

## Digital Quality Innovation: How to be Quality 4.0 Professional

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可拓學學術交流中心副主任

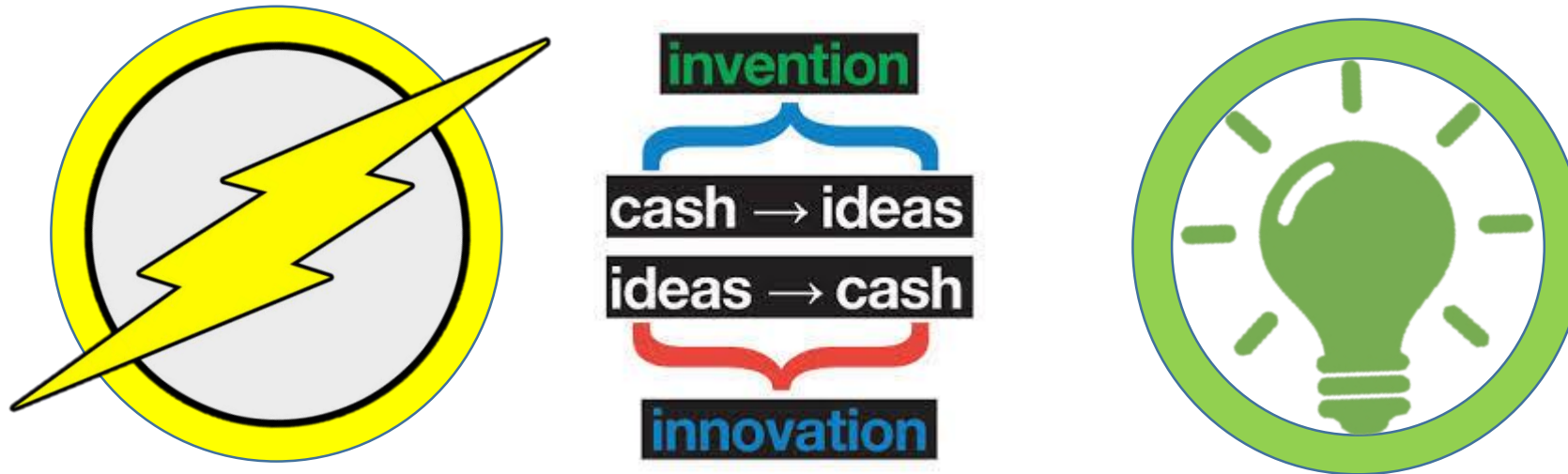


- **Digital Quality Innovation**
  - **Introduction of Innovation & Quality**
  - **Digitalization**
  - **Industry 4.0**
  - **Quality 4.0 (Professional Model)**

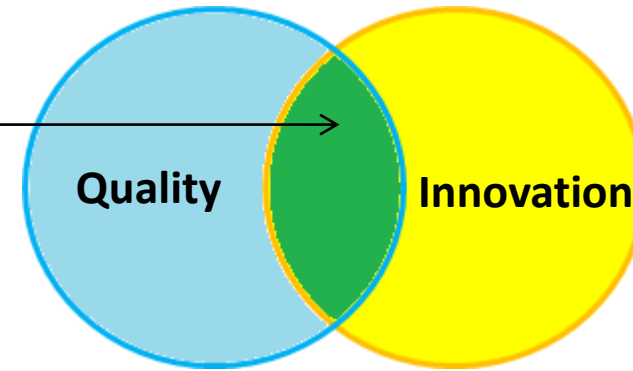
- **ISO 9000-2015** (QMS – Fundamentals and Vocabulary)
  - *new or changed object* realizing or redistributing value (cl.3.6.15)
- **BS 7000-1:1999** (Design Mgt System – Guide to managing innovation)
  - 3.1 ⟨product⟩ ***transformation of an idea into*** a novel product, operational process or new service in industry or commerce [BS 7000-10:1995, definition 23011a)]
  - 3.2 ⟨techniques, materials⟩ employment of design or construction techniques, or materials, ***that do not have a proven history of performance*** or are not covered by the organization's current practice [BS 7000-10:1995, definition 23011b)]
  - 3.3 ⟨ideas⟩ ***successful exploitation of new ideas***
- **CEN/TS 16555-1:2013** (Innovation Management – Part 1: IMS)
  - ***Implementation of a new or significantly improved*** product (good or service), or process, new marketing method, or new organizational method in business practices, workplace organization or external relations
- **ISO 56000:2020** (Innovation management — Fundamentals and vocabulary)
  - **new or changed entity, realizing or redistributing value**

# Invention vs Innovation

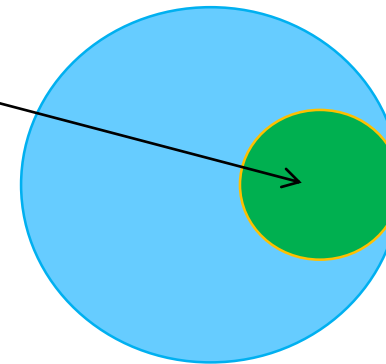
- The distinction between “Invention” and “Innovation” is that invention is the creation of a new idea or concept, and ***innovation is turning the new concept into commercial success or widespread use.***



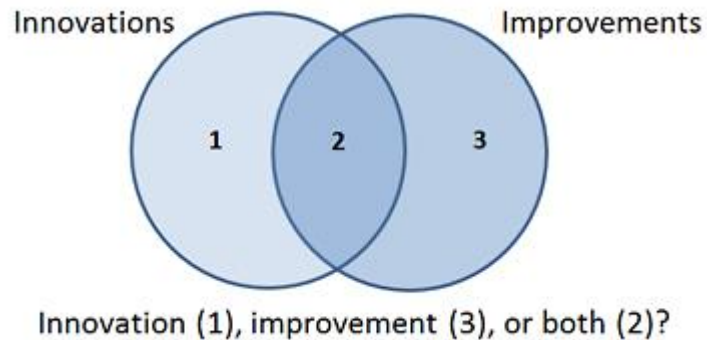
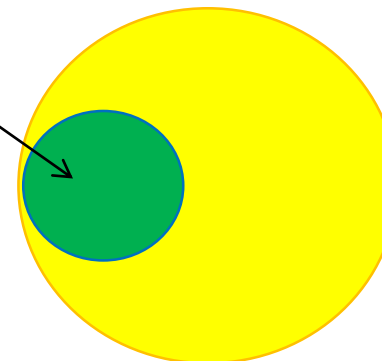
- Quality and Innovation
  - Green color region



- Quality Innovation
  - Innovation is subset



- Innovation Quality
  - Quality is subset



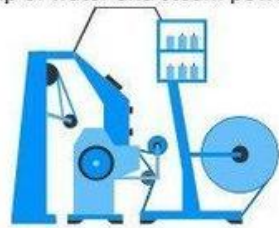
## The 4<sup>th</sup> Industrial Revolution Is Upon Us.

FROM INDUSTRY 1.0 TO INDUSTRY 4.0

### FIRST

#### INDUSTRIAL REVOLUTION

Introduction of mechanical production facilities with the help of water and steam power



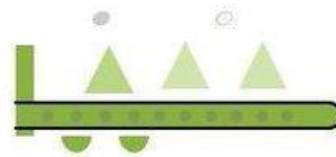
1784

First mechanical loom

### SECOND

#### INDUSTRIAL REVOLUTION

Introduction of a division of labor and mass production with the help of electrical energy



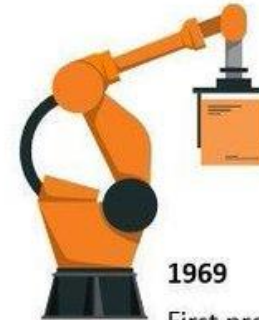
1870

First assembly line

### THIRD

#### INDUSTRIAL REVOLUTION

Use of electronic and IT systems that further automate production



1969

First programmable (PC)

