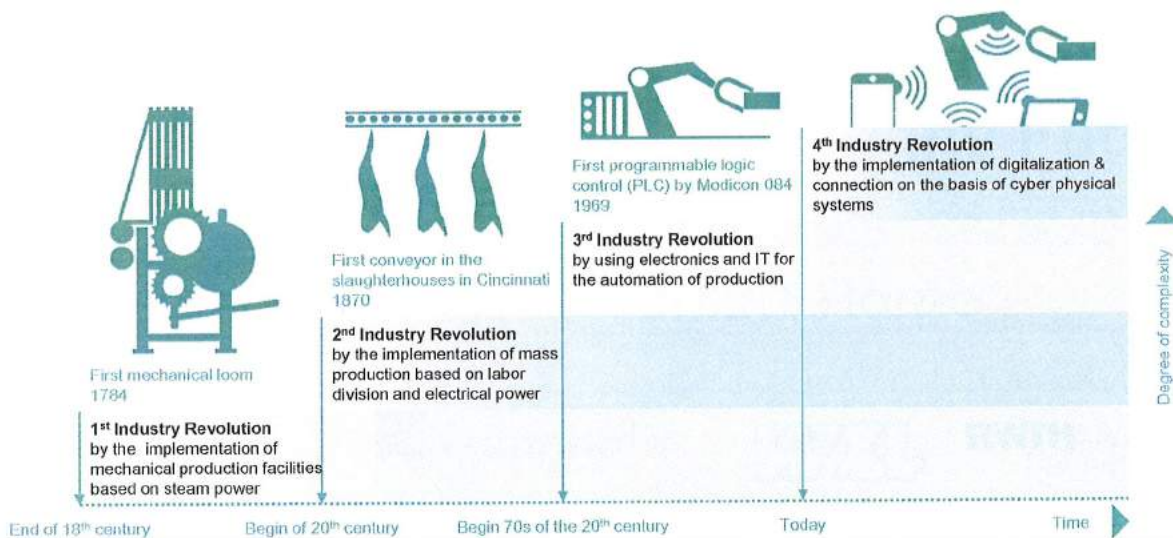
**The necessary data are already available today for most companies. Putting them to proper use is the largest problem.**



Many buzzwords, similar meaning

Industrial Internet  
 Cyber-Physical Systems  
 Smart Services  
 Internet of Services  
 Smart Production  
 Internet of Things  
 Industrie 4.0  
 Digitalization  
 Factories of the Future  
 Smart Cities Smart Products  
 Smart Manufacturing  
 Smart Factory Smart Home

...and is still production oriented



One definition of Industry 4.0

Industry 4.0 is the area-wide entrance of information and communication technology and their interconnection to an *internet of things* which allows a real-time capability in production.

## The “digital maturity level” in several sectors is different



There is a big growth potential in **digitalization & connection** for machine and tools.

## Industrie 4.0 – the digitalization of manufacturing – is a global trend

**Bringing digital innovation to the physical world**

Start-ups for the Internet of Things and a renaissance of manufacturing

**Pragmatic adoption of potentials and long-term strategy**

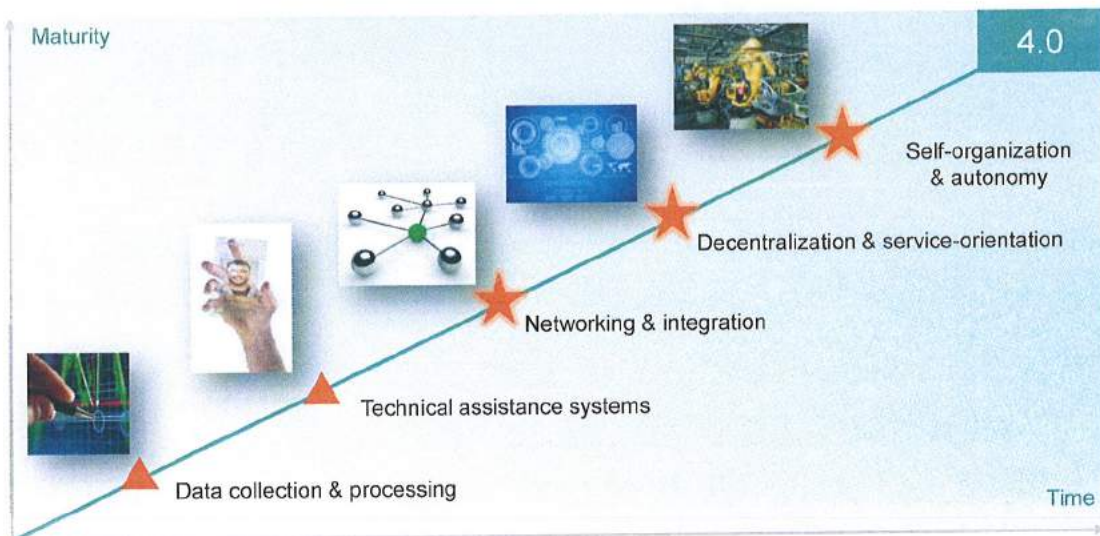
Use of existing technologies and strategic development of selected key technologies

Why is all of Germany speaking about "Industrie 4.0"?

# What are the next technologies and enablers for a change?

## Introduction

The 4.0 vision can be reached step by step



Most of the manufacturing companies are working at the first two steps...

Source: BMBF – Umsetzungsempfehlungen für das Zukunftsprojekt Industrie 4.0

# Overview – Smart Devices

## Smart Glasses and Tablets

### Smart Glasses



Technological Maturity



- Smart glasses enable manufacturing workforce to receive information and alerts from enterprise networks while remaining hands-on with their work
- Many new devices in "pipeline" from producers with both better hardware and software.
- Field of application: display of information, communication with peers, or to gather information about orders for example via scanning of RFID chips
- Price ~ [200 US\$ - 1500 US\$] for the majority of available smart glasses

- Handling of complex applications due to touch display enabling to control processes
- As a mature technology already a rich and versatile software portfolio to choose from making it a very good starting point to use smart devices in the production
- User have experience with the technology
- Price ~ [200 US\$ – 900 US\$] for three majority of available smartphones and tablets

