29th International Conference of the
TOC Practitioners Alliance - TOCPA

www.tocpractice.com

November 11-12, 2016 Vilnius, Lithuania

Industry 4.0

Overview and TOC Opportunities

11 November 2016

Jürgen Kanz
Systemic Thinking

Jürgen Kanz

Systemic Thinking

- Diplom Ingenieur in Electrical Engineering
- Several Certifications from Universities and Institutes
- Almost 30 years of experience in Management of Innovation and Operations in Photonics and Power Electronics Industries
- TOCICO certified in Thinking Processes
- Co-author and translator of „Do-It-Yourself Theory of Constraints“ eBooks for „Production, Project Management and Distribution“ in German language, https://leanpub.com/u/juergenkanz
- Personal interests: Systems Thinking, Theory of Constraints, Management Science, and Mathematics

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Starting Point of our Journey

Source: Goldratt Consulting

Different Names – Same Idea

Industrie 4.0

Smart Factory

Integrated Industry

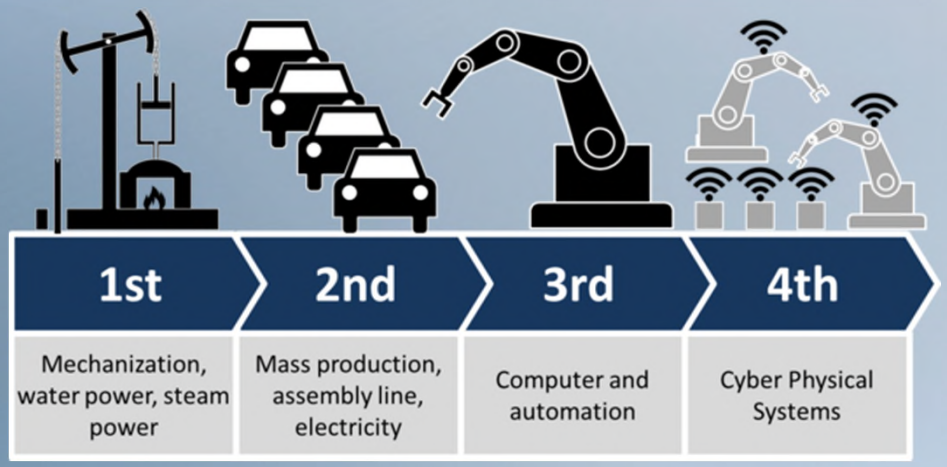
Smart Manufacturing

Industry 4.0

Industrial Internet

What is Industrie 4.0 ?

Industrie 4.0 describes the transformation of “classic” industries by the Internet of things, data and services. Such real time integration of products, processes, and infrastructure marks the start of a **fourth industrial revolution**: supply, production, maintenance, delivery, and customer service are increasingly interconnected through the Internet. Rigid value chains turn into highly flexible value networks.



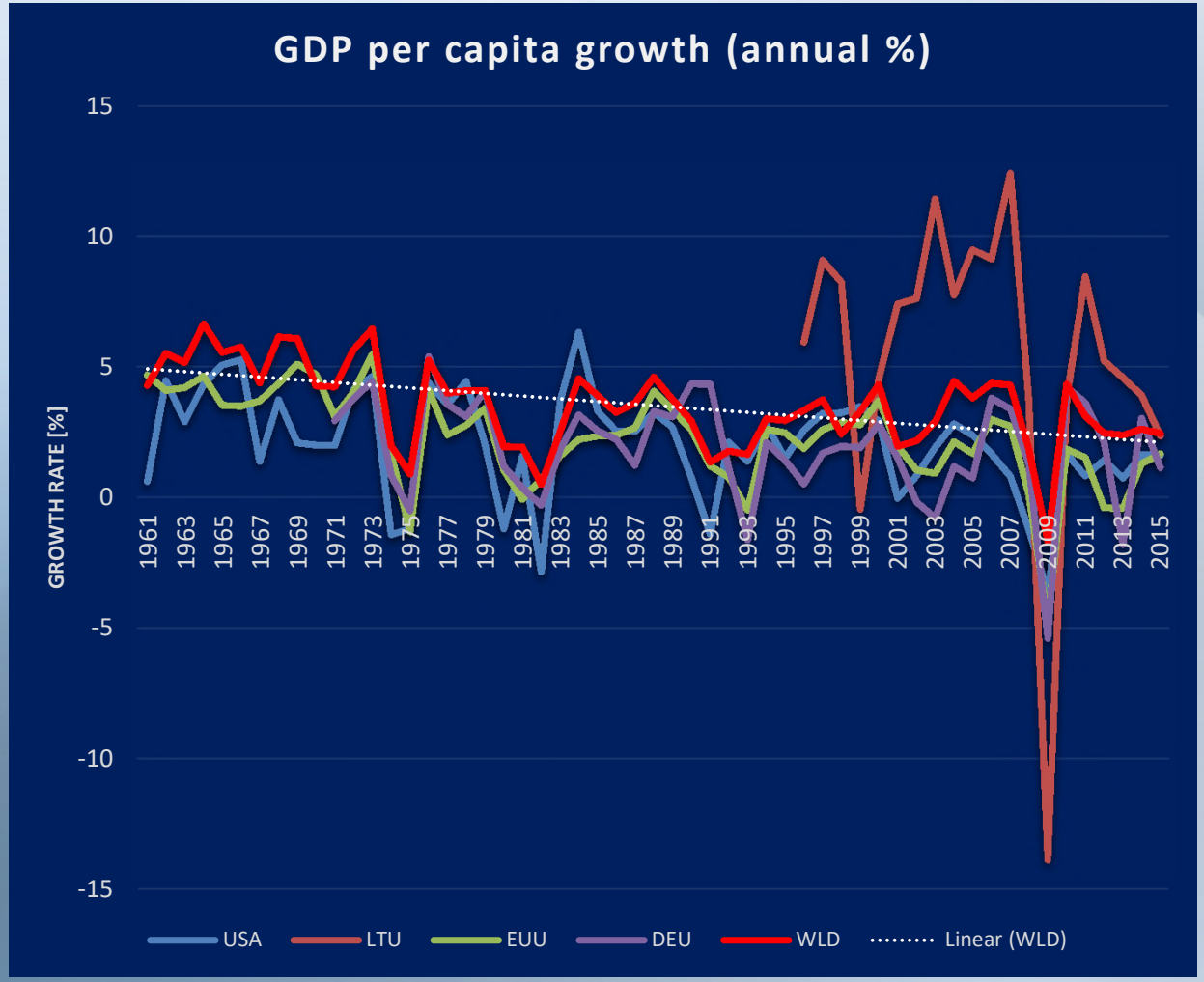
Industrie 4.0

„Whether we consider it revolution or evolution, disruption or transformation – we are witnessing fundamental changes to society and the economy thanks to digitization. To equip ourselves for the race for tomorrow's products and markets, the foundations for the digital transformation of our industries must be laid today. This is one of the central tasks in the coming years, a task that we want to tackle together in Plattform **Industrie 4.0**. At the heart of this transformation is the one factor that is key to the success of **Germany's national economy**: its vigorous, highly innovative, and future-oriented industrial sector."

Federal Ministry for Economic Affairs and Energy (BMWi), Germany, 2016

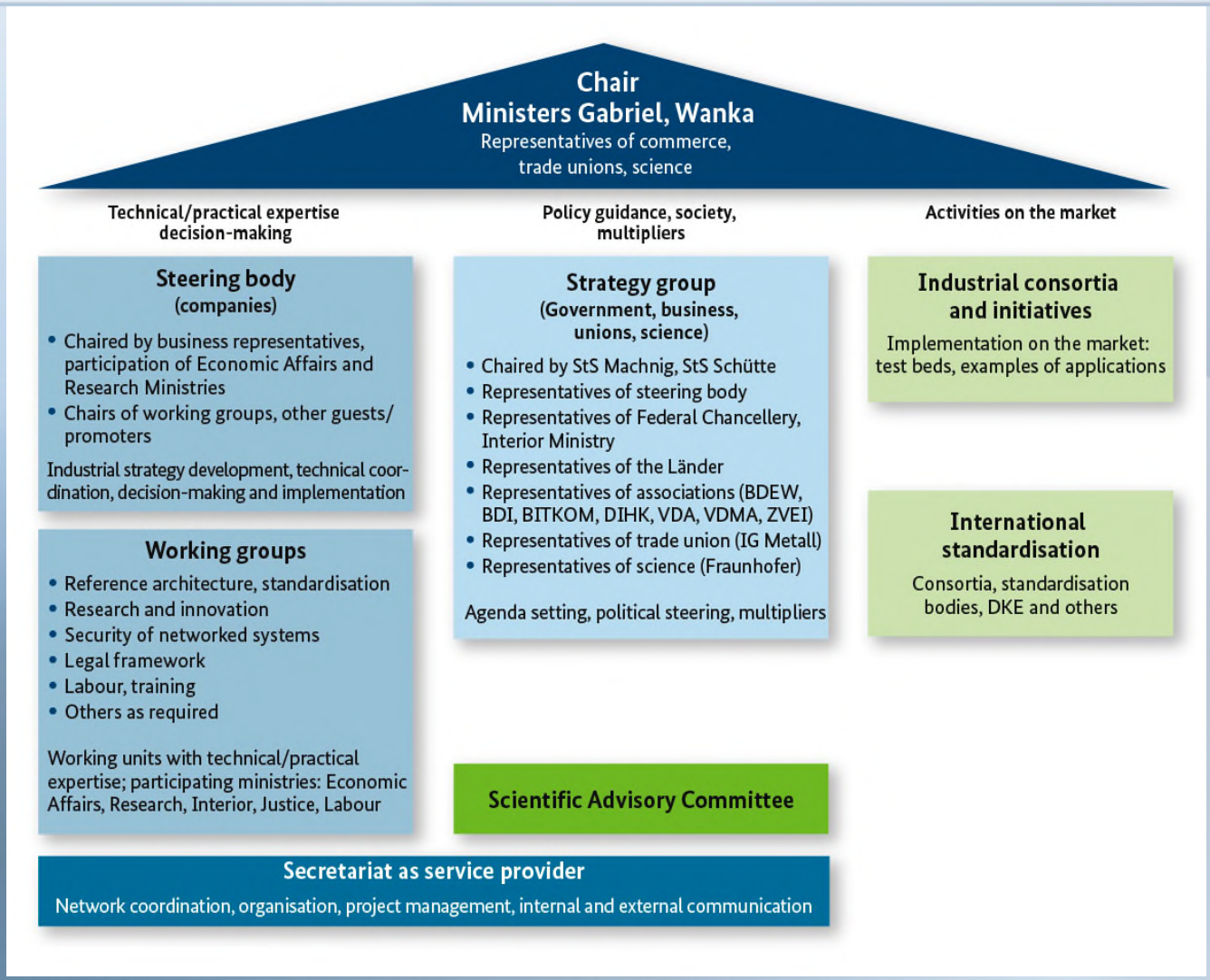
Source: Digitization of Industrie – Plattform Industrie 4.0, Federal Ministry for Economic Affairs and Energy (BMWi), Germany, 4/2016, https://www.bmwi.de/English/Redaktion/Pdf/digitalisierung-der-industrie,property=pdf,bereich=bmwi2012,sprache=en,rwb=true.pdf