### FOURTH

#### INDUSTRIAL REVOLUTION

The Digital Connected World



2000

• Lean  
• Six Sigma

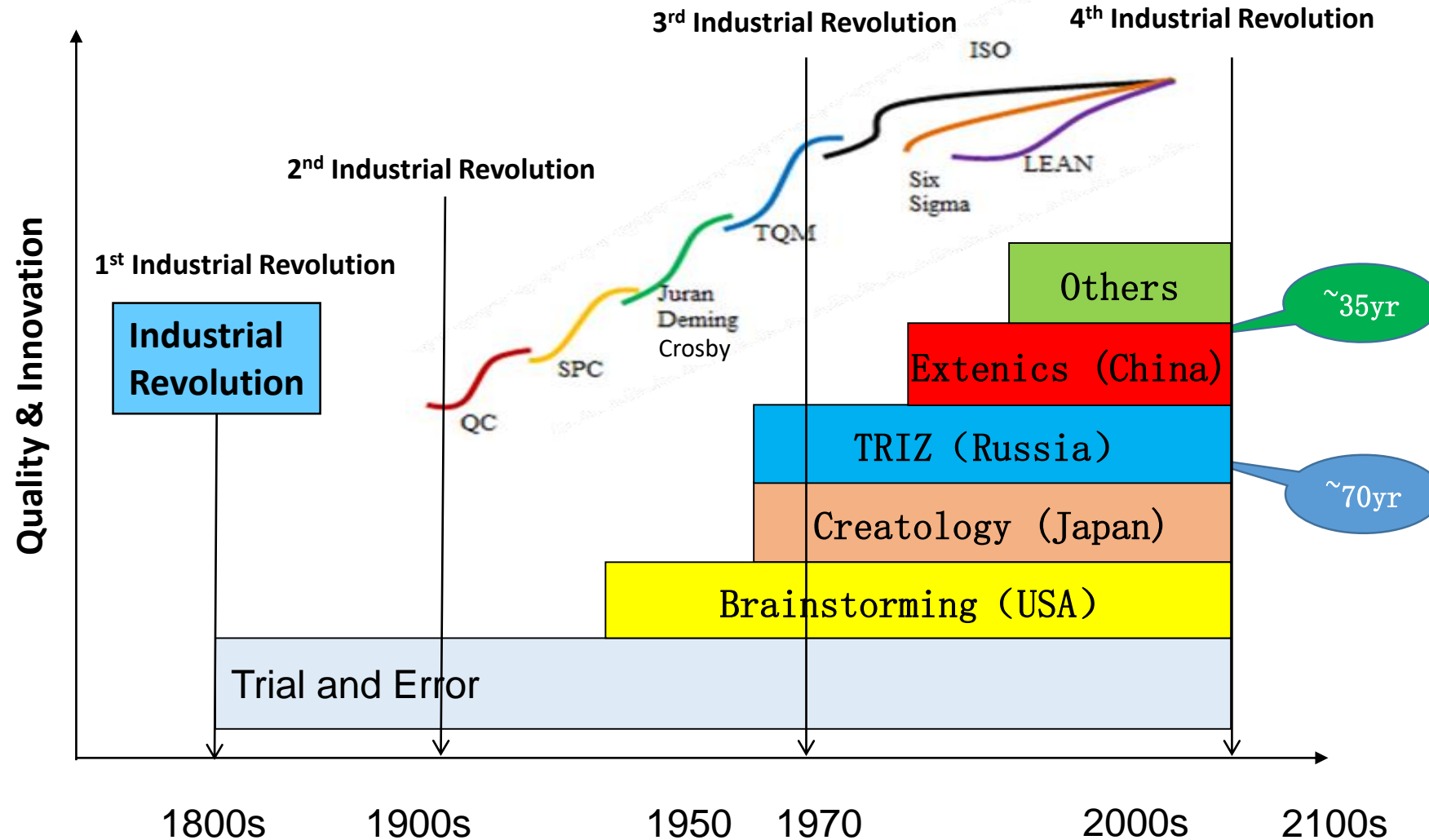
McKinsey  
& Company

*“Industry 4.0 is more than just a flashy catchphrase. A confluence of trends and technologies promises to reshape the way things are made.”*

PRODUCTIVITY



# History of Quality & Innovation in Industrial Revolution





# Evolution of Quality & Innovation from i1.0 to i4.0



Time	Quality Evolution	Innovation Evolution	*Human Capability Extension
<b>1800 – Industrial Revolution</b>		Trial & Error	Power extension through Machine (手的延伸) ( <b>Industry 1.0</b> )
<b>1800 – 1900</b>	Inspection		
<b>1900 – 1950</b>	QC, SPC, QA	Creative problem-solving (1939) (Former name of Brainstorming)	Power extension through Car, Train, (腿的延伸) Telephone (耳朵的延伸) & TV (眼的延伸) ( <b>Industry 2.0</b> )
<b>1950 – 1970</b>	Juran/Deming/ Crosby, TQC, TQM	Brainstorming (1953) TRIZ (1956) Creatology (Japan) NM Method (1970)	
<b>1970 – 2000</b>	ISO 9000 series (1987)  Six Sigma, Lean	Extenics (1983) Six Thinking Hats (1985) Design Thinking (1987) Thinkertoys (1991) USIT (1995)	Power of computer and network (大腦部分功能的延伸) (Information Society– 信息社會) ( <b>Industry 3.0</b> )
<b>2000 &amp; after</b>	<b>Quality 4.0</b> -Digitization, self-induced correction, self-regulate		Power of AI (人類智力的延伸) (Intelligent Society – 智能社會) ( <b>Industry 4.0</b> )

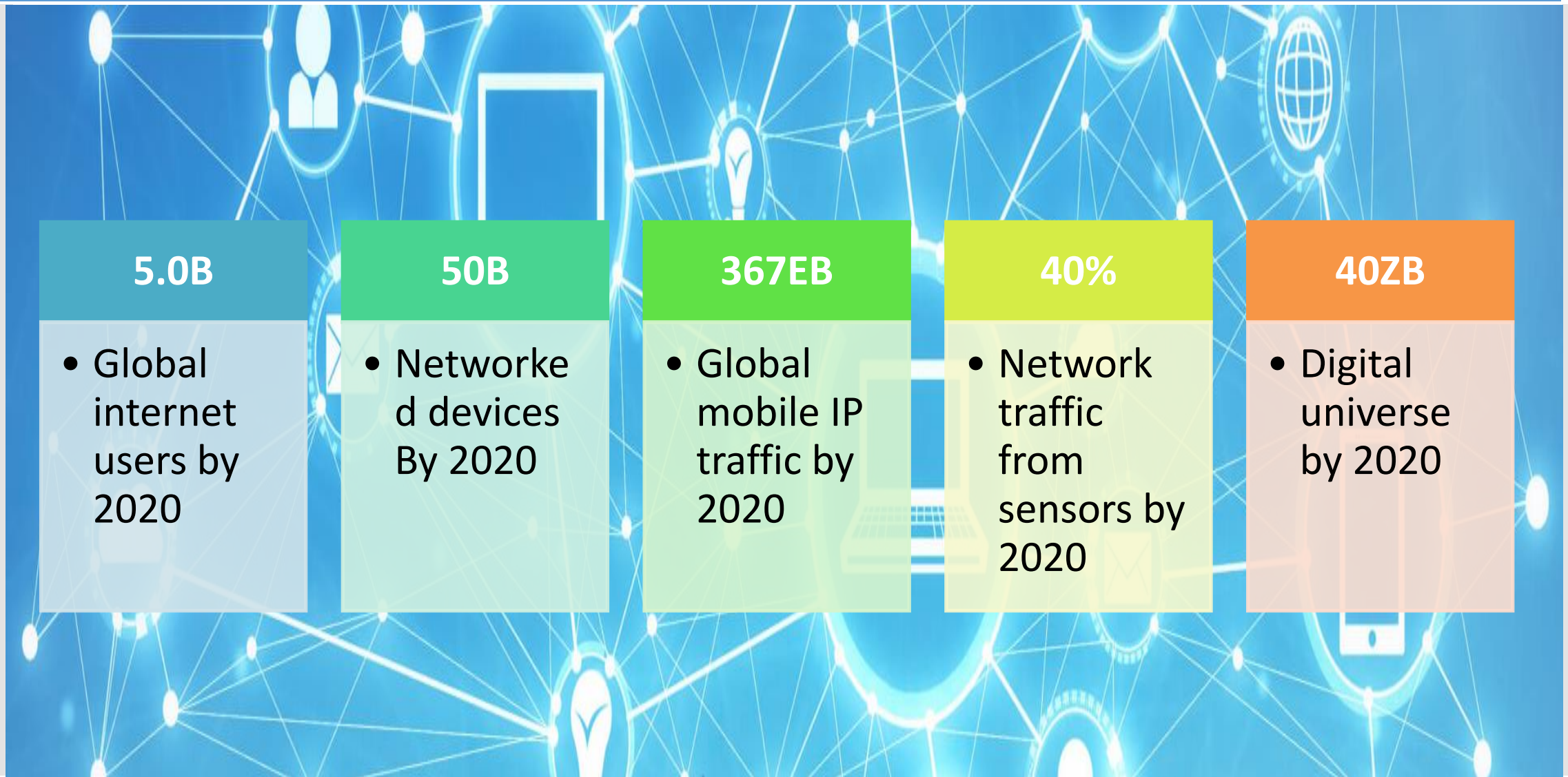
\* From Prof. Cai Wan



The background of the slide features a dense, blue-tinted pattern of binary code (0s and 1s) that appears to be receding into the distance, creating a sense of depth. Overlaid on this pattern is a faint, blue wireframe illustration of a laptop computer, positioned in the upper left quadrant.