### Smartphone & Tablet PC

Technological Maturity



# Overview – Smart Devices

## Smart Watches

### Smart Watches



Technological Maturity



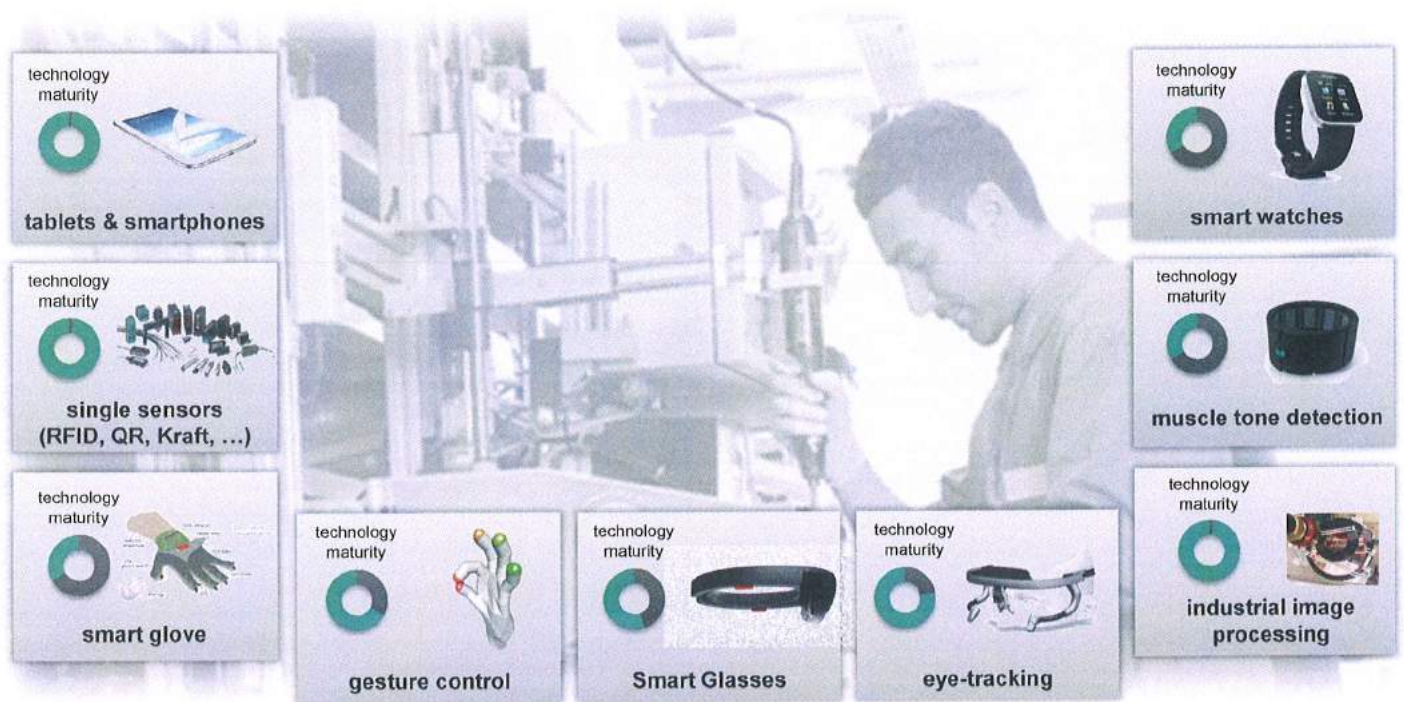
- Usually as an extension for the smartphone in current versions
- Receive important alerts or notifications on the factory floor or make phone calls without hands
- Monitor working conditions to warn if critical threshold values for example for noise gets exceeded
- Warn employee to pause work if necessary to prevent failures
- Price ~ [150 US\$ - 500 US\$] for the majority of available smart watches

Adoption rate of wearables parallels that of tablets.



# production workplace of the future

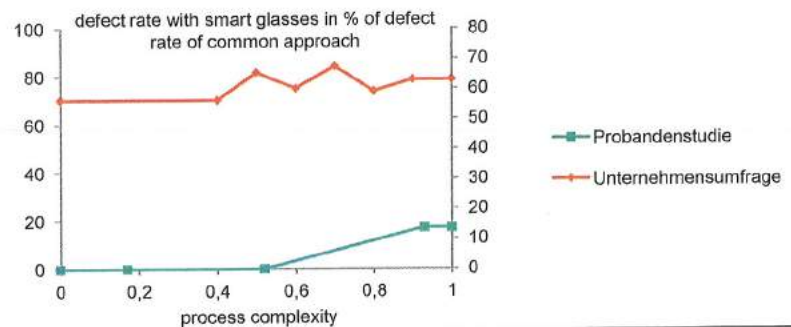
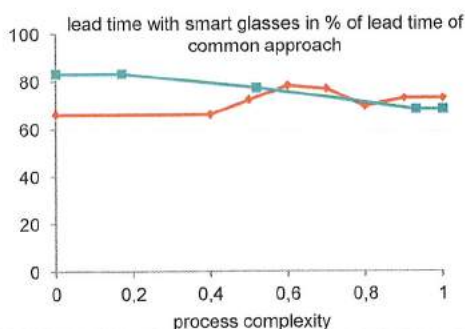
## Smart Devices



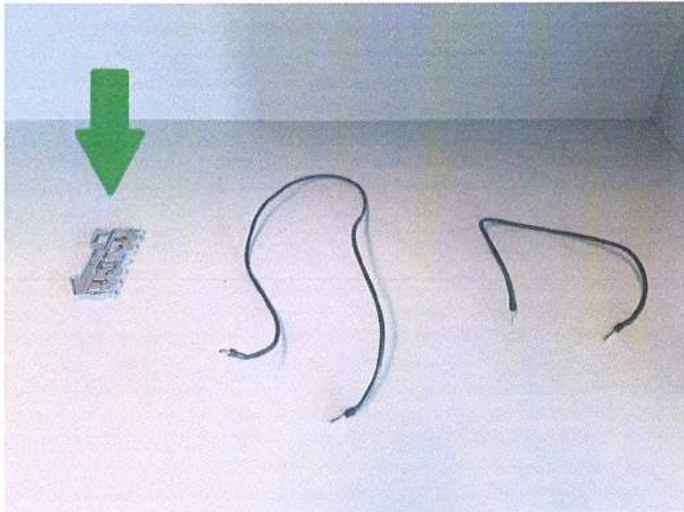
## empirical results of immediate effects on process quality



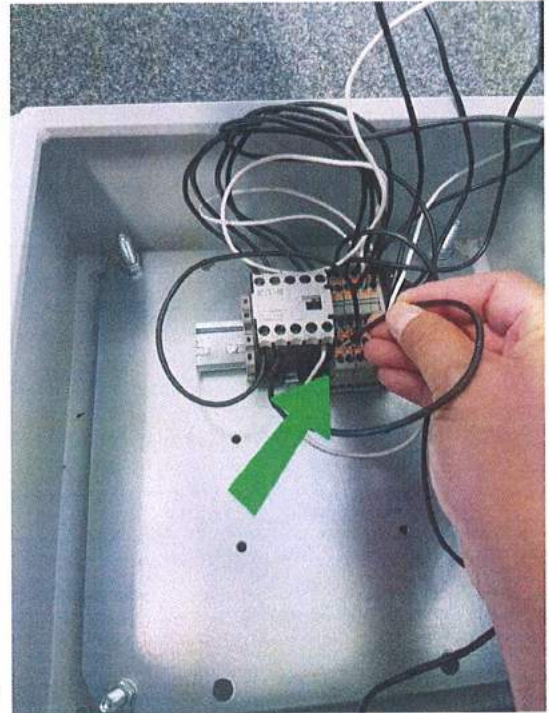
- test group studies, with n=44 persons mounting cabinets of three different degrees of complexity (examination of 3 degrees of complexity depending on the quantity of parts, tools and task)
- group A assembles paper based (static information visualization by text and figures)
- group B assembles supported by smart glasses (dynamic information visualization by text, figures, videos, and 3D-models)