Macro Economic Background



Source: OECD Data, accessed 07.10.2016, https://data.oecd.org/lprdty/gdp-per-hour-worked.htm

Plattform Industrie 4.0



Source: www.plattform-i40.de

towards SMART FACTORIES

Plattform Industrie 4.0, Germany, http://www.plattform-i40.de

OPC Foundation, https://opcfoundation.org/

Industrial Internet Consortium (IIC), US, http://www.iiconsortium.org

Alliance Industrie Du Futur, France,
http://allianceindustrie.wixsite.com/industrie-dufutur

Industrial Value Chain Initiative (IVI), Japan, http://www.iv-i.org

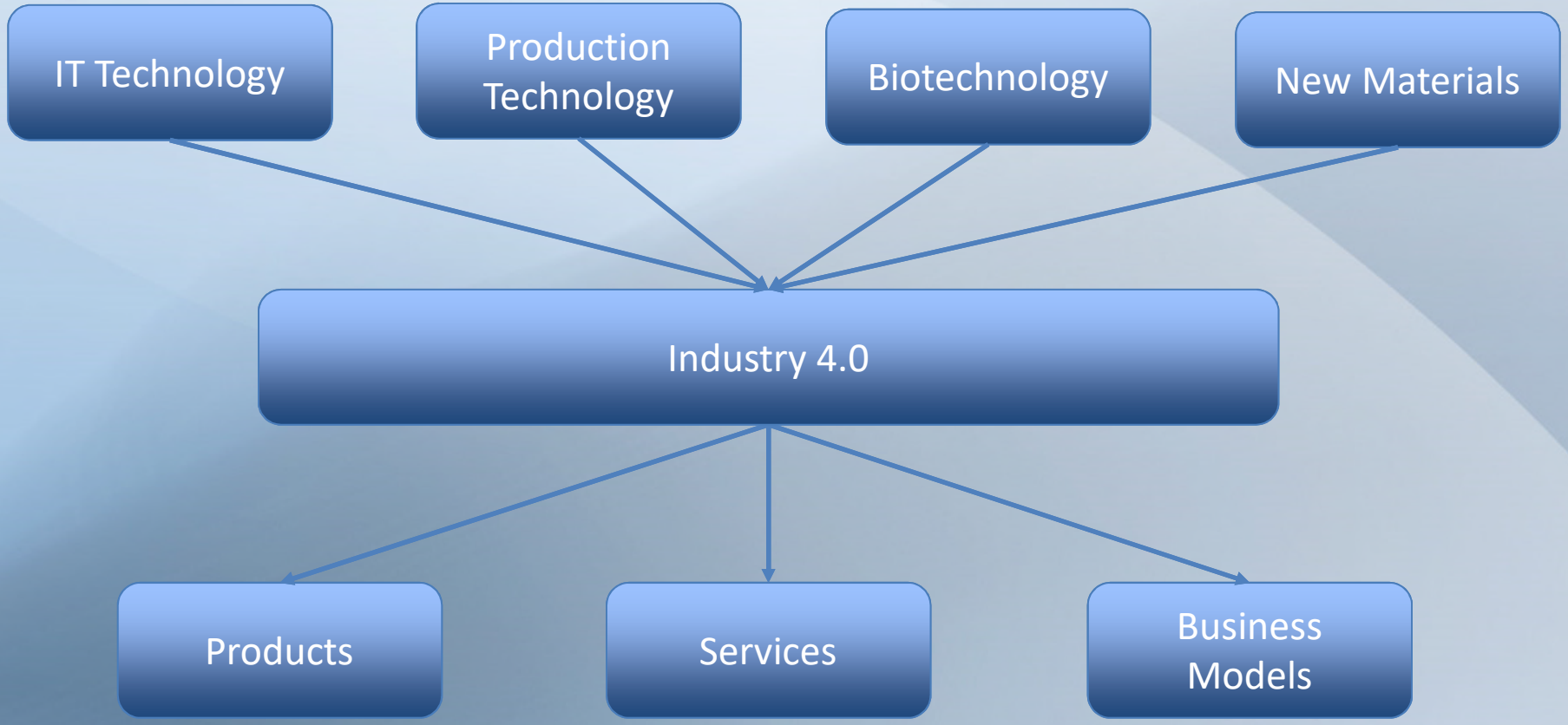
China Government, China,
http://english.gov.cn/policies/latest_releases/2015/05/19/content_281475110703534.htm

What about Lithuania ?

http://www.industrie40.lt

HOME EVENTS INDUSTRIE 4.0 CONFERENCE PARTNERS IMAGES DOCUMENTS LIETUVIŠKAI

Economic Goal: Increased Productivity



Interlinking of real (physical) and virtual (cyber) world leads to Cyber-Physical Systems

Cyber-Physical Systems

Physical World

- Robotics
- Automation equipment

- Traditional machinery
- Traditional & semiconductor based sensors

- Traditional machinery
- RFID
- Automation equipment

- Camera & imaging systems
- Visual sensors
- Traditional sensors

+

Cyber World

- Advanced algorithms
- Machine learning
- High performance hardware

- Advanced data analytics
- Data mgmt. Systems
- Cloud computing

- Embedded systems
- Real-time image processing
- Data storage hardware

- Real-time image processing
- Advanced data analytics
- Advanced algorithms

=

Industry 4.0 solutions

- Self-learning robots

- Predictive maintenance

- Self-reconfiguring machines

- Smart environment recognition

Only a Dream?

No, INDUSTRY 4.0 Building Blocks are already in operation for further investigation

Smart Production

Collaborative Robotics

3D Food Printing

Traceability

Augmented Reality

Conditional Maintenance

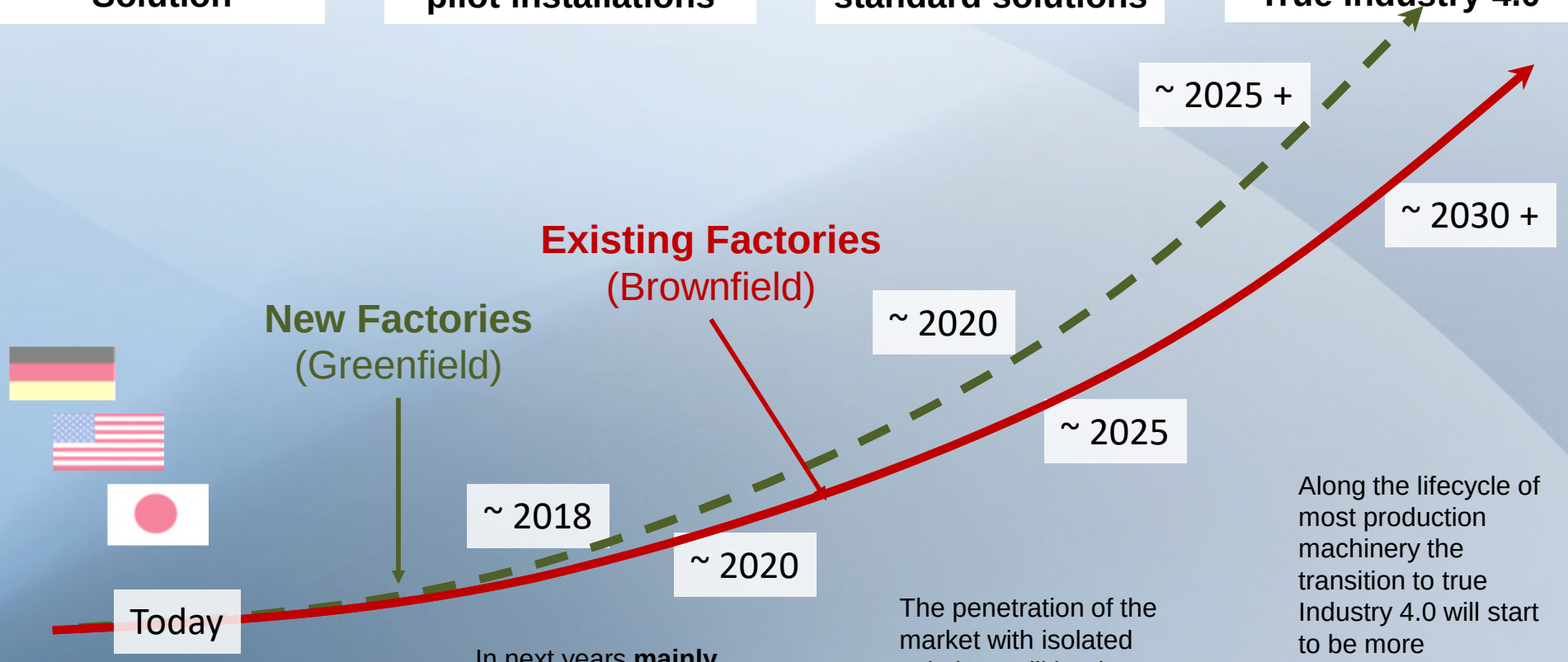
Intelligent Logistic Bins

Humanoid Robotics

Source: press review, companies websites

Industry 4.0 Roadmap

Laboratory Solution	Isolated / selective pilot installations	Broad adoption of standard solutions	Transition to "True Industry 4.0"