# Digital Transformation & Industry 4.0

# Digital Disruption is Underway



Prof. Mohamed Zairi (UK) topic entitled “Defining the Role of Quality in an Uncertain Future: The Disruptive Thinking of Quality 4.0” in ANQ 2018 on 19 Sep 2018.

# Digital Disruption has already happened!



**World's largest  
Taxi company**

- Owns No Taxis



**World's largest  
Accommodation  
provider**

- Owns No Real estate



**World's largest  
Phone companies**

- Owns No Telco infra



**World's most  
Valuable retailer**

- Owns No inventory



**Most popular  
Media Owner**

- Owns No Content



**World's fastest  
Growing bank**

- Owns No Actual  
money



**World's largest  
Movie house**

- Owns No Cinemas



**World's largest  
Software vendors**

- Owns No Apps

1

- What does Digital Disruption really mean?
- What are technologies driving Digital Transformation?
- How company implement Digital Transformation?

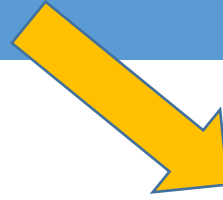


我消灭你，与你无关

I destroy you, it has nothing to do with you

The one who defeats you at this stage is not necessarily an opponent, but a passerby.

- Going paperless
- Connected devices
- Driverless cars
- Artificial intelligence
- Data warehouses
- Cloud computing



## Making Big Data Useful

Big Data needs to be properly collected, cleansed, stored, formatted and accessible for analysis to make better and more consistent decisions, not simply hoarded.

**Jim Duarte**

Academician

International Academy for Quality (IAQ)





Fraunhofer Institute for Production Technology

In-house 5 days Training

德国的弗劳恩霍夫生产技术研究  
工业4.0的内部培训





# What does Industry 4.0 really mean?



Industry 4.0 is not just automation





## Plattform Industry 4.0:

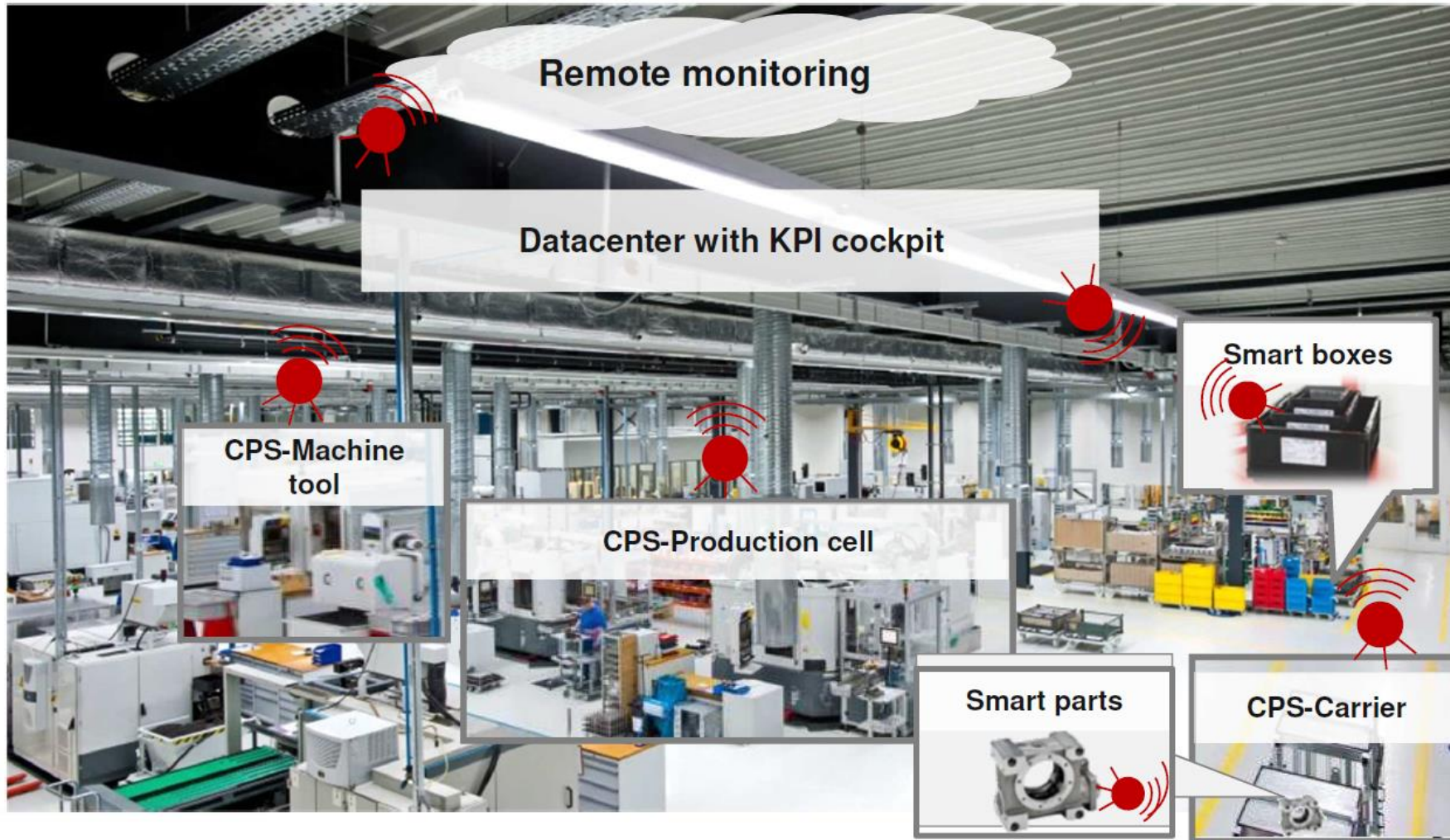
实时

„The Term Industry 4.0 stands for the fourth industrial revolution. Best understood as **a new level of organization and control** over the entire value chain of the **life cycle of products**, it is geared towards increasingly individualized customer requirements. (...) The basis for the fourth industrial revolution is the **availability of all relevant information** in real time by **connecting all instances** involved in the value chain. The ability to derive the optimal value-added flow at any time from the data is also vital. The connection of people, things and systems creates dynamic, **self-organizing, real-time optimized value-added connections** within and across companies. (...)”