## „OK glass, show image“






*Pick assistance*

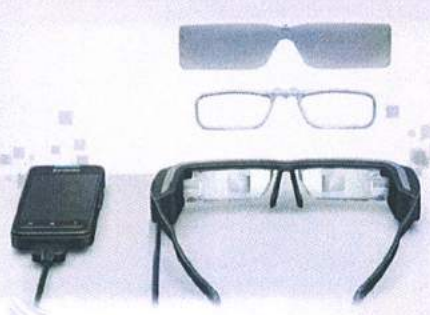


*Assembly assistance*

## Application of Smart Devices

Ultra-fast and hands-free information provision and collection of information on the shop-floor...

Logistics	Assembly and quality	Maintenance
Order confirmation Picking lists Driving ways Inventory taking ...	Working plans Test plans Failure reports Feedbacks ...	Remote maintenance Failure search Documentation Putting into service ...
		
Demo projects in: Logistic companies	Demo projects in Turbomachinery & Automotive	Demo projects in Machine Tool Making



Effects of Smart Glasses

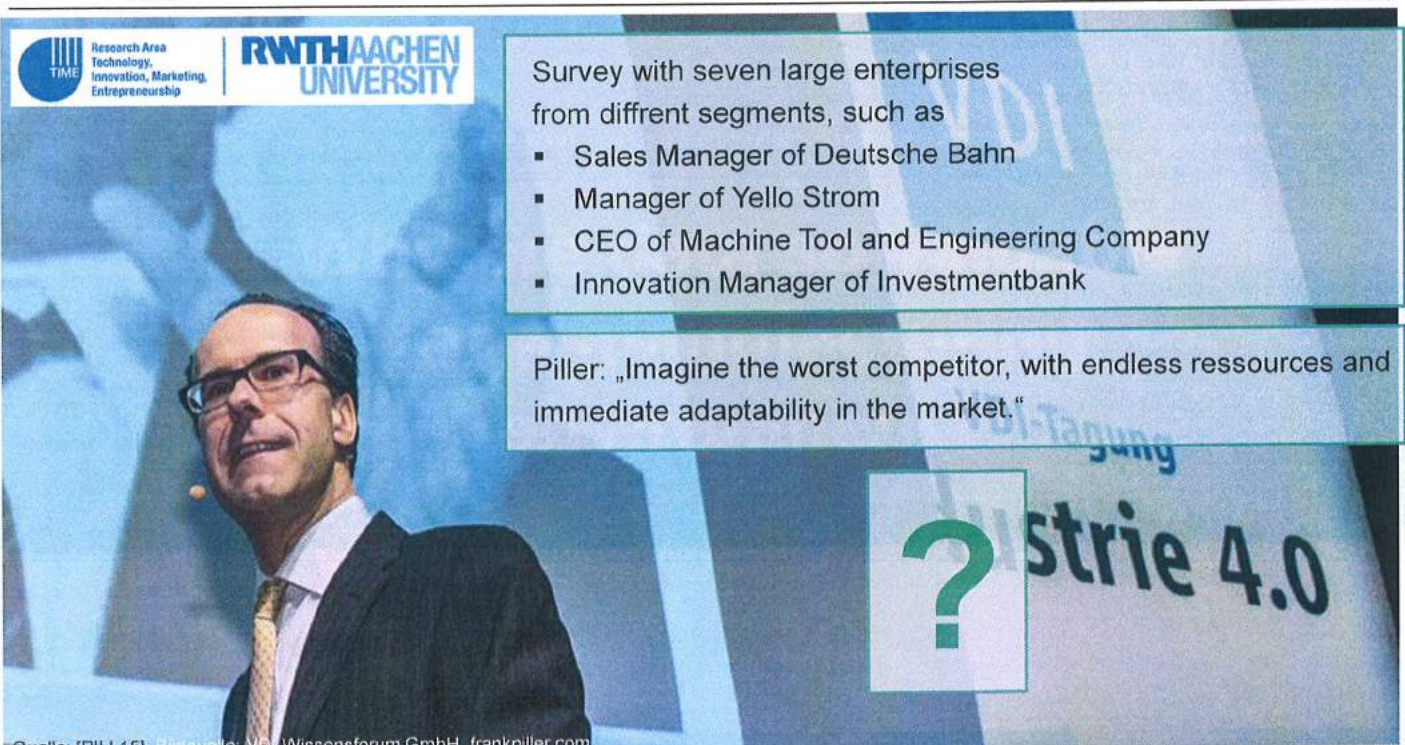
- Cycle time reduction
- Failure reduction
- Failure reaction time reduction
- Faster learning curves
- Adaptive information provision

Why is all of Germany speaking about "Industrie 4.0"?

What are the next technologies and enablers for a change?

Why are data so valuable for a manufacturing environment?

## The biggest Threat?



Research Area  
TIME  
Technology,  
Innovation, Marketing,  
Entrepreneurship

RWTHAACHEN  
UNIVERSITY

Survey with seven large enterprises from different segments, such as


- Sales Manager of Deutsche Bahn
- Manager of Yello Strom
- CEO of Machine Tool and Engineering Company
- Innovation Manager of Investmentbank

Piller: „Imagine the worst competitor, with endless resources and immediate adaptability in the market.“