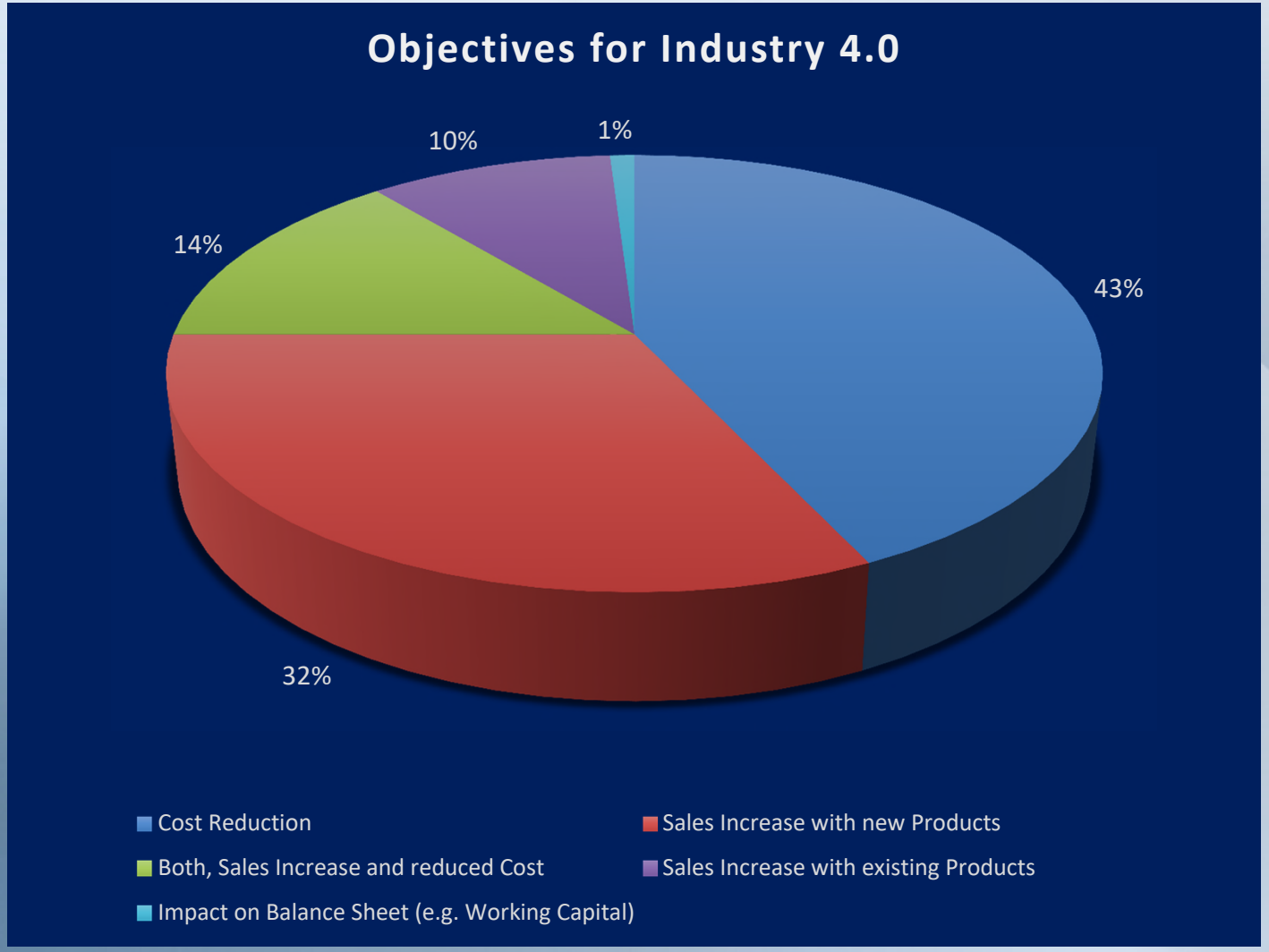
Mainly **showcases** or laboratory solutions in development

In next years **mainly technology driven** isolated standalone /plug-in solutions will be developed

The penetration of the market with isolated solutions will lead to an **interconnection of many solutions** via existing connectivity channels

Along the lifecycle of most production machinery the transition to true Industry 4.0 will start to be more comprehensive once most **machinery, infrastructure and employees are Industry 4.0 ready**

Top-Manager Expectations



Source: Roland Berger, Umfrage unter 300 Top-Managern der deutschen Wirtschaft

General Objectives

- **Connectivity** as the key factor **is linking the physical and cyber world** in each solution
- **Highly flexible** (high volume) series **production** down to batch size 1
- Individualized or **mass customized products**

That means

More Industries will move from **Make-To-Stock** towards **Make-To-Order / Make-To-Availability** !

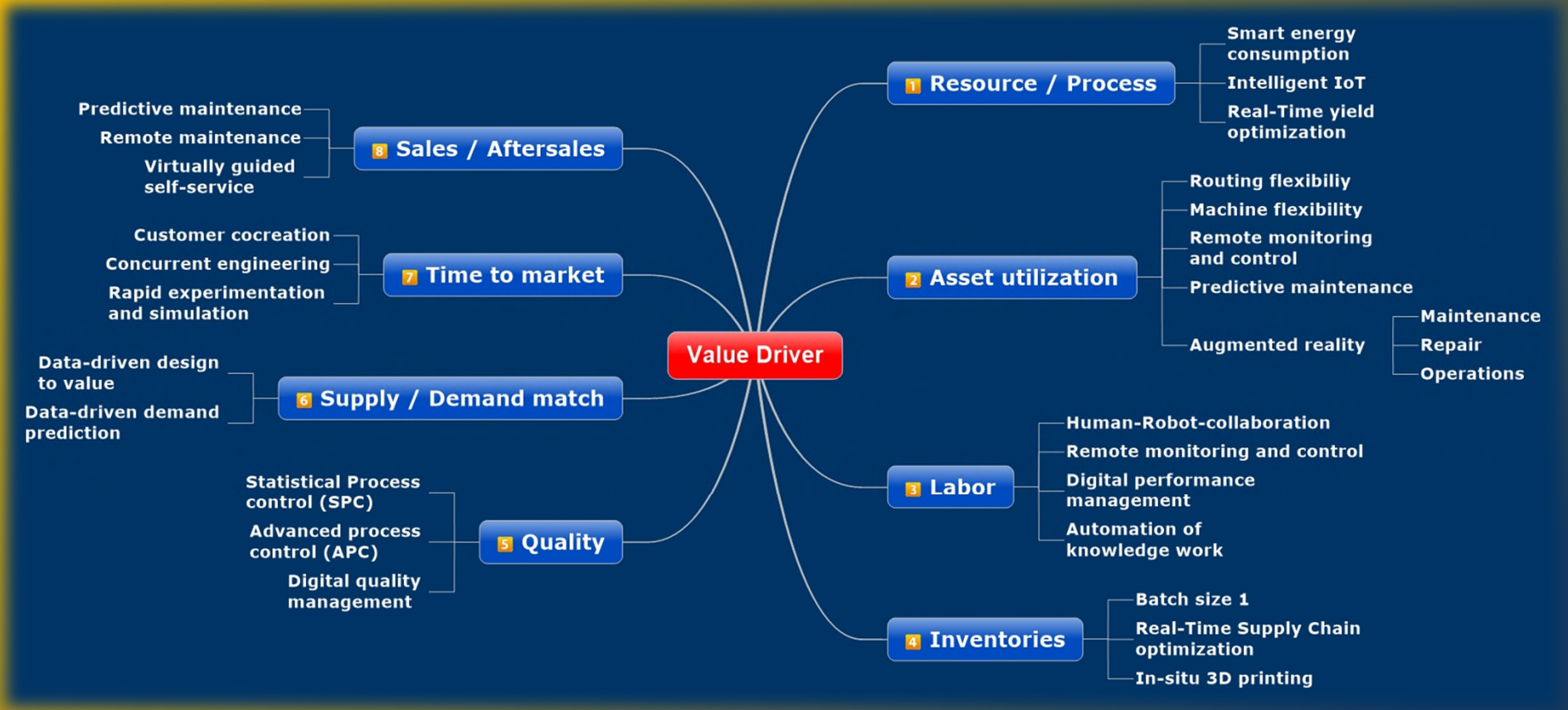
Good News !