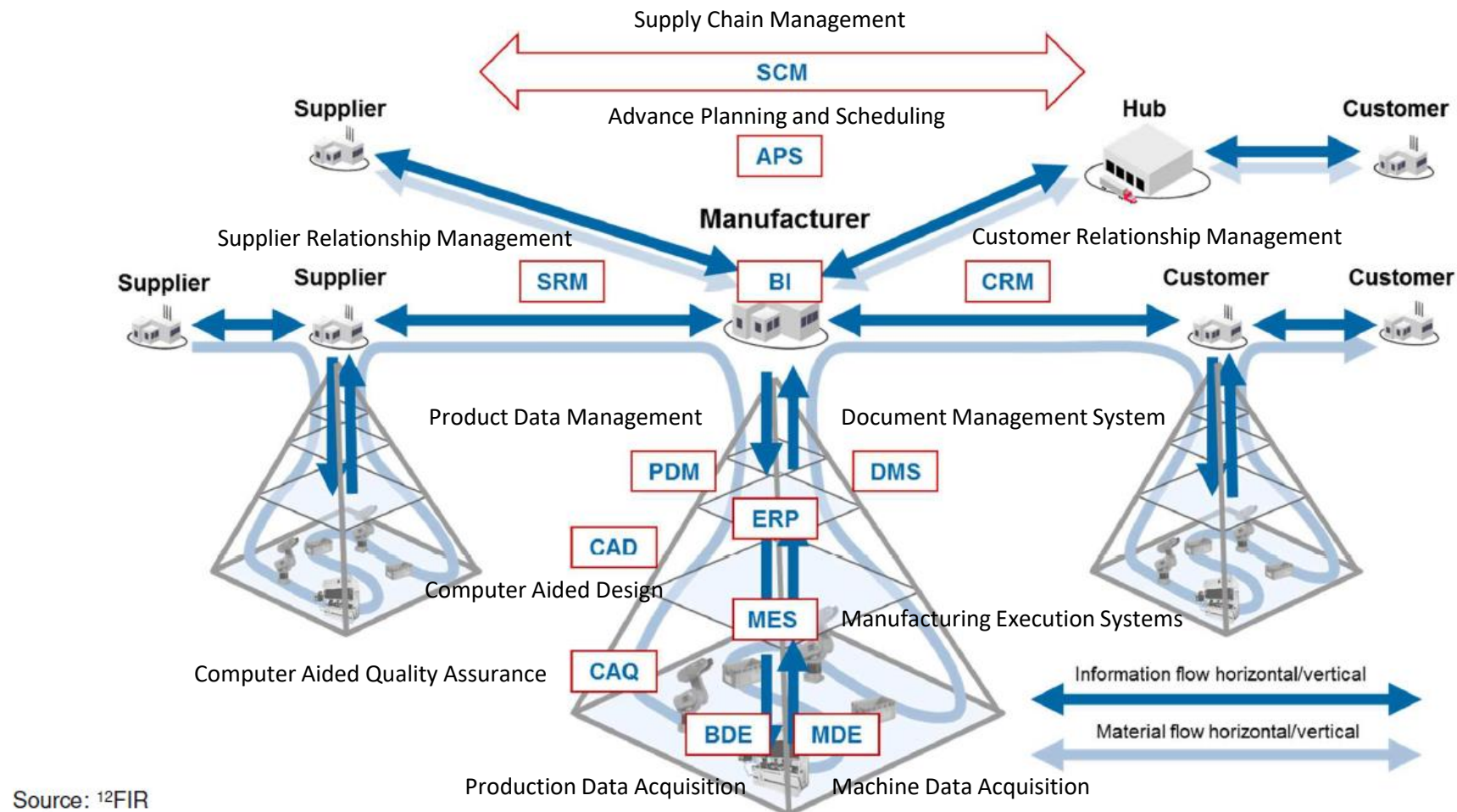
自组织

实时优化的增值连接

# Intelligence bring Whole Value Chain



# Digital Horizontal and Vertical Integration

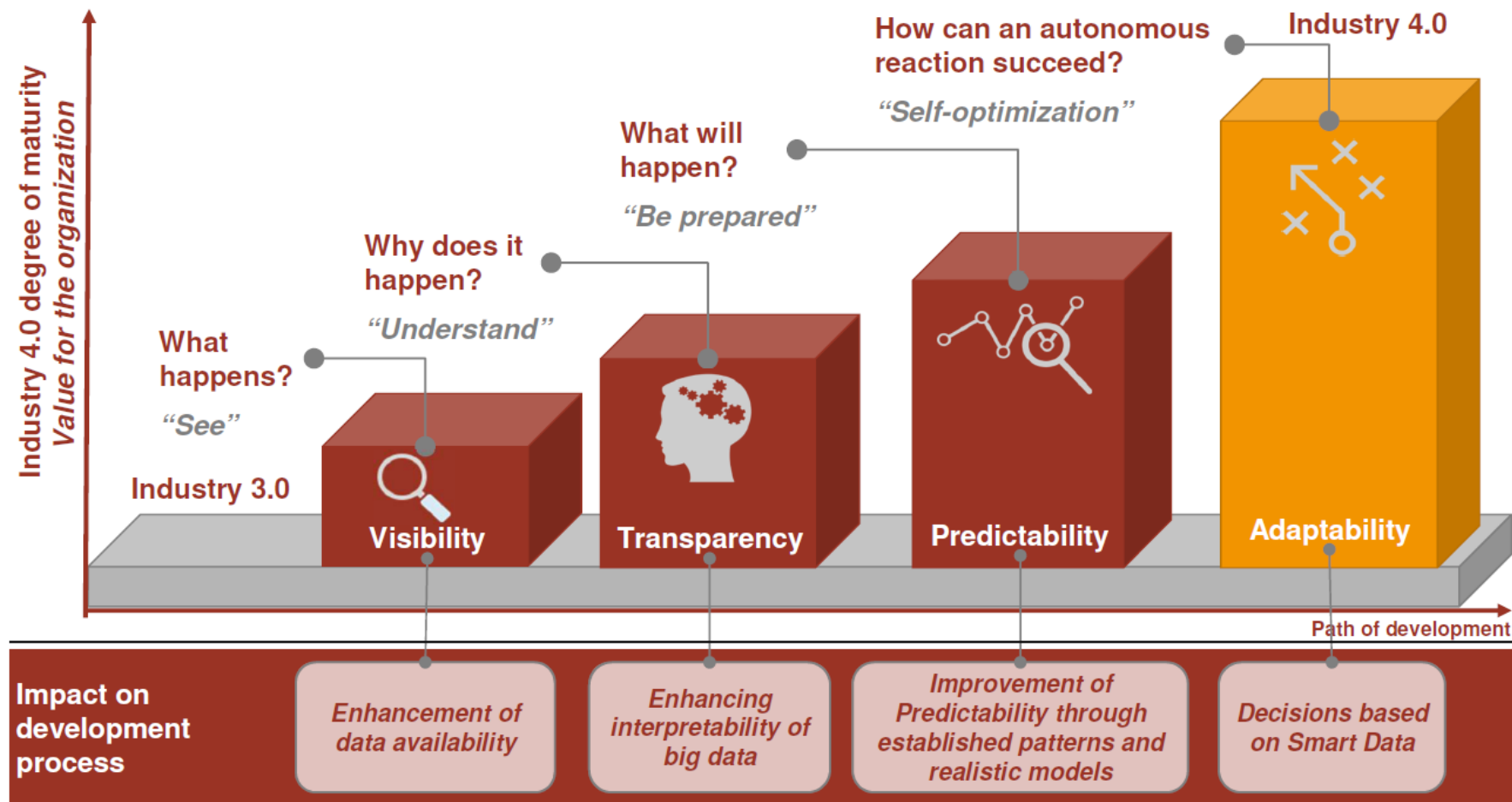


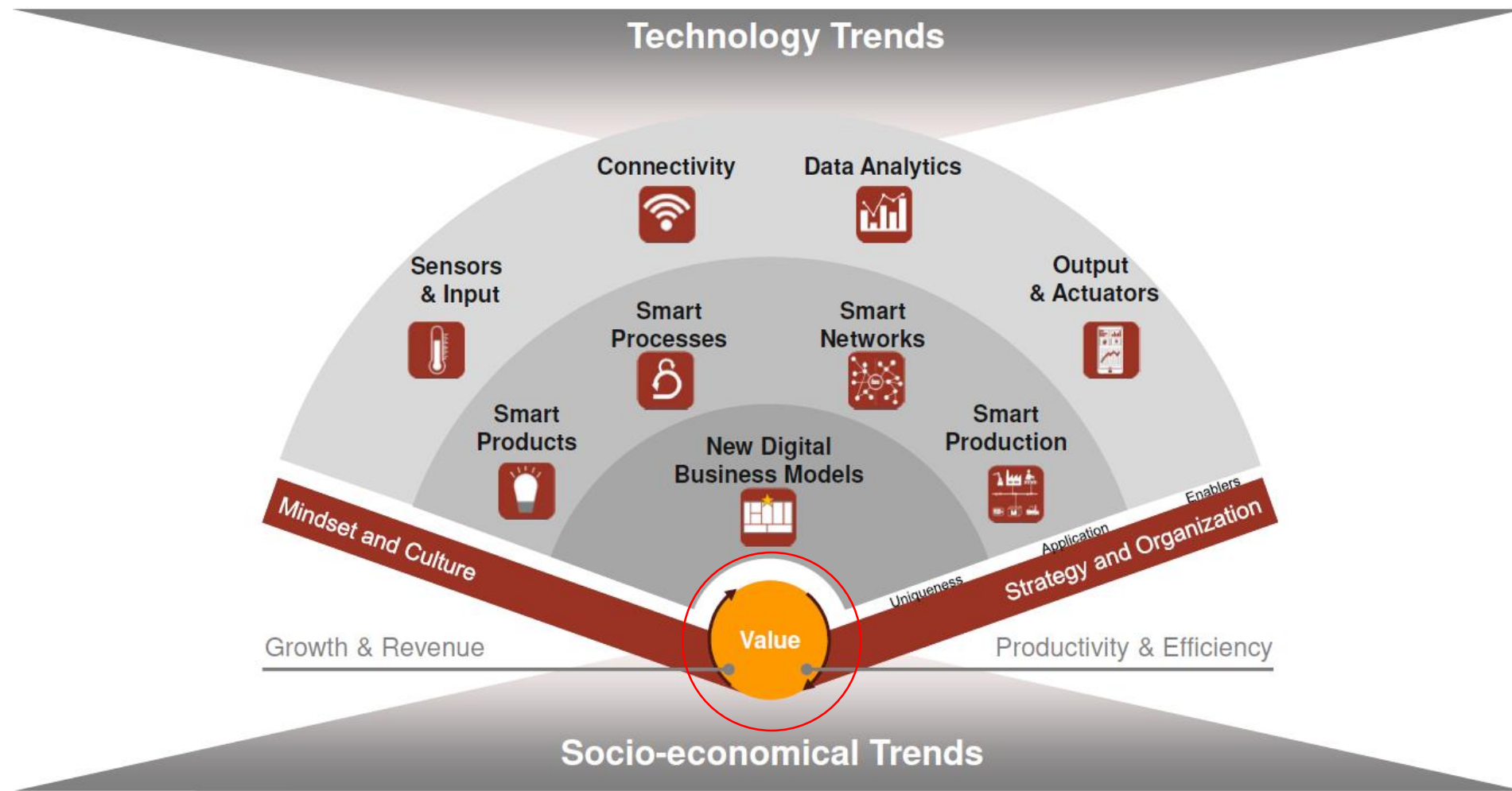
Source: <sup>12</sup>FIR

Information is collected by different IT-System-Modules



# i4.0 Improved Decision Making





## Margins

						
Inventory costs	Manufacturing costs	Labor costs	Logistics costs	Quality costs	Flexibility	Time
30-50%	10-20%	10-30%	20-30%	10-20%	20-30%	20-30 %
↓	↓	↓	↓	↓	↑	↑
Inventory cost reduction due to minimization of minimum inventory level through real time information over the whole supply chain and production.	Manufacturing cost reduction due to real time optimization of production KPI and improvement of planning quality as well as machine utilization.	Labor cost improvement by leveraging flexibility of labor in production and higher degree of automation.	Logistics cost reduction over the whole supply chain due to better automation and material flow harmonization.	Quality cost reduction due to real time data availability to optimize quality issues.	Improvement of flexibility due to higher planning quality, forecasting capability and agile company processes.	Faster value generation due to agile organization and collaboration as well as steering the value chain based on data transparency.

Companies will gain in average up to 20% total productivity and address more individual products with lower complexity costs through smart production and smart networks. Especially early movers will be able to create market barriers.

