

THE FOURTH INDUSTRIAL REVOLUTION: HOW "INDUSTRY 4.0" BECOMES SMART PRODUCTION

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AALBORG UNIVERSITY
DENMARK

Voxpop



- How many of you had a conversation this week with a person using WhatsApp?
- How many used the Uber or Airbnb services within the last year?
- How many of you can monitor or control devices in you home using your smartphone?



Outline of the talk

- A new wave of IT innovation is transforming industry and worldwide governments are preparing for re-industrializing their countries. Visions like “Industry 4.0” and Smart Manufacturing sets the agenda for developing automated and integrated companies in the future.
 - The purpose of the presentation is to discuss how “Industry 4.0” become Smart Production.
- One of the challenges of digitizing manufacturing the supply chain is how to build capabilities for working with the new technologies and models, and how to get benefits from the innovations.
 - This presentation presents the Danish approach and outlines a Roadmap towards smart production.



Everything gets smart...

Source: Zülke, 2013

Smart phones



Smart Homes



Smart Cars



Smart Factories



Market Pull



Technology Push



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Agenda

What is the fourth industrial revolution?

- What are the central concepts, challenges and opportunities?

How will “Industrie 4.0” become Smart Production?

- Smart Production is the connection of millennial consumers, employees, smart factories and supply chains

What is the Danish approach to Smart Production?

- The AAU and MADE roadmap towards Smart Production

What are the summary and conclusions?

- Reflections from the back of the theatre



What is the fourth industrial revolution?



FIRST Industrial Revolution

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



SECOND Industrial Revolution

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



THIRD Industrial Revolution

- Use of electronic and IT systems that further automate production



FOURTH Industrial Revolution

- Use of cyber-physical systems: Distributed dynamically collaborative systems of systems