Industrie 4.0


Quelle: [PILL15], Bildquelle: VD Wissensforum GmbH, frankpiller.com

# The biggest Threat?



Research Area  
Technology,  
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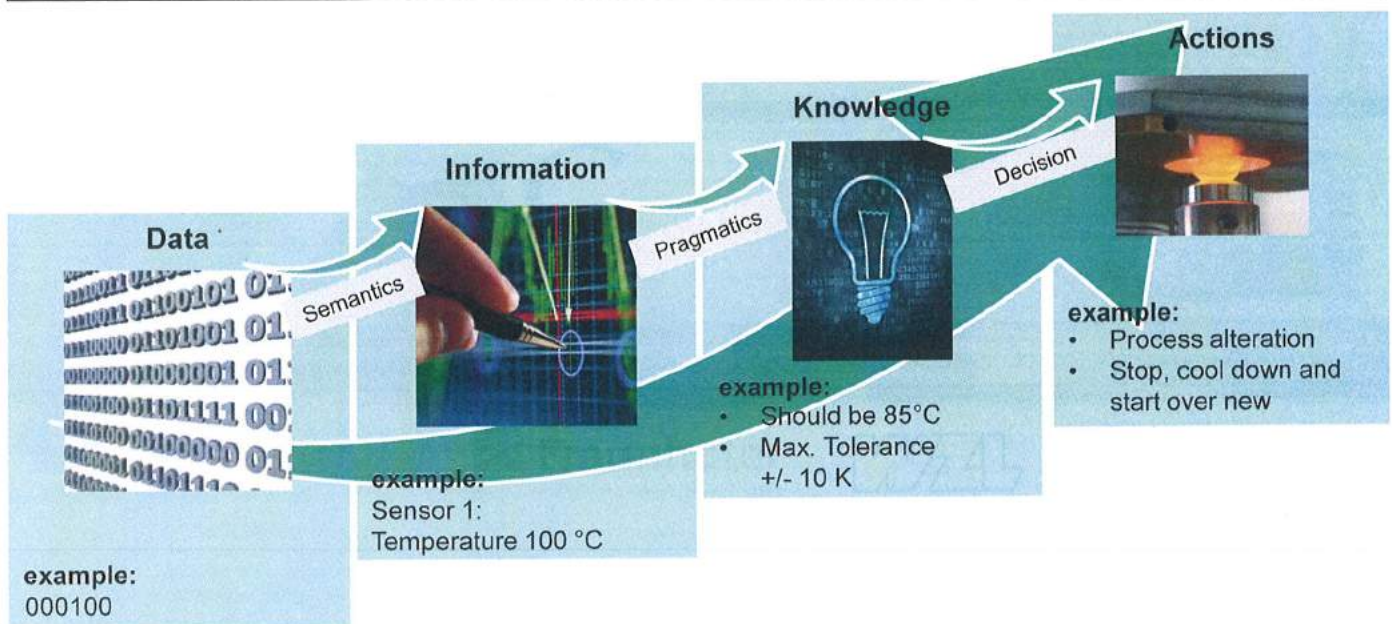




Quelle: [PILL15], Bildquelle: MD Wissensforum GmbH, frankpiller.com

# The goal of data analytics

From datification to the creation of information to knowledge



Industrie 4.0 is heavily based on the direct and quick connection of knowledge, originating in the usage of data and information.



# Value creation

## value and usage of big data in production

When can Big Data Analytics create value?  
 → Processes with large number of dependencies and potentials for losses



# DAIMLER

Reduction of waste

Predictive Maintenance

Prediction of resource consumption

„...causal dependencies in systems are no longer a way of knowledge protection in a big data world [...]

We've come to realize that by using algorithms and IT performance, causality can very often be replaced correlation and still lead to some convincing results...“



Dr.-Ing. Heinrich Hiesinger  
 CEO  
 thyssenkrupp AG  
 Jan 2016

ThyssenKrupp

sources: IBM 2014, Lee 2014, Shin 2014, faz.net| Bildquelle: ersatzteile-autoteile.de, Daimler, IBM, faz.net

## Data Mining Models

### Scrap reduction in a light metal foundry



Scrap / Week

Production vol.:  
 7,256 crankcases

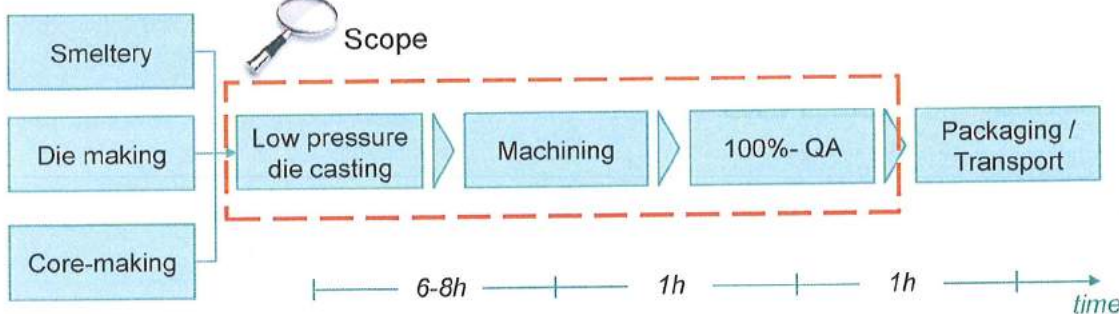
No defects	93,1%
Sprue defects	4,7%
Other defects	2,2%

1 Goal



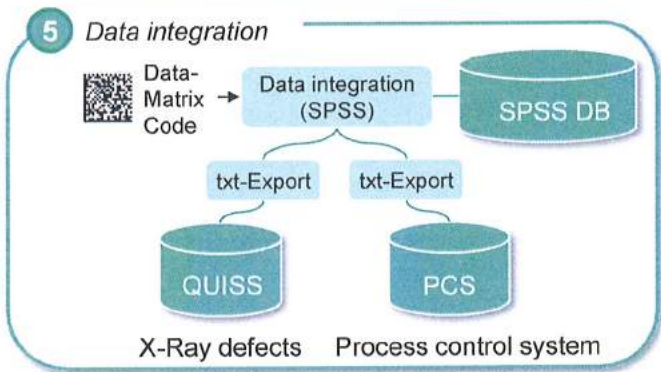
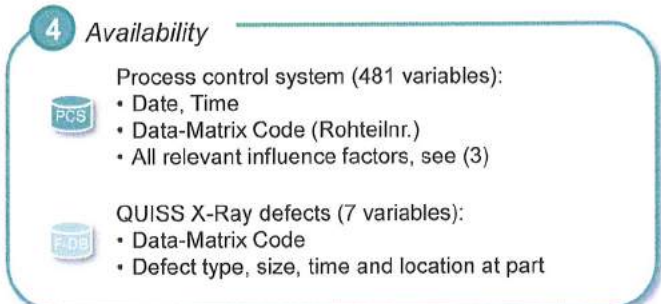
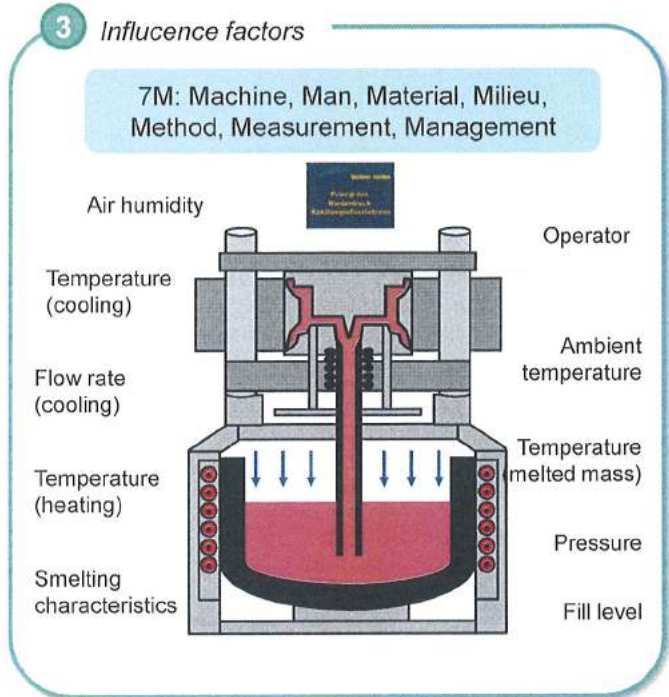
Reduction of sprue defects  
 • Rules for process parameters