感应状况

Sense  
Condition



Visualize  
& Adopt

可视化和采用



连接网络

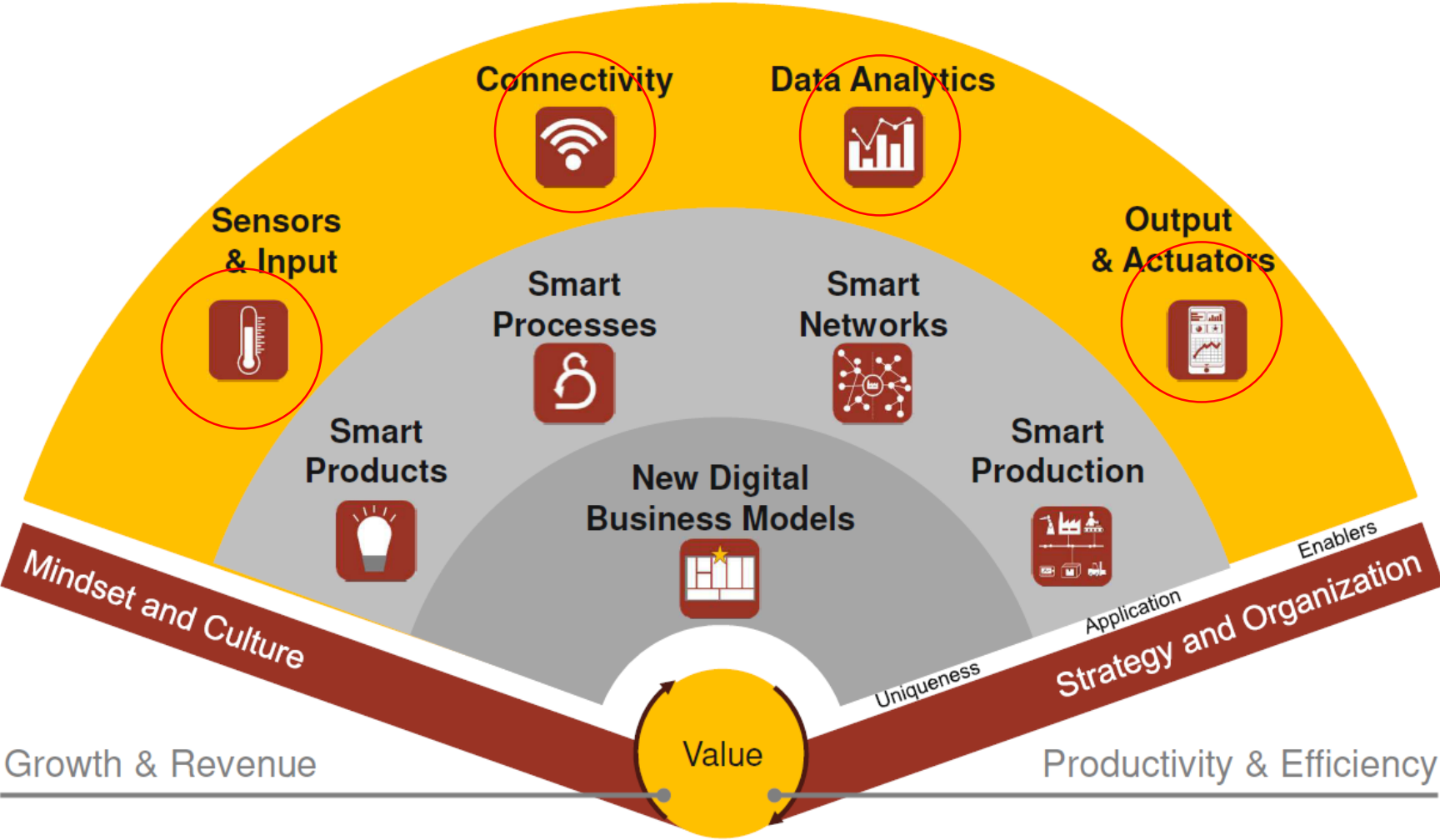
Connect  
Network



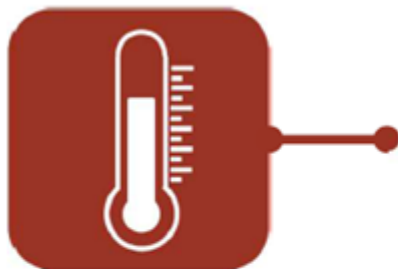
Analyze  
& Predict

分析和预测





**Sense  
Condition**




**Visualize  
& Adopt**

**Connect  
Network**



**Analyze  
& Predict**

Corporate Certificate  
Certificate No: **HC 023**



*This is to certify that the Quality Management System of*

**HONG KONG SCIENCE AND TECHNOLOGY PARKS  
CORPORATION**


8/F Bio-Informatics Centre 2 Science Park West Avenue Hong Kong Science Park  
Shatin New Territories Hong Kong

*complies with the requirements of ISO 9001 : 2008 quality management system standard,  
applicable to:*


**Provision of facilities, services and management to companies operating  
in the Science Park, InnoCentre and Industrial Estates**

*This certificate remains valid subject to satisfactory maintenance of the certificates  
CC2713, CC3432, CC3459, CC5460, CC5461  
which will be monitored by Hong Kong Quality Assurance Agency.*

Signed for and on behalf of  
**HONG KONG QUALITY ASSURANCE AGENCY**



Chief Executive Officer



Director

Registered address 19/F K. Wah Centre 191 Java Road North Point Hong Kong  
Note: In accordance with the Agency Regulations, the Hong Kong Quality Assurance Agency undertakes no liability or responsibility for any product or service supplied by the organization in accordance with the requirements of this Certification Scheme. This certificate remains the property of HKQAA and shall be returned when required by the Agency.