General Objectives

- **Integration** of customers and value adding partner **into value creation**
- Coupling of **production and high-value services**
- **Cost** and **efficiency** benefits and **quality** improvements
- **Self-optimized** Production **Systems**
- **Reduction** of Production **Time**
- Higher degree of **Automation**
- Make use of **Production Data**
- …

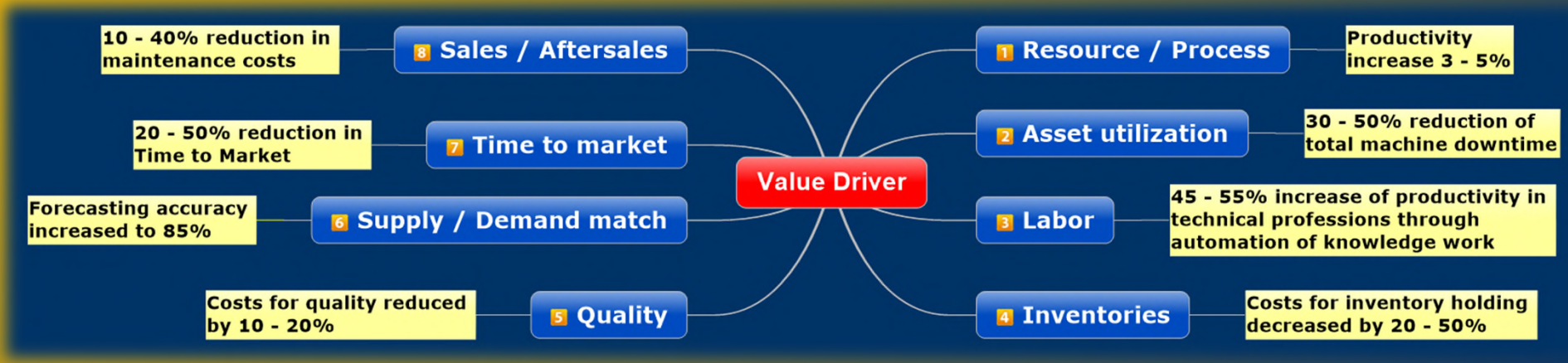
- To be more specific …

Improvement Areas



Adapted from McKinsey Digital 2015, Industry 4.0: How to navigate digitization of the manufacturing sector

Expected Improvements



Adapted from McKinsey Digital 2015, Industry 4.0: How to navigate digitization of the manufacturing sector

Connected World

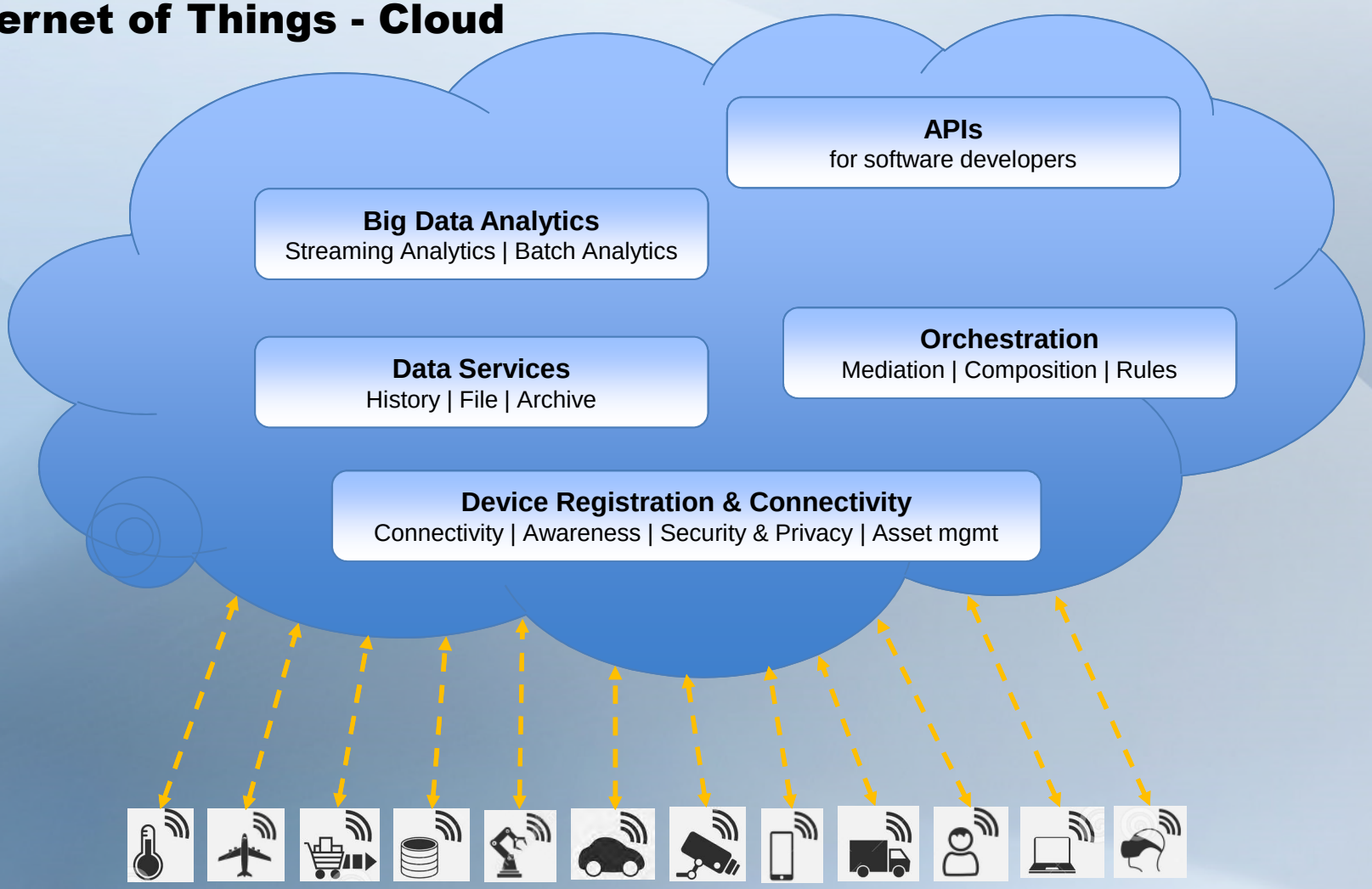
Internet of Things (IoT)

system of systems

THE INTERNET OF THINGS

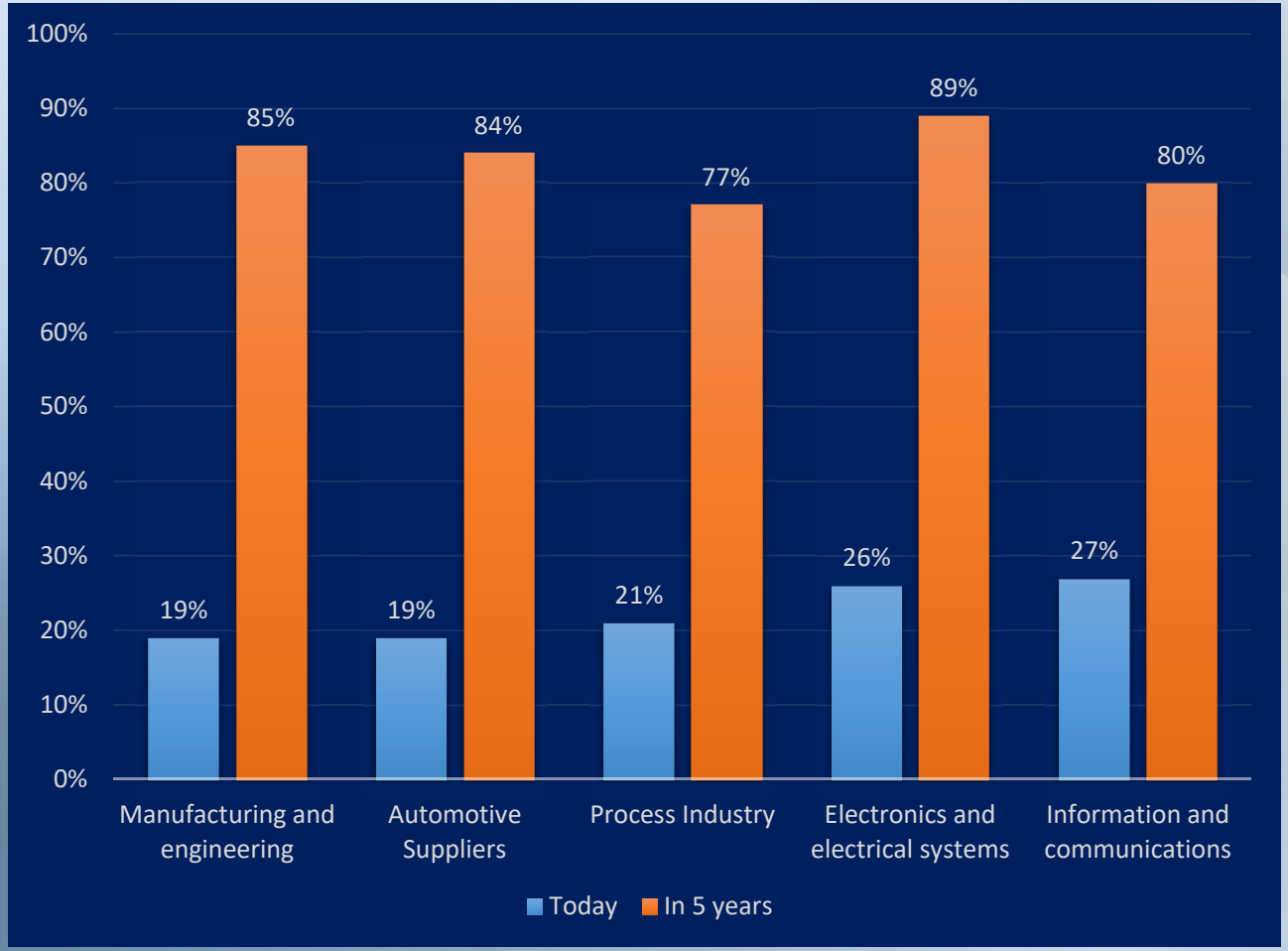
System of Systems

Internet of Things - Cloud



The digitization of value chains

Degree of digitization of the value chain by industry sector[1]



[1] Horizontal and vertical value chain.