2 Production process



# Data Mining Models

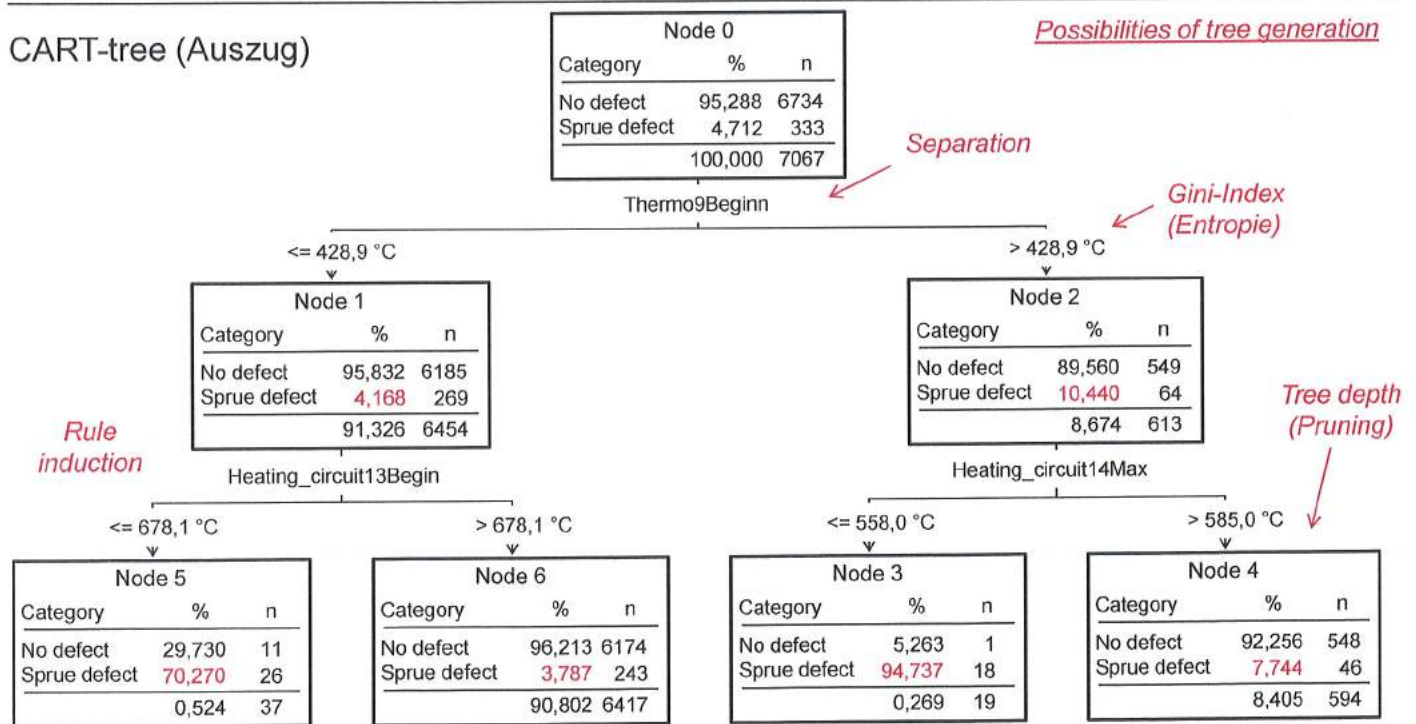
## Scrap reduction in a light metal foundry



# Data Mining Models

## Scrap reduction in a light metal foundry

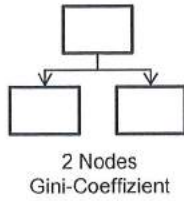
### CART-tree (Auszug)



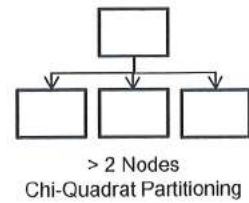
# Data Mining Models

## Scrap reduction in a light metal foundry

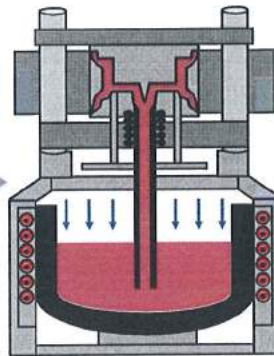
CART-Baum



Chaid-Baum



Rules for parameters

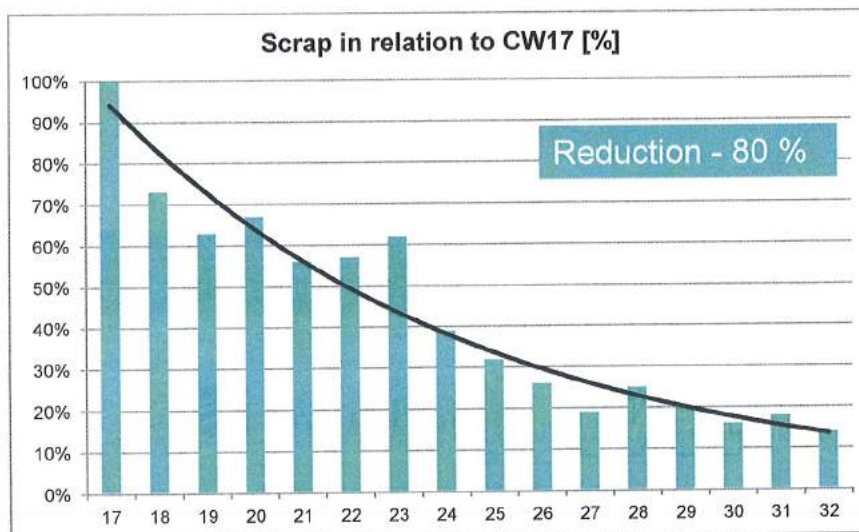


### 7 Anchoring of procedure:

- Regular checks (e.g. new or repaired dies are used)
- Change of process parameters

## Result:

### Scrap reduction in a light metal foundry



Data Mining Models can be a tool to reduce scrap rates in complex manufacturing processes.