Original Certification 26 March 2012

HKQAA F224-ENC Rev3

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P.24



## 3 Factors

Determines AI's Potential

### Algorithms and Architecture

Recent AI innovations have been powered by combining algorithms and architecture together in novel ways to solve specific sets of problems.

### Computing Power

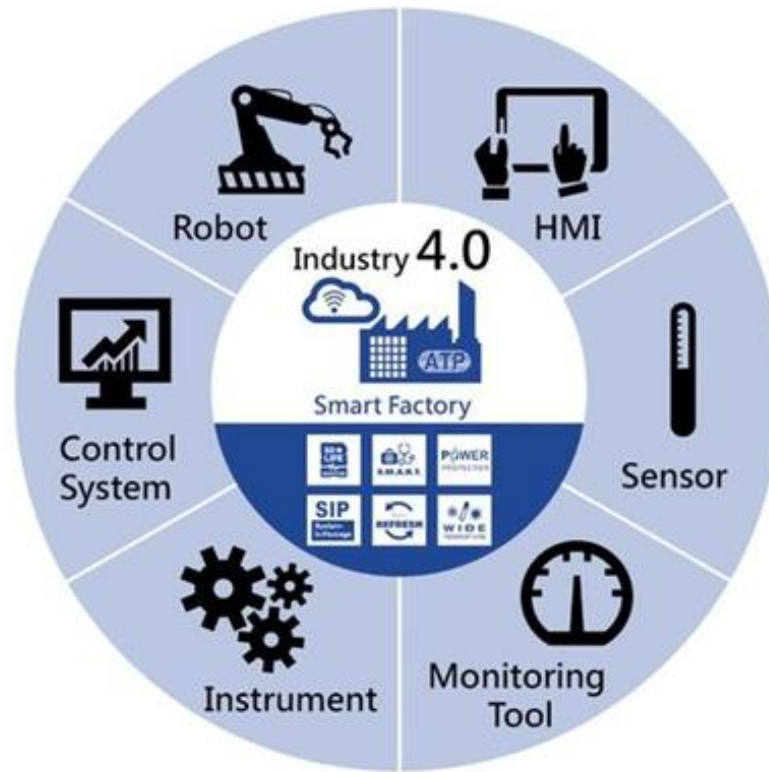
Exponential increases in computing power has meant that certain algorithms and architecture which were impractical in the past, e.g. DL, have become viable.

### Big Data

Access to large amounts of data available in the cloud, has made DNNs feasible.



Volume	Velocity	Variety	Veracity*
Data at Rest	Data in Motion	Data in Many Forms	Data in Doubt
Terabytes to exabytes of existing data to process	Streaming data, milliseconds to seconds to respond	Structured, unstructured, text, multimedia	Uncertainty due to data inconsistency & incompleteness, ambiguities, latency, deception, model approximations





## Lean Six Sigma: 8 Wastes



**(Digital Lean Production)**

# I4.0 Maturity Level

i3.0 / i2.0

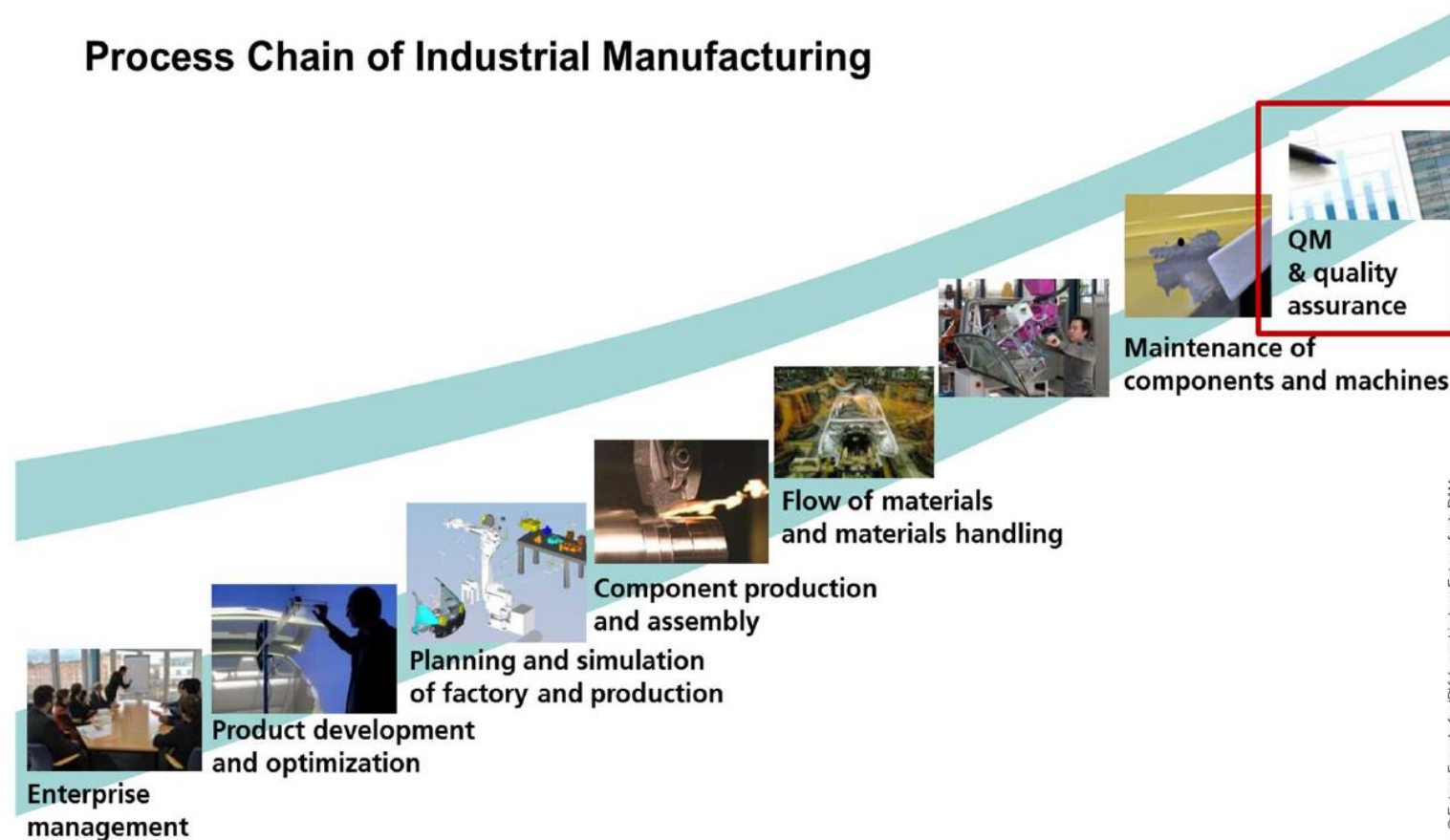
Maturity of Industry 4.0

	Level	Explanation	Characteristics	
	-2	i2.x	Predomenientaly Industry 2.0 processes in the company	<ul style="list-style-type: none"> <li>▪ Devision of labor</li> <li>▪ No information technology/system</li> </ul>
	-1	i3.x	Predomenientaly Industry 3.0 processes in the company	<ul style="list-style-type: none"> <li>▪ Automation</li> <li>▪ IT System Application</li> </ul>
	0i	Frame conditions	Organizational and infrastructural enablers for the implementation of Industry 4.0	<ul style="list-style-type: none"> <li>+ Industry 4.0 awareness</li> <li>+ IT-infrastructure and data security</li> <li>+ Lean processes</li> <li>+ Advanced tools adopted &amp; mastered</li> </ul>
	1i	Real-time Information generation	Generation and availability of data and information of all activities in real time.	<ul style="list-style-type: none"> <li>+ Digital horizontal and vertical integration into the value chain</li> <li>+ Single Source of Truth by sensor data</li> <li>+ Sensor, feedback, machine control</li> </ul>
	2i	Real-time Information-processing and -integration	Development of knowledge and insights through the analysis and aggregation of all available information and data sources.	<ul style="list-style-type: none"> <li>+ Aggregation of data</li> <li>+ Big data analysis</li> <li>+ Improving forecast ability</li> </ul>
	3i	Integration of cyber-physical systems	Mobile assistance systems and human-machine/machine-machine collaboration for decentralized decision-making	<ul style="list-style-type: none"> <li>+ Decentralizes decision-making</li> <li>+ HMI/MMI, Industrial apps</li> <li>+ Mobile assistance systems</li> </ul>
	4i	Intelligent, autonomous & Self-organized processes	Self-optimizing processes and autonomous control of products in the value chain	<ul style="list-style-type: none"> <li>+ High degree of automation</li> <li>+ Self-learning and -optimization of processes and products</li> </ul>





## Process Chain of Industrial Manufacturing



## Speed



- Due to shorter lead time and less deficit
- Due to consistent data and new possibilities of simulations from the first concept to the completed product

## Quality



- Due to transparent processes and reproducibility
- Due to sensors and controller, which can monitor the actual production in real-time and which are able to step in occurring faults.