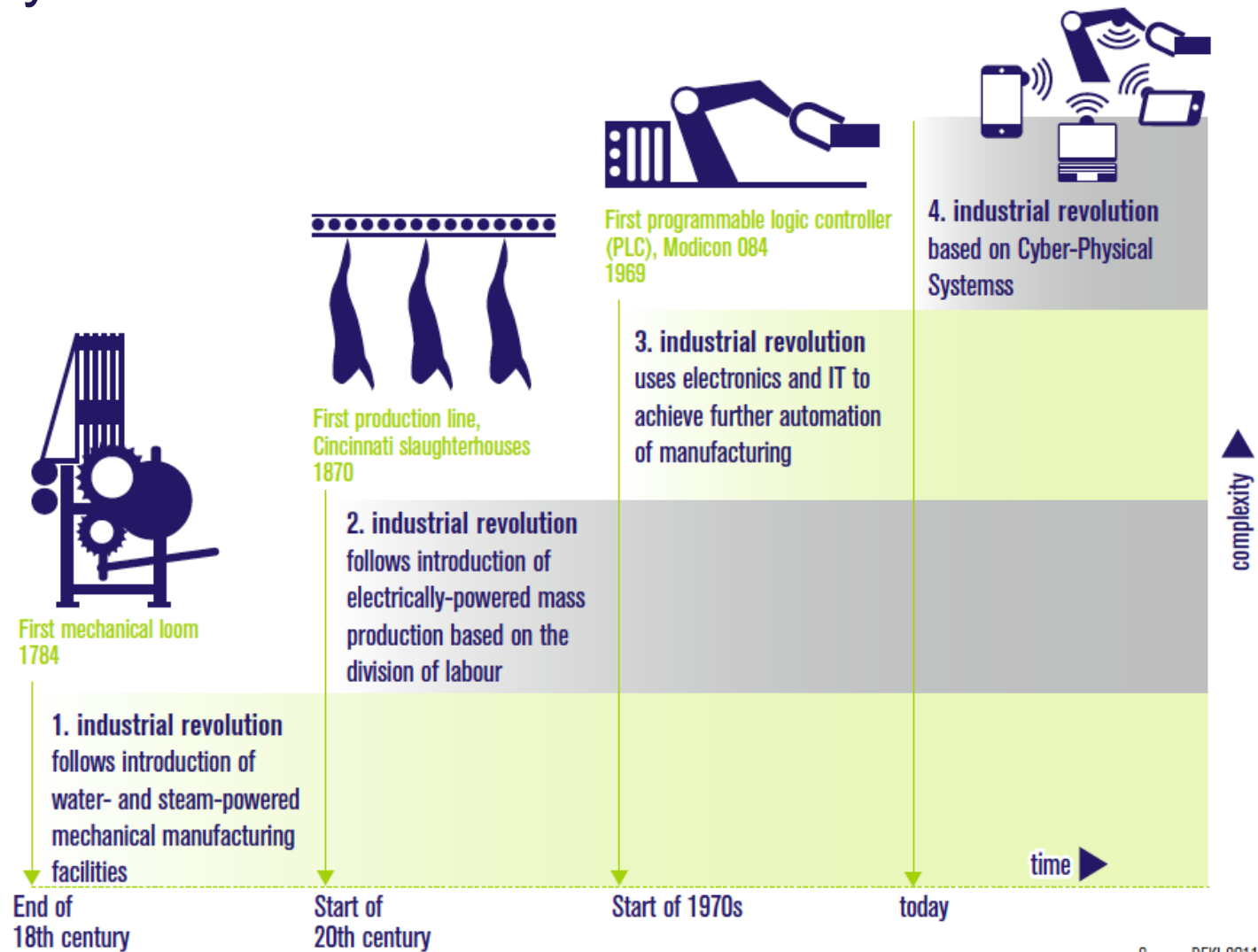
Definition: Industry 4.0

Source: <http://www.plattform-i40.de/was-industrie-40-f%C3%BCr-uns-ist>

- The term Industry 4.0 stands for the fourth industrial revolution, a new level of organization and control of the **entire value chain** of the **life cycle of products**.
 - This cycle is based on the increasing individualization of customer requirements and is aimed at covering all the steps from the idea/design, order creation and execution, delivery of a product to the end customer, further to recycling, including all the associated services.
- Industry 4.0 is based on the availability of all relevant information in **real time** by **networking** all instances involved in the value chain and collecting the **data**; as well as on the ability to derive the optimal value chain **decision** at each point in time based on the existing data.
 - By connecting people, objects and systems dynamic, real-time optimized and self-organizing, enterprise-wide value networks are created, which can be optimized according to different criteria such as, cost, availability and use of resources.