Source: PwC, Industry 4.0 – Opportunities and challenges of the industrial internet (PDF)

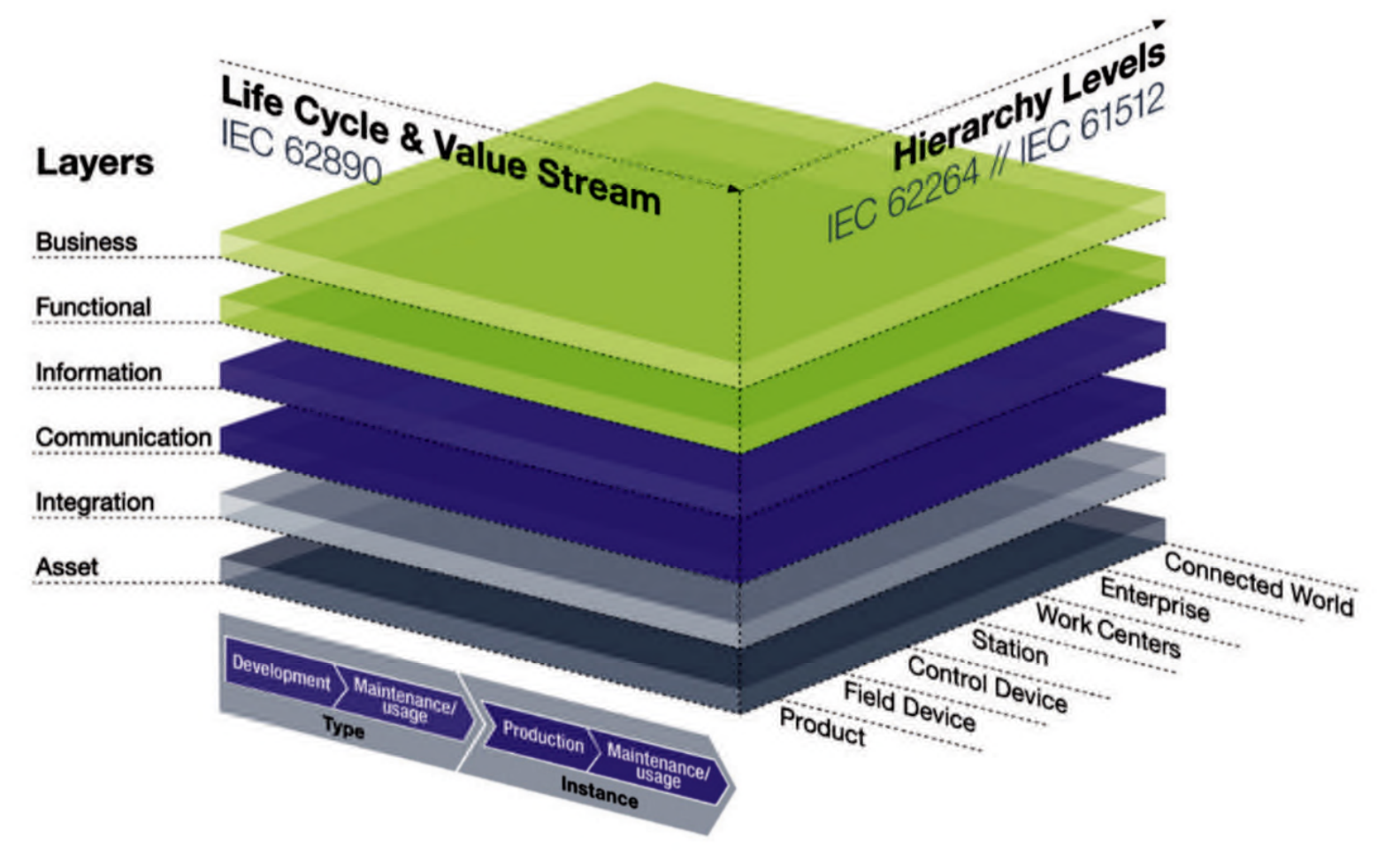
System of Systems

IoT – need for a reference architecture

Internet of Content	Internet of Services	Internet of People	Internet of Things
• Web 1.0 • Web-sites • Search • eMail • HTML	• Web 2.0 • eCommerce / eServices • all other new functions	• Social Media • Mobile enablement • HTML 5 • Wearables	• „Things“ semantically represented in the Internet • Active & Passive components • Device to device communication

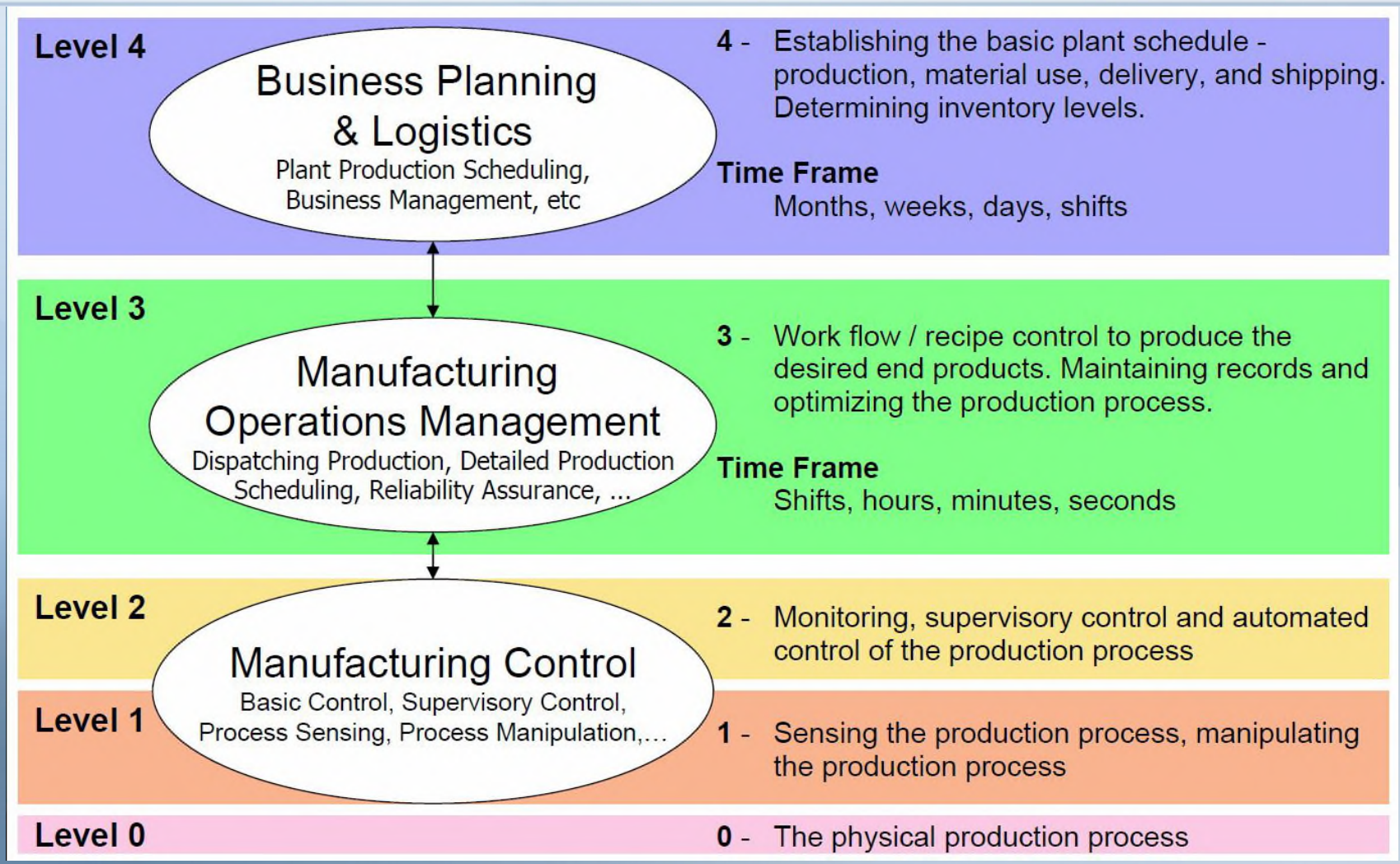
- No single definition for „Internet of Things“ but common features:
  - „Things“ have semantic representation in the Internet
  - „Things“ can be acted upon in a structured manner (e.g. status, capabilities, location, measurements) or can report in structured data or can communicate directly with other „Things“
  - „Things“ maybe active (e.g. sensor, motor or actor in general) or passive (e.g. RFID tag)
- The Internet of Things needs a Reference Architecture, like other entities of Industry 4.0

Reference Architecture Model Industrie 4.0 (RAMI4.0)