## Productivity



- Due to a higher level of automation and shorter downtimes
- Due to a flexible production and an integration of the value added chain on a higher level

## Ergonomics



- Due to the decline of physical straining activities
- Due to work-sharing robot systems, which diminish hard physical work for the benefit of the operators

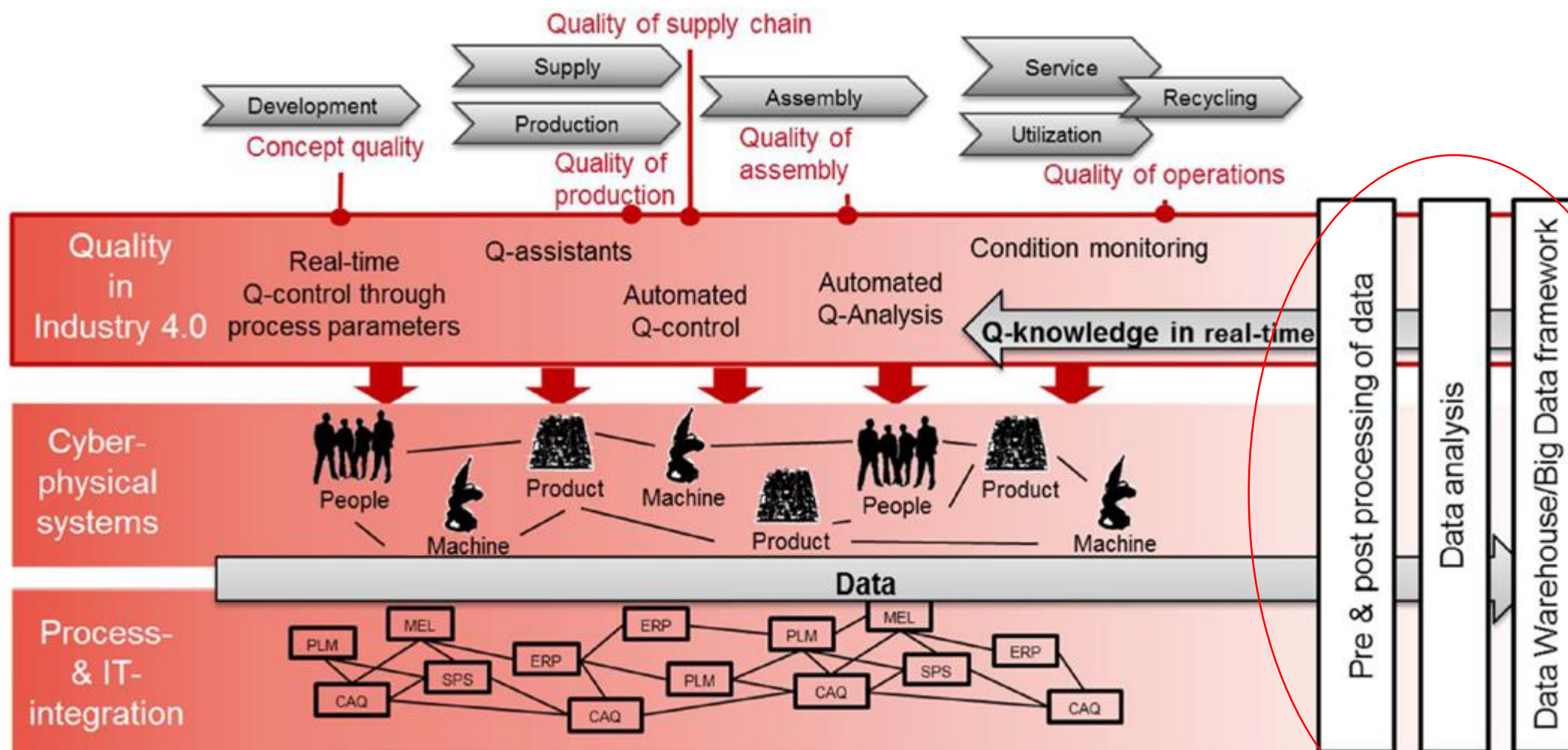
## Flexibility



- Due to the batch sizes and batch versions: adjusted mass production
- Due to machines and robots, which execute the single production steps for a big amount of products

Prof. Dr.-Ing. Roland Jochem, Division Director Quality Management, Fraunhofer IPK

# Data Analysis is a Key Factor in Quality 4.0



## Fields of action



## How can Quality Management benefit from digitalization?

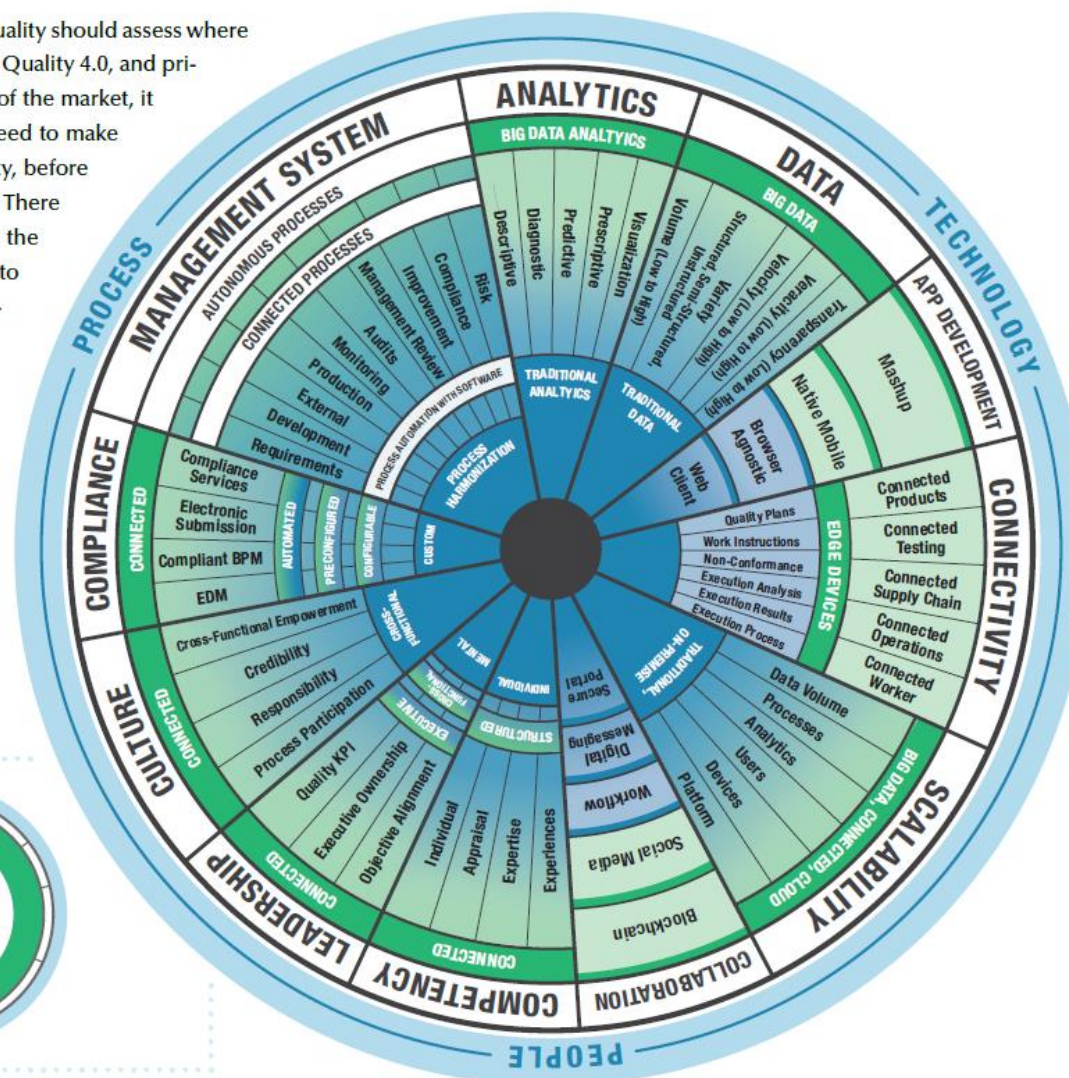
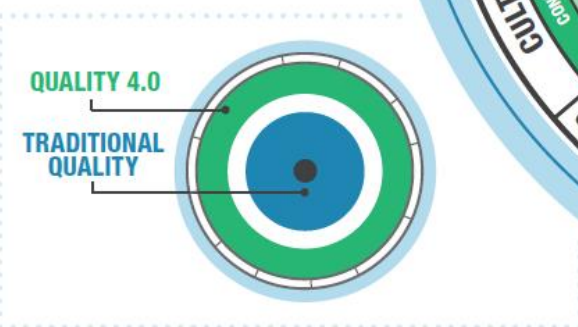
- Accelerated Development through systematic Requirements Engineering
- Early Validation through Simulations
- Less breakdowns and lower warranty cost through supporting systems for Supply Chain Quality
- More transparency through continuous monitoring with cockpits
- Transparent decisions through context-based, intelligent analysis and prognosis models
- Higher reactivity through early-warning systems
- Higher Product-Quality through better understanding of customer processes
- Better service quality through employee qualification