Source: Dörman Osuna, H.W.: Ansatz für ein prozessintegriertes Qualitätsregelungssystem für nicht stabile Prozesse.

## Data Mining can be applied to different applications...



Gear manufacturing



Assembly



Hot rolling



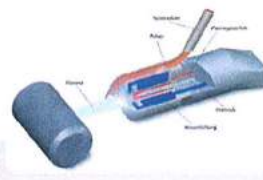
Turning



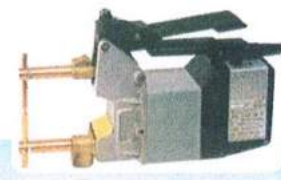
Wafer production



Glass moulding



Plasma coating



Welding

Why is all of Germany  
speaking about  
"Industrie 4.0"?

What are the next  
technologies and  
enablers for a  
change?

Where does all of  
this lead to?

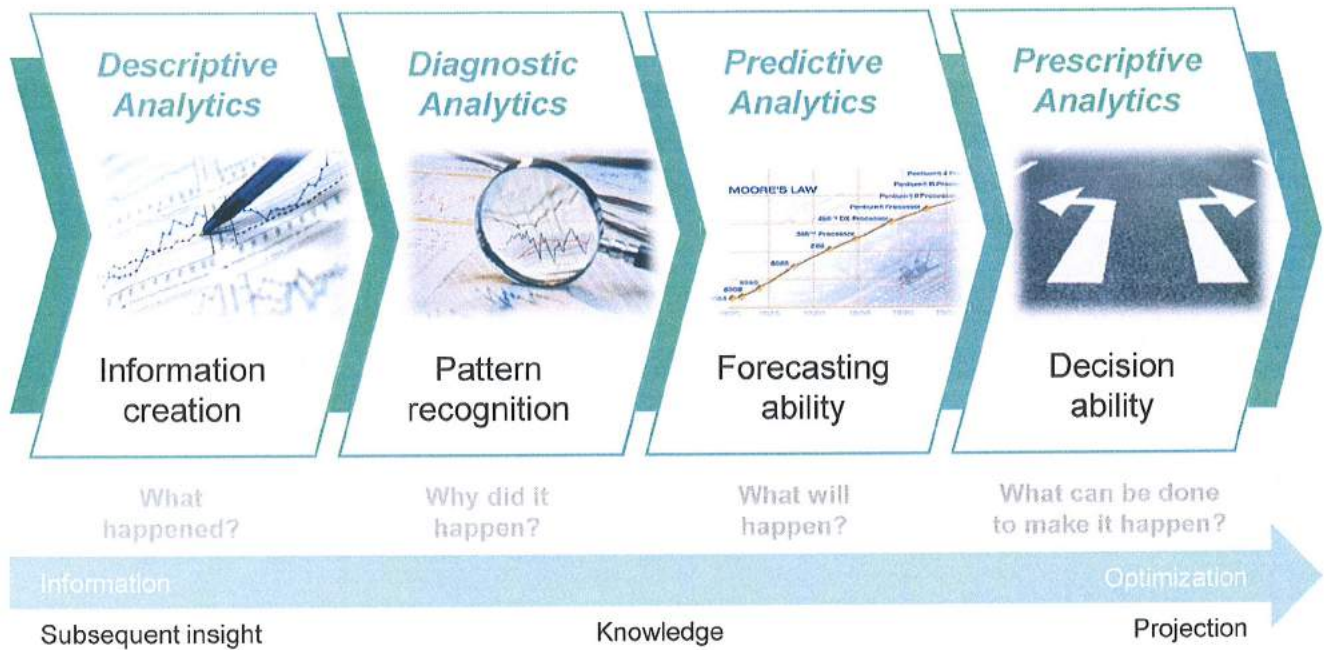
Why are data so valuable for  
a manufacturing  
environment?

# Scalable adaptive Production

## Steps of Data Analytics



The improvement of predictive and decision ability requires the processing of big data:

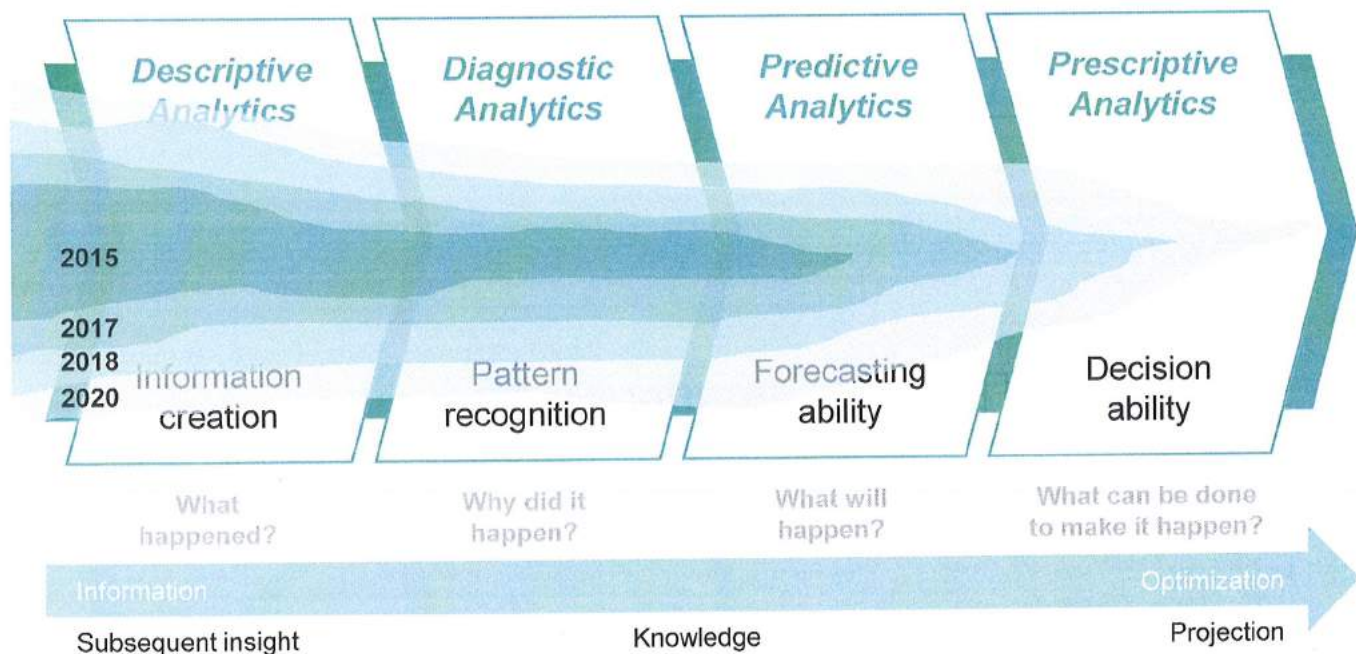
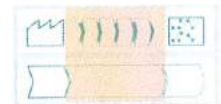