Industry 4.0: The Fourth Industrial Revolution

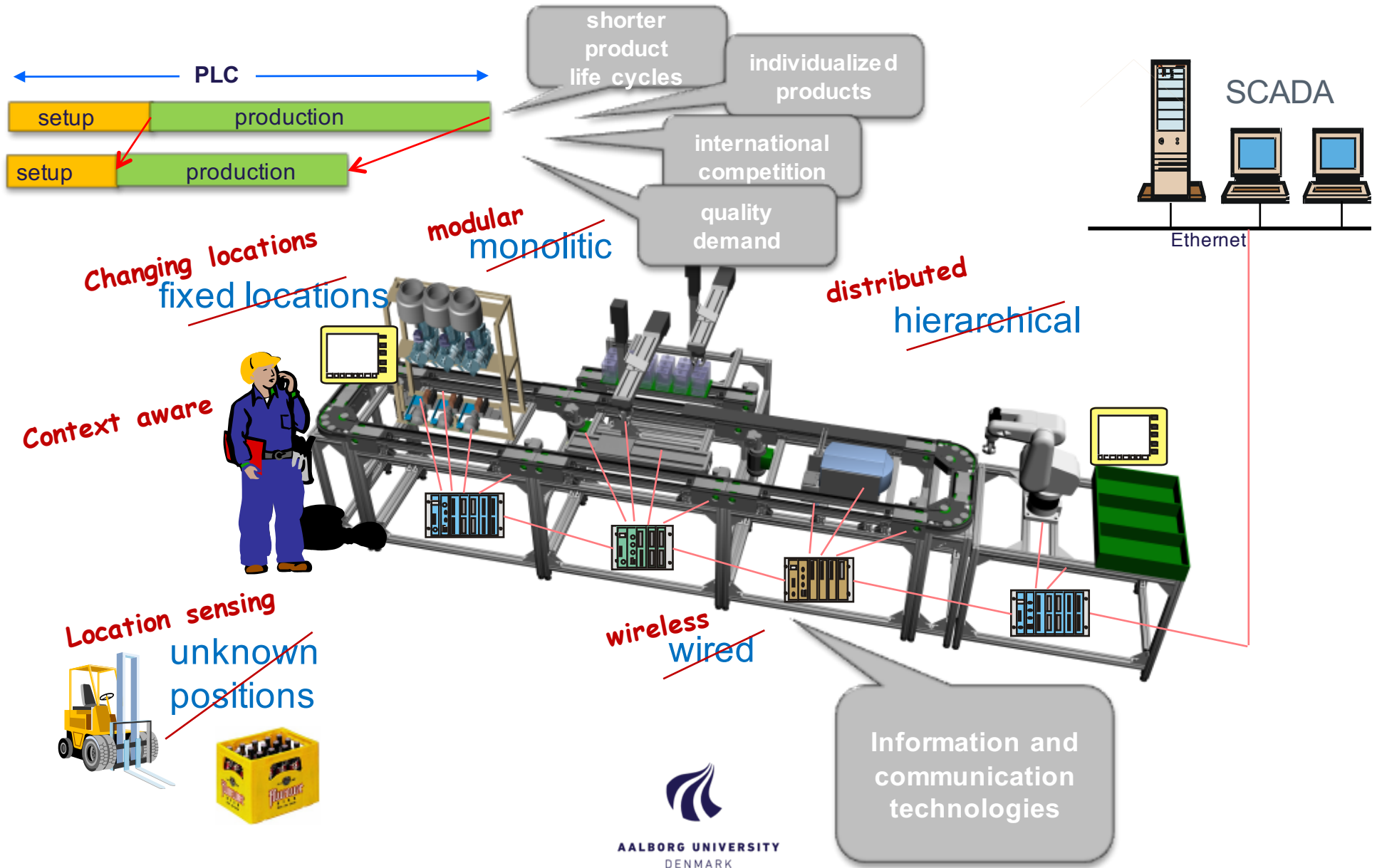


Source: DFKI 2011



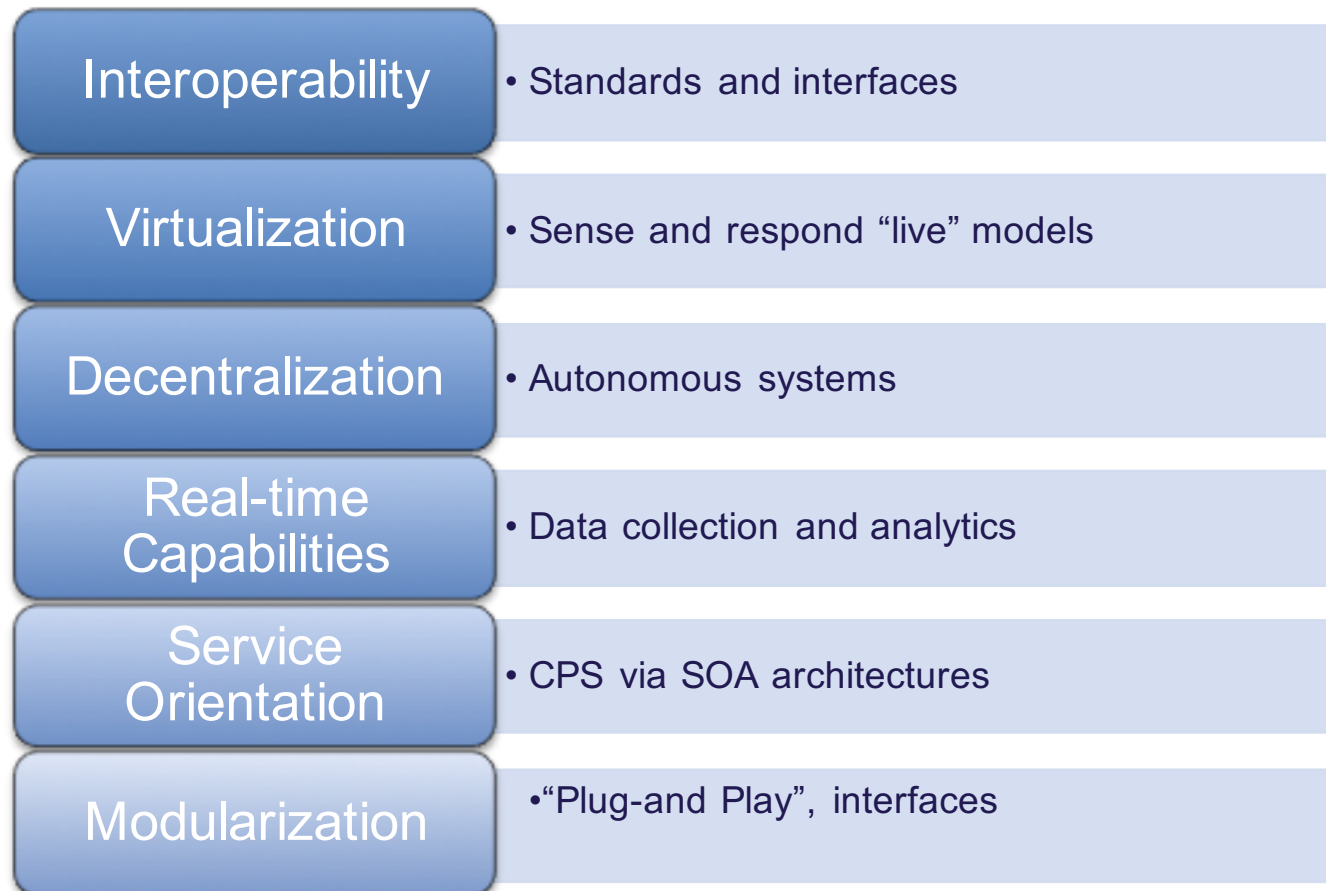
Transformation of the factory

Source: Zülke, 2013



Six Design Principles of Industry 4.0

Hermann, Pentek, Otto, 2015: Design Principles for Industrie 4.0 Scenarios



Background of Industry 4.0

- Origin
 - DFKI
 - Hannover, 2011+
 - German Government and Industry (200 mEUR)
- The Vision of Industry 4.0
 - Smart Factory
- Germany
 - As the biggest market
 - With the best vendors
- Enabling Technologies
 - Cyber Physical Systems
 - Internet of Things
 - Big Data and Analytics
 - Cloud and Mobile Computing
 - Additive Manufacturing
 - Mass Customization
- Goals
 - Cost containments
 - Flexibility and agility
 - Sustainability