# Defining Quality 4.0

## Quality 4.0: A Big Picture View

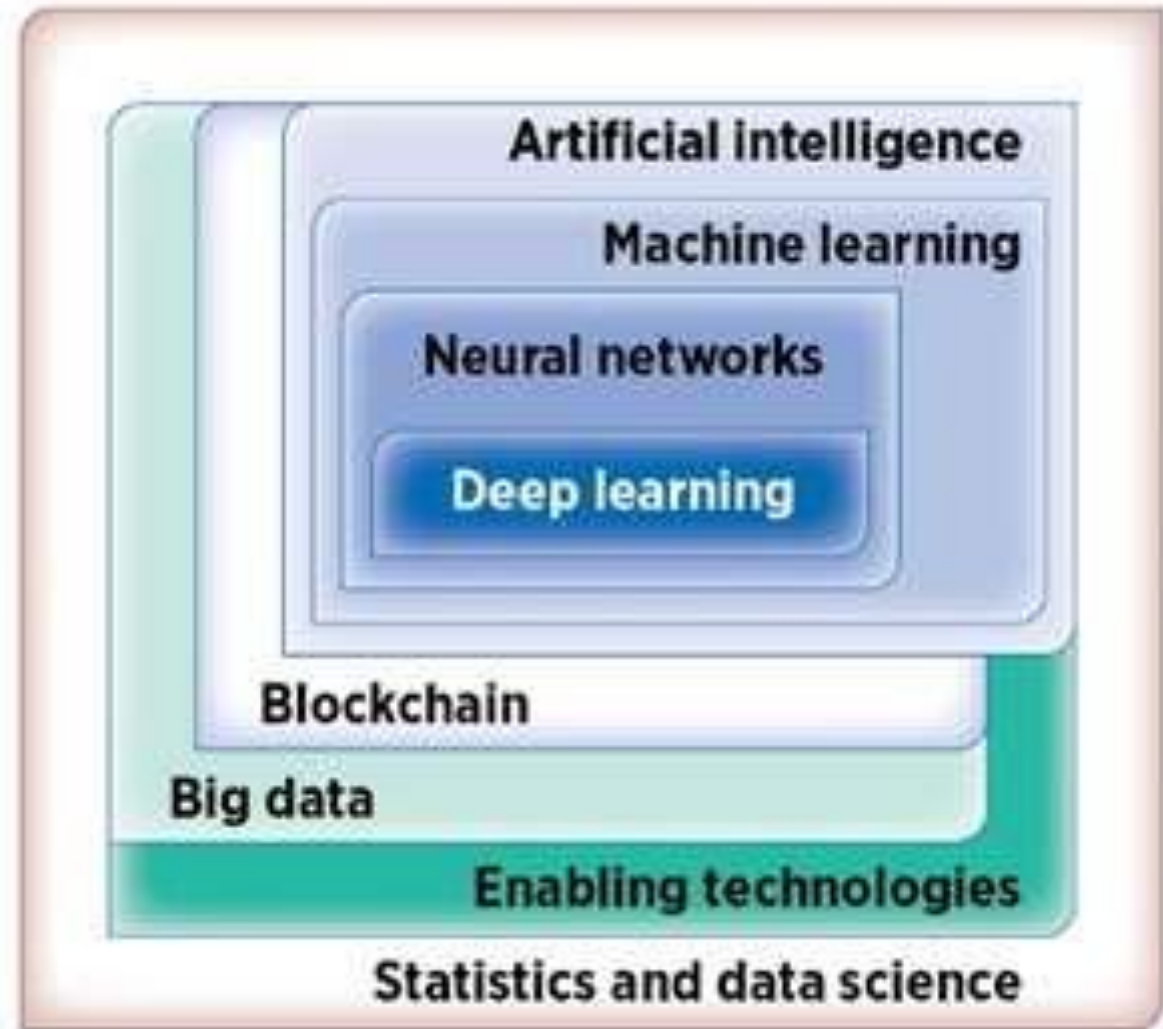
Manufacturers looking to improve quality should assess where they stand on each of the 11 axes of Quality 4.0, and prioritize investments. Given the state of the market, it is likely that many companies will need to make investments first in traditional quality, before they can fully leverage Quality 4.0. There are clearly interrelationships among the axes, and adding new capabilities to certain axes enables new applications on other axes.



<https://blog.Insresearch.com/topic/enterprise-quality-management-system-eqms/page/2>

Period	Summary Description	Quality	Summary Description
Anticipated changes that will occur during Industry 4.0 – 1995 to present	<ul style="list-style-type: none"><li>• Integrated cyber-physical interfaces automate working environments.</li><li>• Automated process deal with end-to-end systems.</li><li>• Humans serve only in positions where human judgment cannot be automated and human interactions cannot be simulated.</li><li>• Machines learn to learn (artificial intelligence).</li></ul>	Quality 4.0	<ul style="list-style-type: none"><li>• Digitization is used to optimize signal feedback and process adjustment, and adaptive learning supports self-induced system corrections.</li><li>• Quality shifts its control-oriented focus from the process operators to the process designers.</li><li>• Machines learn how to self-regulate and manage their own productivity and quality.</li><li>• Human performance is essential; the emphasis shifts from production to system design and integration with the business system.</li></ul>

- **Artificial intelligence**
- **Big data**
- **Blockchain**
- **Deep learning**
- **Enabling technologies**
- **Machine learning**
- **Data science**





# Seven Newer Tools for Quality 4.0



1. Predictive Modeling (supervised)
2. Network Diagrams (unsupervised disrupting Pareto)
3. Cluster Analysis (unsupervised)
4. Text Analysis (unsupervised) – 85% of today's data
5. Discrete Event Simulation (queueing theory)
6. Event Stream Processing (unsupervised)
7. Sankey Diagrams (unsupervised)

Introduced at ASQ European Quality Conference –Berlin  
2017, modified 2020



**Jim Duarte**

Academician at International  
Academy for Quality (IAQ)

- Quality 4.0 is a holistic view of the evolution of quality management from industry 1.0 to industry 4.0.
- Quality 4.0 covers **new role, technologies, management, new service and product** in the changing world.
- **Quality 4.0 need new QC tools.**
- **Making things “Smart”** indicating that intelligence, automation, flexibility, agile, effectiveness and efficiency, so as to **maximize the customer value.**
- Digitalization and Data Analytics are enabled technology for Q4.0
- Quality and Innovation Integration as a result