Source: FIR

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# Scalable adaptive Production

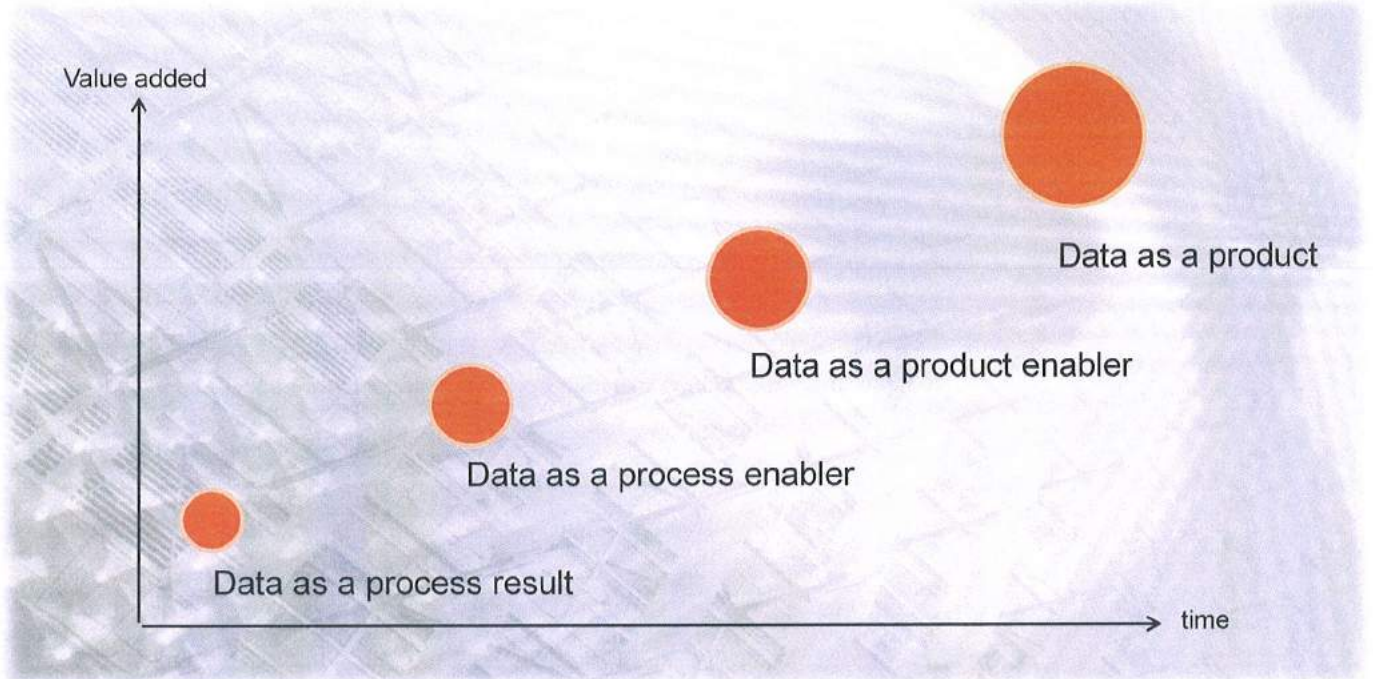
## The penetration of data analytics is a successive process