Case: Toy Industry



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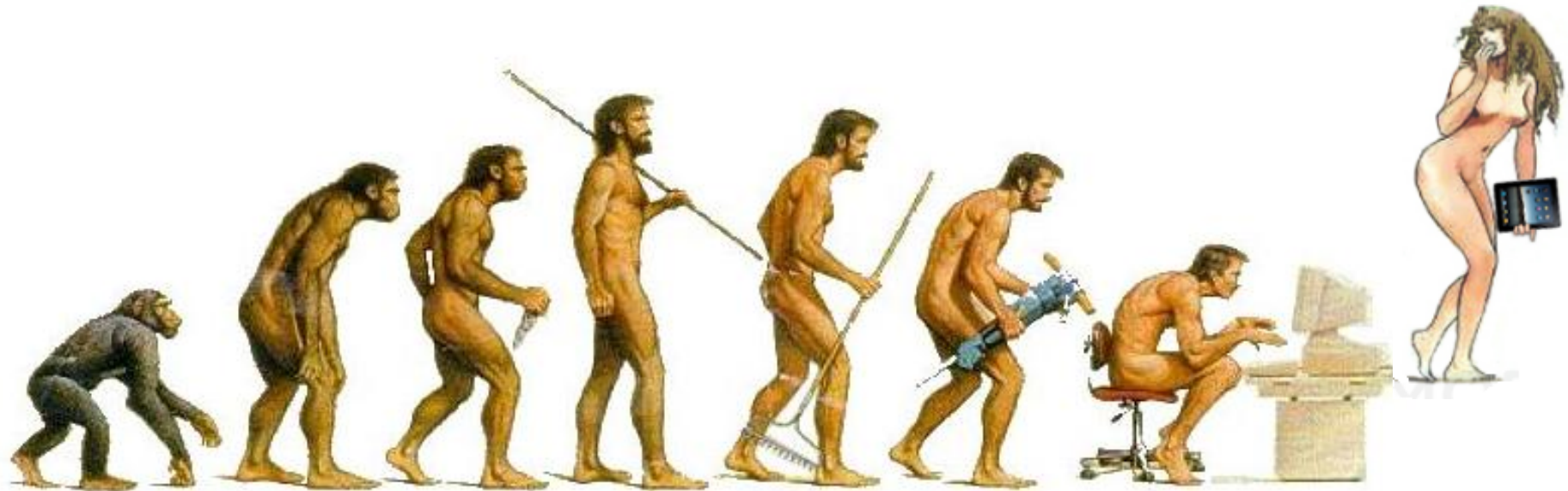
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Technology, Evolution and Innovations...



- *Predictions about IT*
 - *“I think there is a world market for maybe five computers.” - Thomas Watson (Chairman of IBM), 1943*
 - *“There is no reason anyone would want a computer in their home.” - Ken Olsen (CEO, Digital Corp.), 1977*
 - *“The internet is just a passing fad.” – Bill Gates (CEO, Microsoft), 1995*

MILLENNIAL GENERATION





SMART PRODUCTION IS THE
CONNECTION BETWEEN
MILLENNIAL CONSUMERS,
EMPLOYEES, SMART FACTORIES
AND SUPPLY CHAINS

How will “Industrie 4.0” become Smart Production?

- Smart Production is the successful marriage between Millennial consumers, employees, Smart Factories and supply chains
- To be successful require
 - something old,
 - something new,
 - something borrowed,
 - something blue,
 - and a silver sixpence in her shoe.





SOMETHING OLD SYMBOLIZES THE PAST

Computers in industry is not really a invention

- IT and Computers in industry is not really a new thing
 - Remember CIM?
- However, Industry is lagging behind on digitalization
 - Replacement of the steam engine with electrical motors
- Technological Singularity
 - Moore's Law
 - Metcalf's Law
- We cannot predict the future!