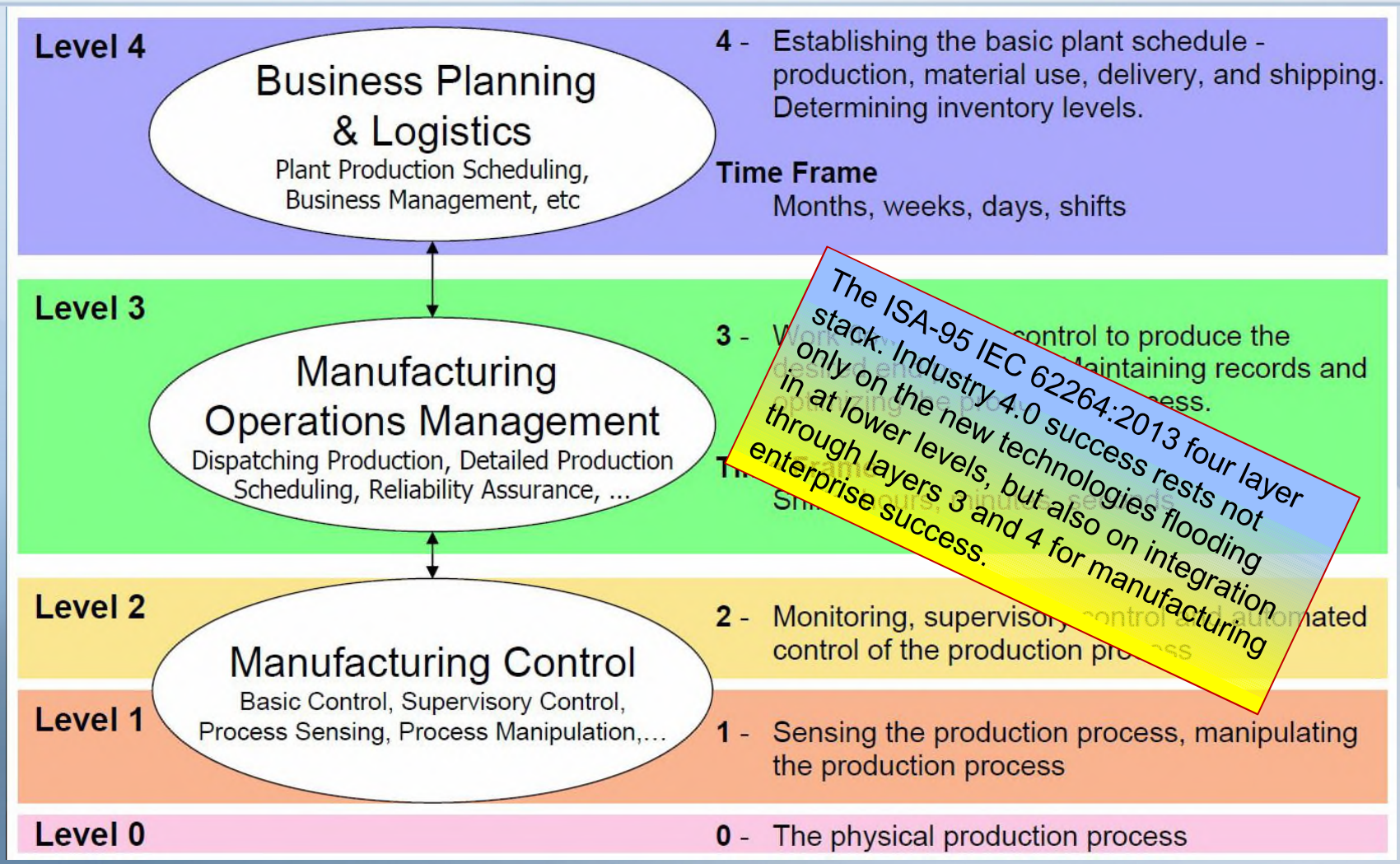
Source: https://www.vdi.de/fileadmin/vdi_de/redakteur_dateien/gma_dateien/VDI_ZVEI-Statusreport_Referenzarchitekturmodell_Industrie_4.0_-_RAMI4.0.pdf, downloaded 09.10.2016

ISA 95 IEC 62264 Levels – a distinct set of activities



Source: © 2008 BR&L Consulting, http://apsom.org/docs/T061_isa95-04.pdf

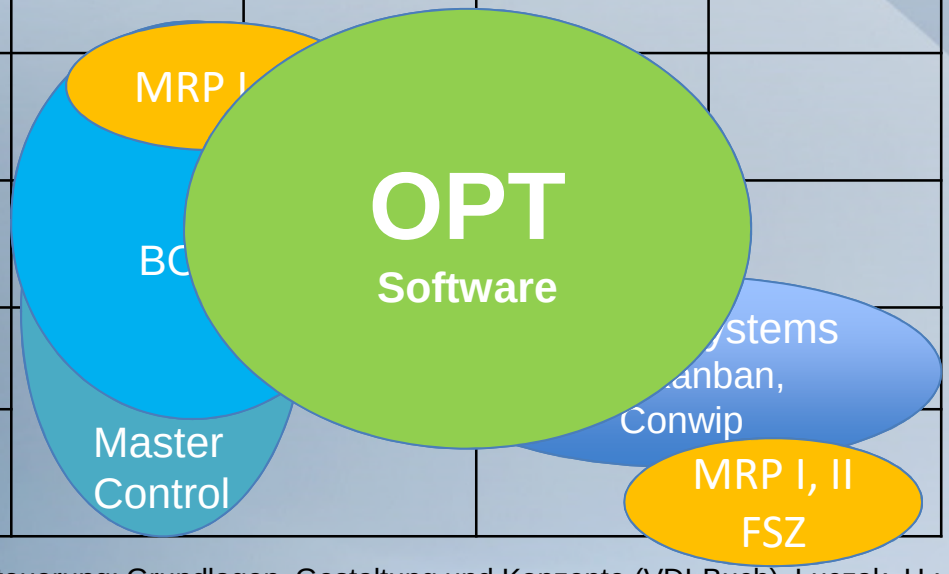
ISA 95 IEC 62264 Levels – a distinct set of activities



Source: © 2008 BR&L Consulting, http://apsom.org/docs/T061_isa95-04.pdf

Operations Planning and Control

Type of Organization		*Type of Performance*: One-Piece Production	Series Production: Small batch Production	Series Production: High Volume: Derived Standard with many Variants	Series Production: High Volume: Standard
Fixed-Site Production					
Shop Floor Principles	Job Shop / Machine Shop				
	Line Flow / Batch Manufacturing cells				
Flow Principles	Assembly Line				
	Continous / Line Production				



Adapted from the book „Produktionsplanung und -steuerung: Grundlagen, Gestaltung und Konzepte (VDI-Buch), Luczak, H.; Eversheim, W.: 2. Auflage, Springer Verlag, 1999“

Example of Scientific Proof of TOC Power

Candid Comparison of Operational Management Approaches

James R. Holt, Ph.D., PE, Jonah-Jonah
Washington State University-Vancouver
Engineering Management Program

Source: http://public.wsu.edu/~engrmgmt/holt/em530/APICS-CM.ppt

Reminder: Ten Rules of OPT

1. Utilization and activation of a resource are not the same – Activation is what should be done Utilization is what can be done “100% utilization of a non-bottleneck is wasteful.”

2. The level of utilization of a non-bottleneck is determined not by its own potential but by some other constraint in the system.

3. An hour lost at a bottleneck is an hour lost for the total system.

4. An hour saved at a non-bottleneck is just a mirage.

5. Bottlenecks govern both the throughput and inventory in the system.

6. The transfer batch may not and often should not be equal to the process batch.

7. The process batch should be variable, not fixed.

8. Capacity and priority should be considered simultaneously, not sequentially.

9. Balance flow, not capacity.

10. The sum of local optima is not equal to the global optimum.

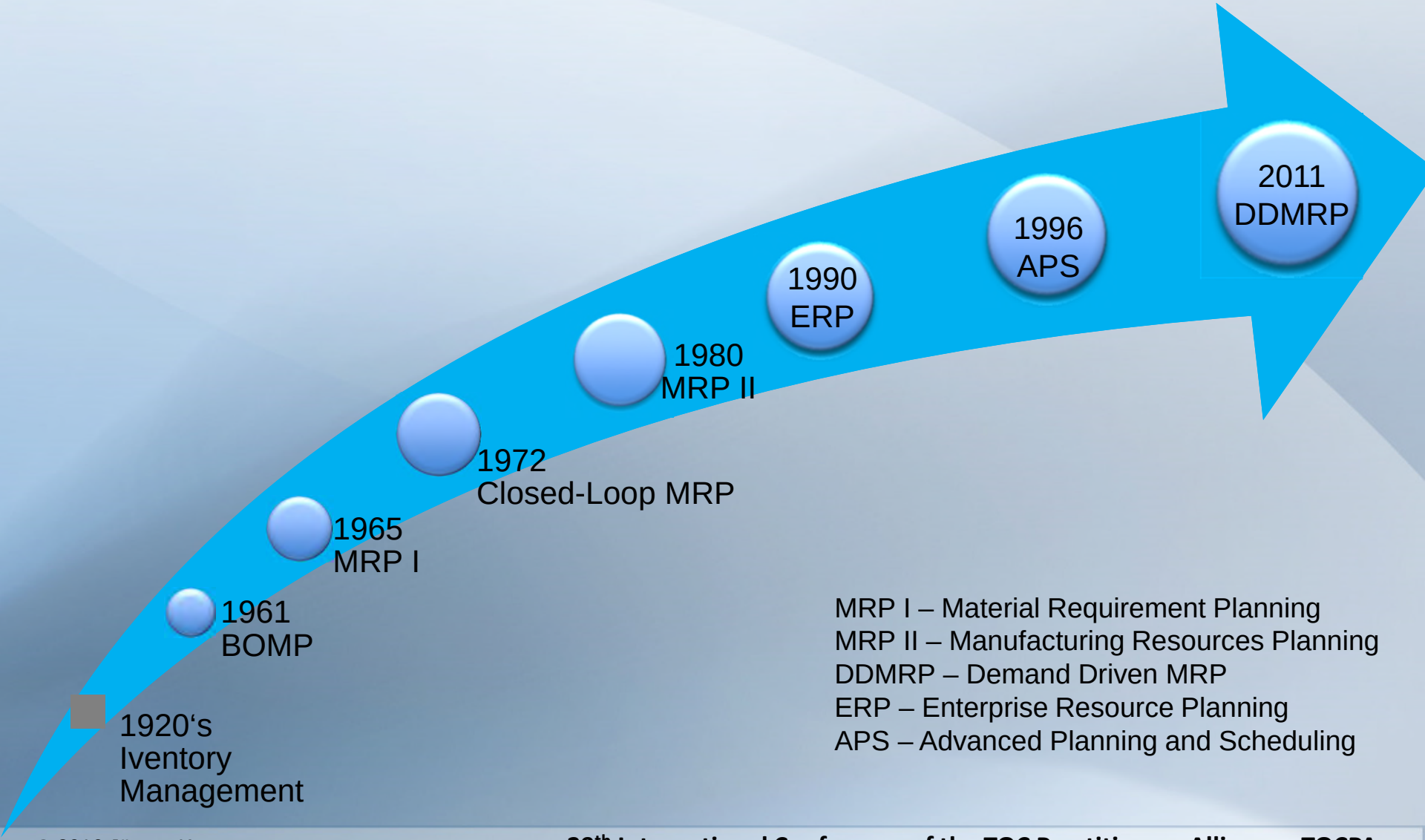
Logistic Solutions

Type of Performance / *Type of Organization*		One-Piece Production	Series Production		
			Small batch Production	High Volume	
				Derived Standard with many Variants	Standard
Fixed-Site Production					
Shop Floor Principles	Job Shop / Machine Shop				
	Line Flow / Batch Manufacturing cells				
Flow Principles	Assembly Line				
	Continous / Line Production				

Parts of TOC and DDMRP

Adapted from the book „Produktionsplanung und -steuerung: Grundlagen, Gestaltung und Konzepte (VDI-Buch), Luczak, H.; Eversheim, W.: 2. Auflage, Springer Verlag, 1999“

Material Requirement Planning



MRP I – Material Requirement Planning
MRP II – Manufacturing Resources Planning
DDMRP – Demand Driven MRP
ERP – Enterprise Resource Planning
APS – Advanced Planning and Scheduling

OPT – Optimized Production Technology 2.0

Today it's for me the umbrella of all original TOC-solutions and all derived application solutions for Operations & Supply Chain Management.