Source: FIR

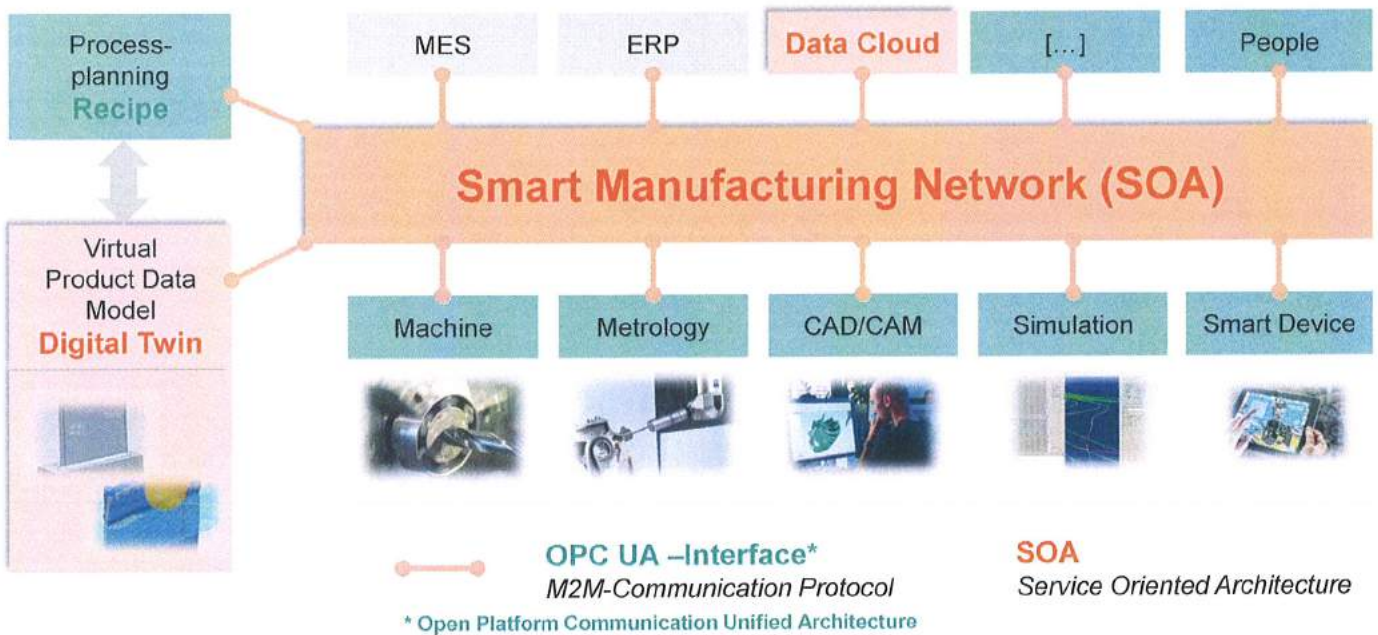
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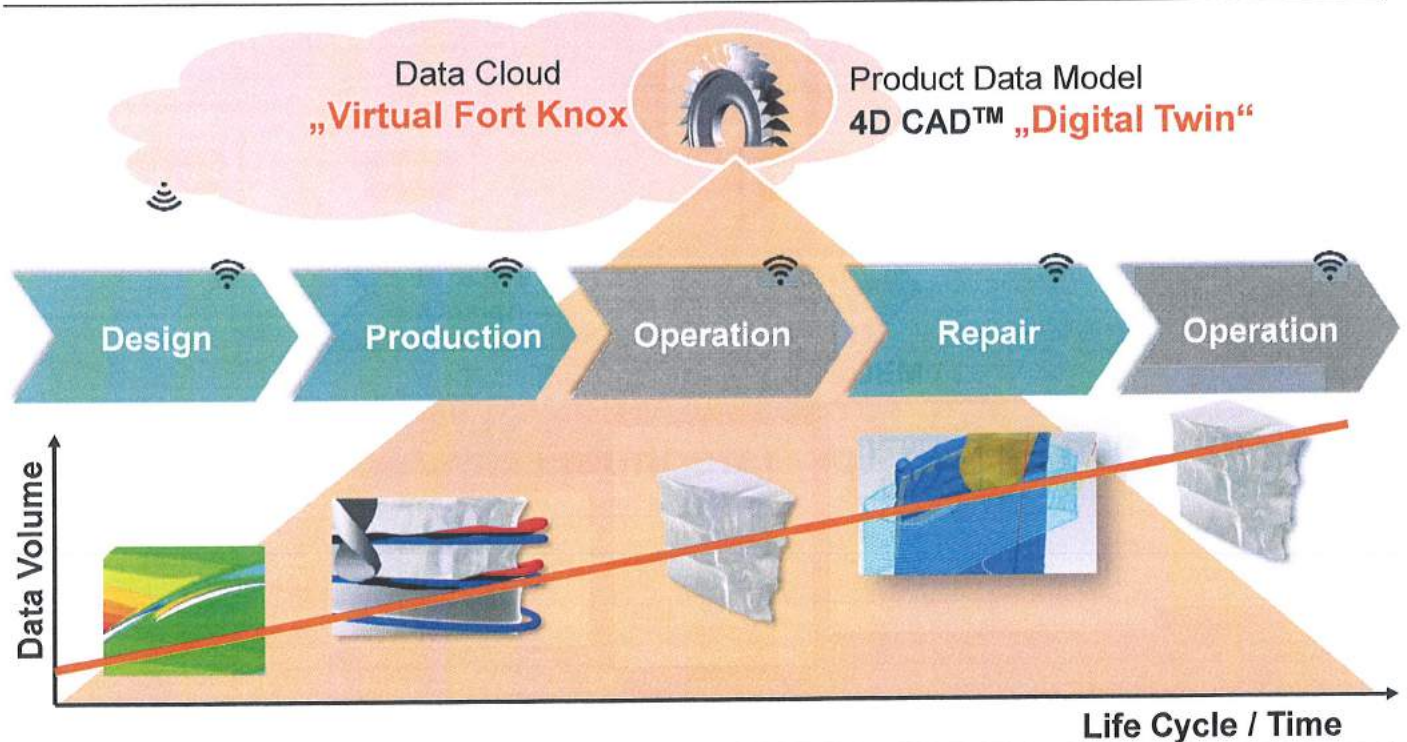
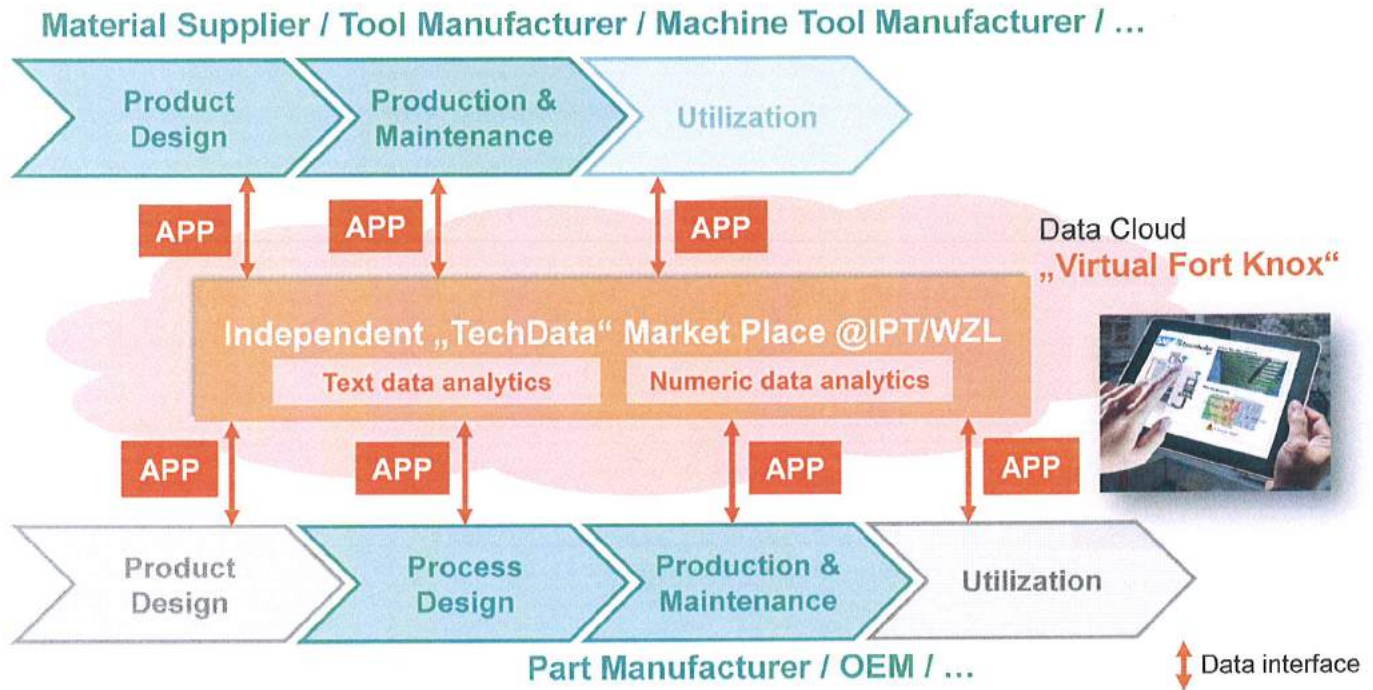
# Data will be strategical resource for companies in the future



## Industrie 4.0

### Selfadaptive Process Chains - „Smart Manufacturing Network“





# Open Research Platform for Industry – „Fraunhofer Leistungszentrum“



Validation of I4.0 solutions



Pilotlines for advanced component manufacturing

## ■ Goal

Increase of productivity and enhanced flexibility for advanced part manufacturing by networking and digitalization of production facilities

## ■ Budget

6.4 M€ for 30 months  
(40% NRW, 40% Industry, 20% Fraunhofer)

## ■ Participating Fraunhofer-Institutes

- Institute for Production Technology IPT
- Institute for Lasertechnology ILT
- Institute for Molecular Biology IME

## ■ Participating Industry Partners (LOI)



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Ministerium für Innovation,  
Wissenschaft und Forschung  
des Landes Nordrhein-Westfalen



 **Fraunhofer**  
IPT





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## Thank you for your attention!



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