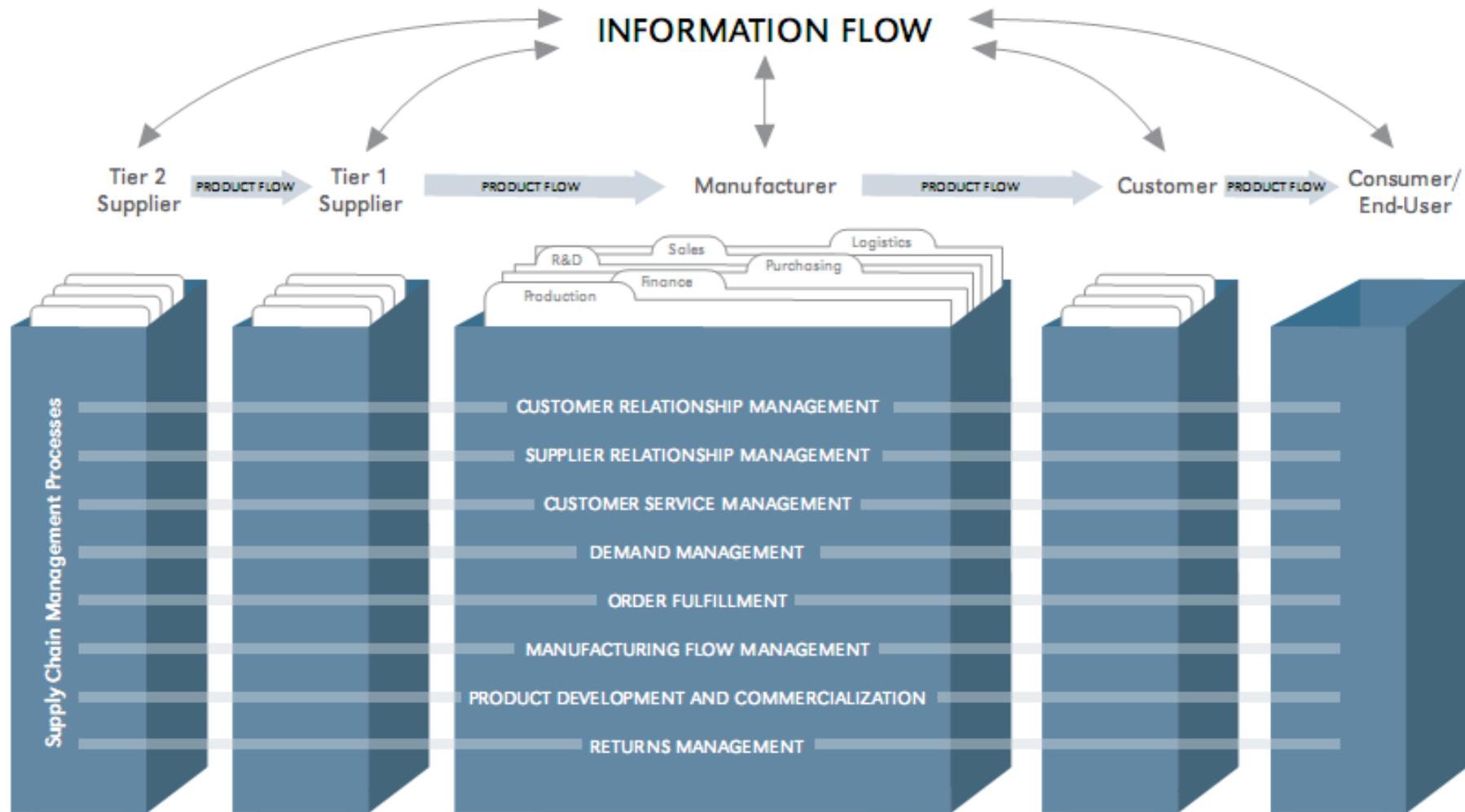




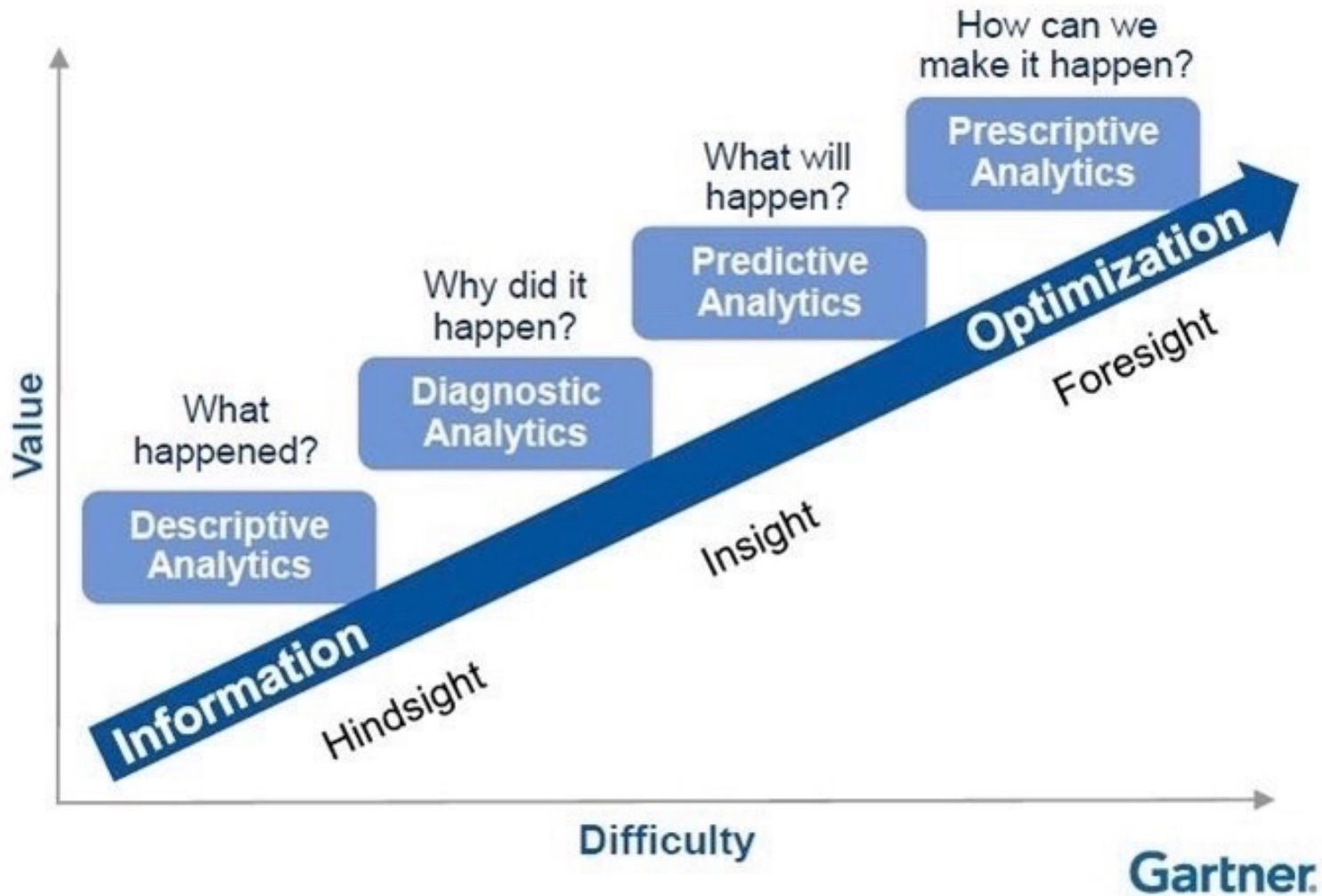
SOMETHING NEW SYMBOLIZES
GOOD FORTUNE AND SUCCESS

Smarter Supply Chain of the Future?

Source: Lambert, 2008



Require Maturity of Analytics Models



Case: Renewable Energy



Something borrowed symbolizes the love and support of family and friends

- Innovation and development of the Enabling Technologies is not driven by industry
 - Internet of Things
 - Big Data and Analytics
 - Cloud and Mobile Computing
- Industry is trying to catch up!
 - Cyber Physical Systems
 - Mass Customization
 - Additive Manufacturing
 - New business models
- Maker movement (Anderson, 2012)
 - The new industrial revolution?
- Personal fabrication...



You probably don't recognize this one?

- The FABtotum is a 3D multi-purpose personal fabrication device (36 x 36 x 36 cm)
- Print, Cut, Mill, Scan, Manipulate, Rinse and repeat
- A seamless interaction between the physical and digital world
- Build on open source components
- Crowd funded on Indiegogo
- Cost EUR 800!
- Imagine the impact this device may have on
 - Mattel?
 - Maersk Line?