Abbreviations

DBR	Drum Buffer Rope
S-DBR	Simplified Drum Buffer Rope
CCPM	Critical Chain Project Management
DDMRP	Demand Driven Material Requirement Planning
S&T	Strategy and Tactics Trees

Why CCPM?

IF (TOUCH TIME ≤ ≈12% THROUGHPUT TIME)

THEN

DRUM – BUFFER – ROPE (DBR)

ELSE

CRITICAL CHAIN PROJECT MANAGEMENT (CCPM)

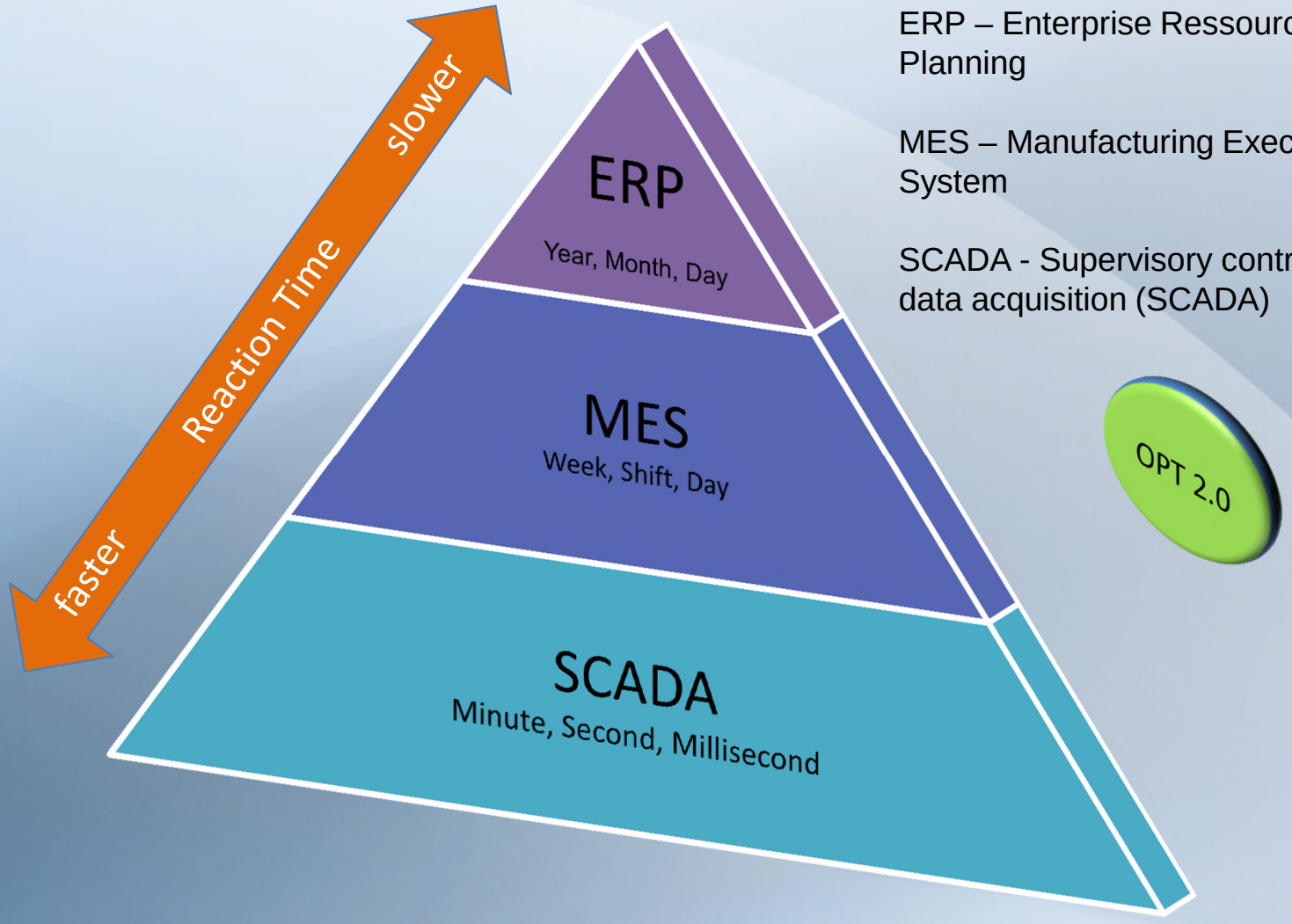
OPT – Optimized Production Technology 2.0

Today it's for me the umbrella of all original TOC-solutions and all derived application solutions for Operations & Supply Chain Management.

Industry 4.0 – Design Principles

- **Interoperability:** The ability of machines, devices, sensors, and people to connect and communicate with each other via the Internet of Things (IoT) or the Internet of People (IoP).
- **Information transparency:** The ability of information systems to create a virtual copy of the physical world by enriching digital plant models with sensor data. This requires the aggregation of raw sensor data to higher-value context information.
- **Technical assistance:** First, the ability of assistance systems to support humans by aggregating and visualizing information comprehensibly for making informed decisions and solving urgent problems on short notice. Second, the ability of cyber physical systems to physically support humans by conducting a range of tasks that are unpleasant, too exhausting, or unsafe for their human co-workers.
- **Decentralized decisions:** The ability of cyber physical systems to make decisions on their own and to perform their tasks as autonomous as possible. Only in case of exceptions, interferences, or conflicting goals, tasks are delegated to a higher level.

Software Systems

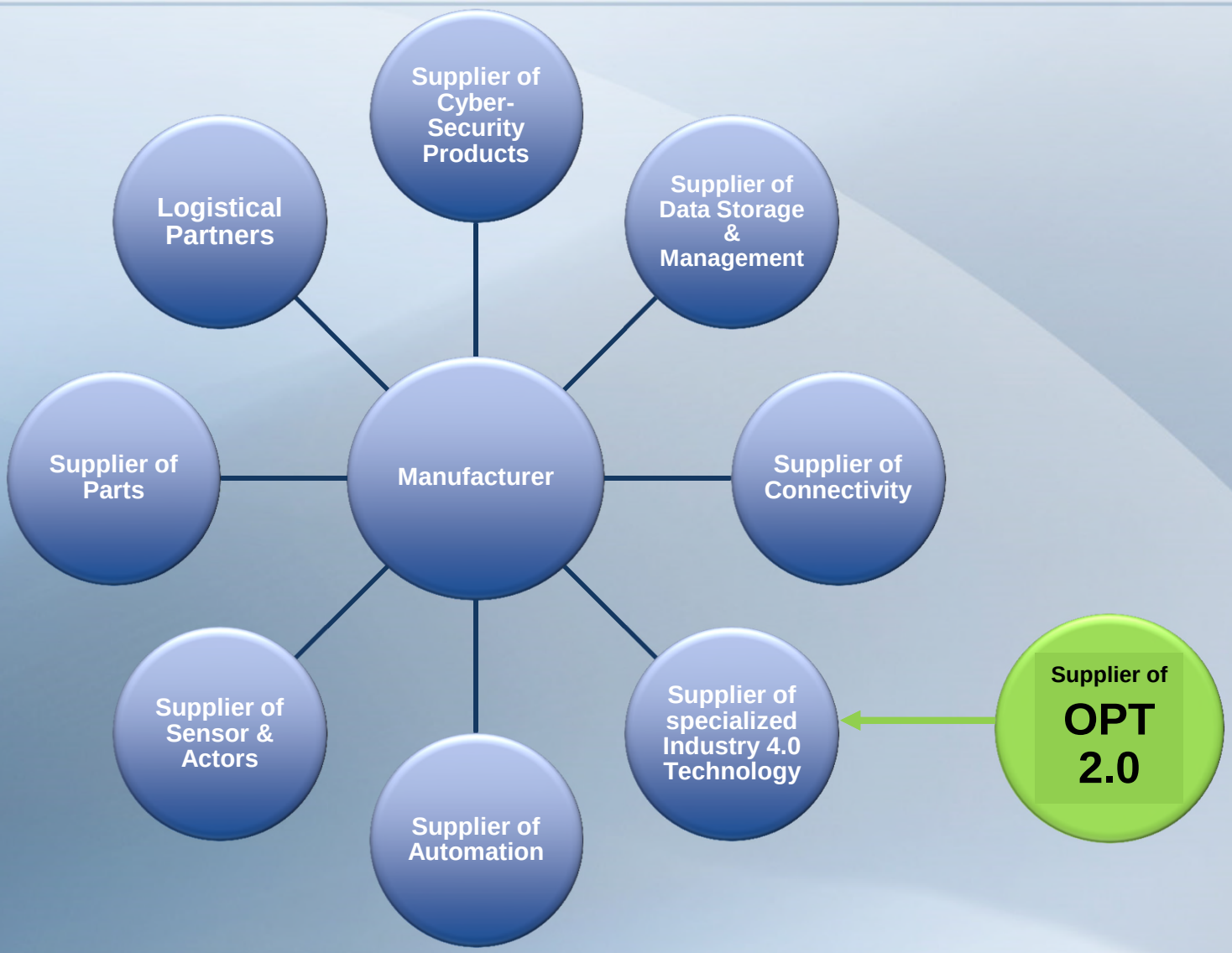


ERP – Enterprise Ressource Planning

MES – Manufacturing Execution System

SCADA - Supervisory control and data acquisition (SCADA)

Supplier Landscape in Industry 4.0



STATUS QUO

The following three slides are entirely taken from

McKinsey Digital 2016

Industry 4.0 after the initial hype - Where manufacturers are finding value and how they can best capture it

https://www.mckinsey.de/files/mckinsey_industry_40_2016.pdf

Expectations and attitudes

- **Most** German **players** (67 percent) and Japanese players (74 percent) **are** as **optimistic** about the potential of Industry 4.0 as they were a year ago while 44 percent of US companies say they have become even more optimistic.

- 90 percent say their **competitiveness will increase** or stay the same with Industry 4.0. Yet, while 89 percent expect Industry 4.0 to impact their operational effectiveness, only 80 percent foresee Industry 4.0 having an impact on their business model.

- 70 percent expect **new competitors** from other industries to use Industry 4.0 to enter their markets; this expectation is much more pronounced in the US and Japan (81 and 75 percent) than in Germany (55 percent) and among technology suppliers (80 percent) than among manufacturers (65 percent).

- **Six out of ten** survey participants consider their company **well prepared for Industry 4.0**, but this varies by region with more German and American companies (68 and 71 percent) feeling prepared than Japanese companies (36 percent).

Actions taken and progress made

- While “feeling” prepared, **only 30 percent** of technology suppliers and 16 percent of manufacturers **have an overall Industry 4.0 strategy in place**, and only 24 percent have assigned clear responsibilities for Industry 4.0.
- About half of the US and German players (50 and 56 percent) report having **made at least good/substantial progress** last year in implementing Industry 4.0 applications, while only a small fraction of Japanese players (16 percent) report this level of progress.
- Also, technology suppliers claim to have made more progress (47 percent report at least good/substantial progress) than manufacturers (of which only 37 percent report at least good/substantial progress).
- In most US, German, and Japanese companies that **have assigned clear responsibilities for Industry 4.0**, **Business Unit Heads are responsible** (33 percent). **CEOs** are driving the Industry 4.0 strategy in only 19 percent of these companies.
- Companies remain **conservative regarding their investment** in Industry-4.0-related R&D – with an average investment of only 14 percent of their R&D budget and higher shares in the US and Germany (17 and 13 percent) than in Japan (10 percent).
- Industry 4.0 applications that companies have made the most progress in implementing over the last year include smart energy consumption, real-time supply chain optimization, remote monitoring and control, digital quality management and digital performance management.

Implementation barriers

The **main implementation barriers** cited by companies were difficulties in

- coordinating actions across different organizational units (silo thinking)
- concerns about cybersecurity and data ownership when working with third-party providers
- lack of courage to push through a radical transformation and
- lack of necessary talent.

Industry 4.0

Implementation Strategy 04/2013

Enterprises are the intended target group

Source:
http://www.acatech.de/fileadmin/user_upload/Baumstruktur_nach_Website/Acatech/root/de/Material_fuer_Sonderseiten/Industrie_4.0/Final_report__Industrie_4.0_accessible.pdf

A first Summary for TOC Enthusiasts

- Industry is moving towards Make-To-Order / Make-To-Availability.
- There is a need for TOC / OPT solutions and a need for DDMRP solutions.
- These solutions should be available as software solutions (OPT 2.0) that fit into RAMI 4.0.
- There are opportunities to contribute right now in already existing working groups of Industry 4.0
- On the other hand there will be industries / firms that will remain without a higher automation level. Current tools can be sufficient.
- TOC applications for SERVICES will become more important.
- Don‘t forget the „hardware“ engineers. Still 80% of engineering projects are not in time. Show them CCPM. Too much focus on „software“ engineers can be a constraint for your own business.

A first Summary for TOC Enthusiasts

- The Thinking Processes
- The Strategy & Tactic Trees
- The „Standing on the Shoulder of Giants“ Process
- …

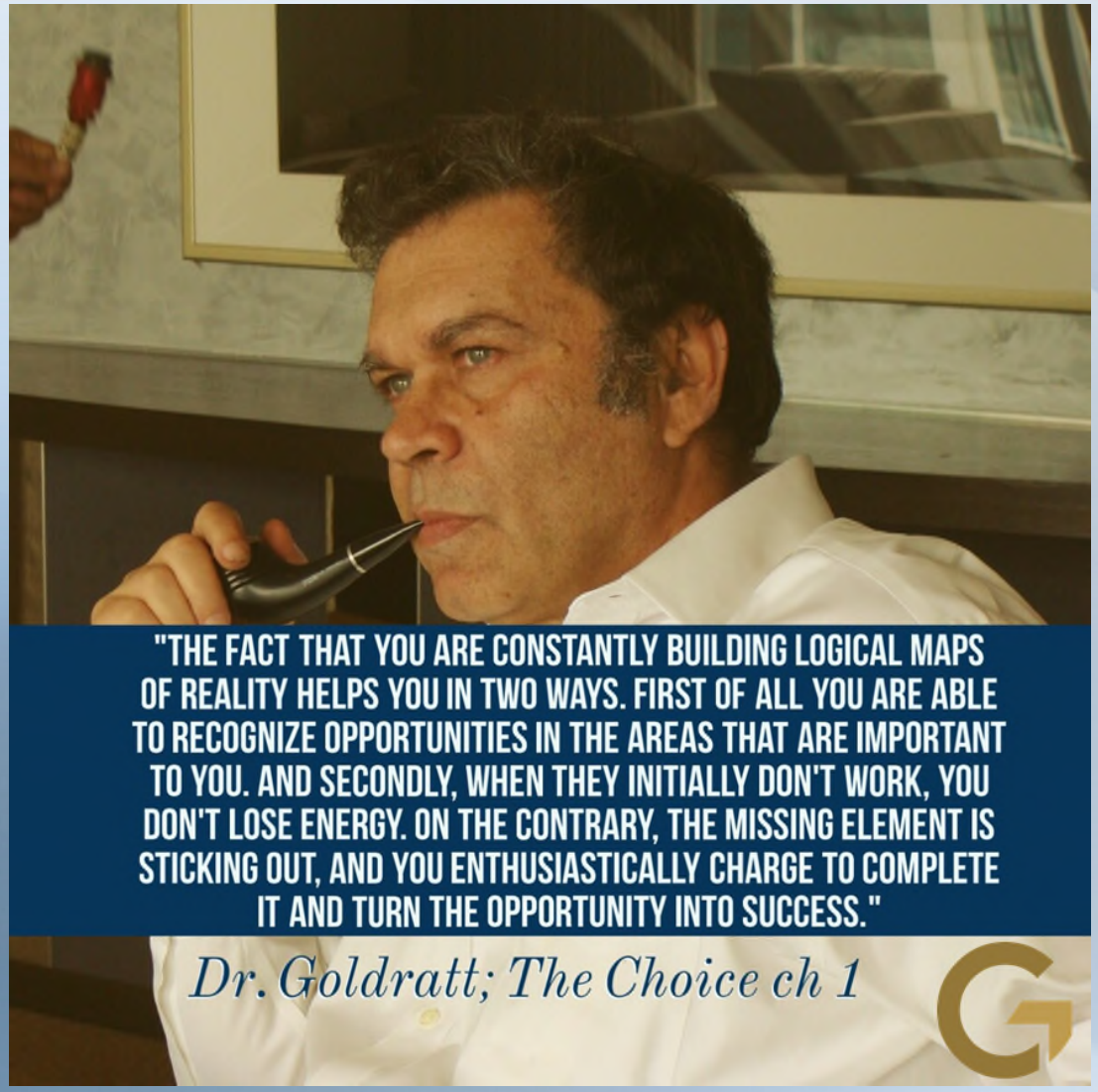
will remain, even when the industry environment will change

Industry 4.0 → Environment Change

Dr. Eli Goldratt
Father of the
Theory of Constraints
Died in 2011

"We should not expect an application to work in environments for which its assumptions are not valid.“

What to do?



Source: Goldratt Consulting

This is the **END** of my **PRESENTATION**,

but it should be **YOUR STARTING POINT**

in **INDUSTRY 4.0** with

the **Theory of Constraints** !

Acknowledgement

I am thankful to all below mentioned ministries, institutions, associations and firms for their freely available data and information about Industry 4.0 on the internet.

Federal Ministry for Economic Affairs and Energy
www.bmwi.de

WORLD ECONOMIC FORUM
www.wef.org

PLATTFORM INDUSTRIE 4.0
www.plattform-i40.de

ZVEI: Die Elektroindustrie
www.zvei.org

OECD
www.oecd.org

pwc
www.pwc.org

McKinsey&Company
www.mckinsey.com

goldratt CONSULTING
www.goldrattconsulting.com

BR&L Consulting
www.brlconsulting.com

Roland Berger
www.rolandberger.com

acatech NATIONAL ACADEMY OF SCIENCE AND ENGINEERING
www.acatech.de

VDI VEREIN DEUTSCHER INGENIEURE
www.vdi.de

A big vision for Industry 4.0

Source: World Economic Forum, Documentary | The Fourth Industrial Revolution, https://youtu.be/kpW9JcWxKq0