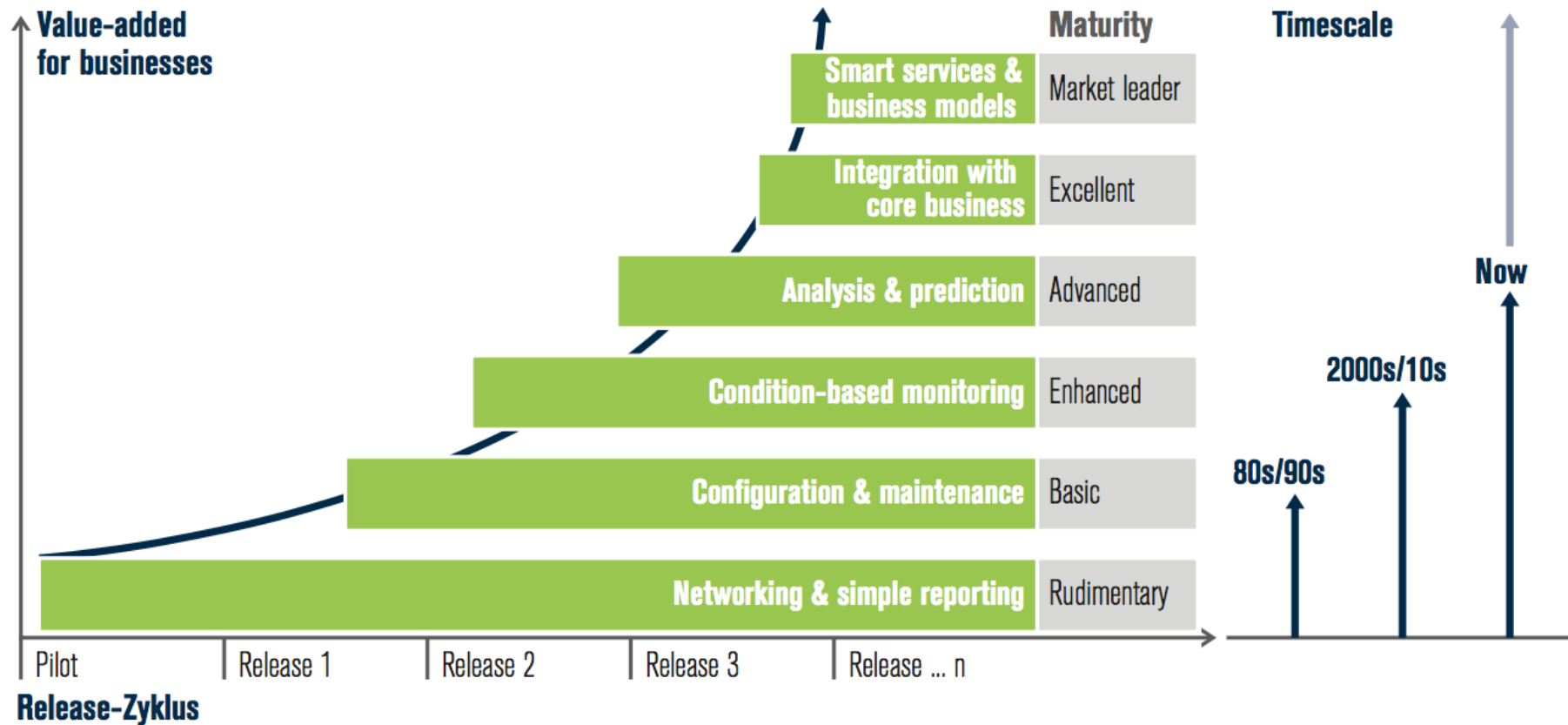
Something blue symbolizes faithfulness, and loyalty

- Digitalization is a long journey that require establishing and building digital competencies
- Learning by modeling (and failing) is a proven strategy
- Startups and SME may be able to leverage their size and the fact that they don't have an installed base to consider
 - Uber
 - Airbnb
 - WhatsApp
 - Nest...



Maturity of digital capabilities

Source: Accenture, 2015



Amazons Future Supply Chain Vision



- Customers want instant gratification!
- Digitalization disruptive to
 - Music
 - Books
 - Movies
- What about physical products?
- Intelligent fulfillment centers within 10 miles from customers
- Last mile by octocopters
- 5 lbs. package cover 83% of shipments
- 30 min delivery promise
- How?



And a silver sixpence in her shoe is a blessing for wealth...

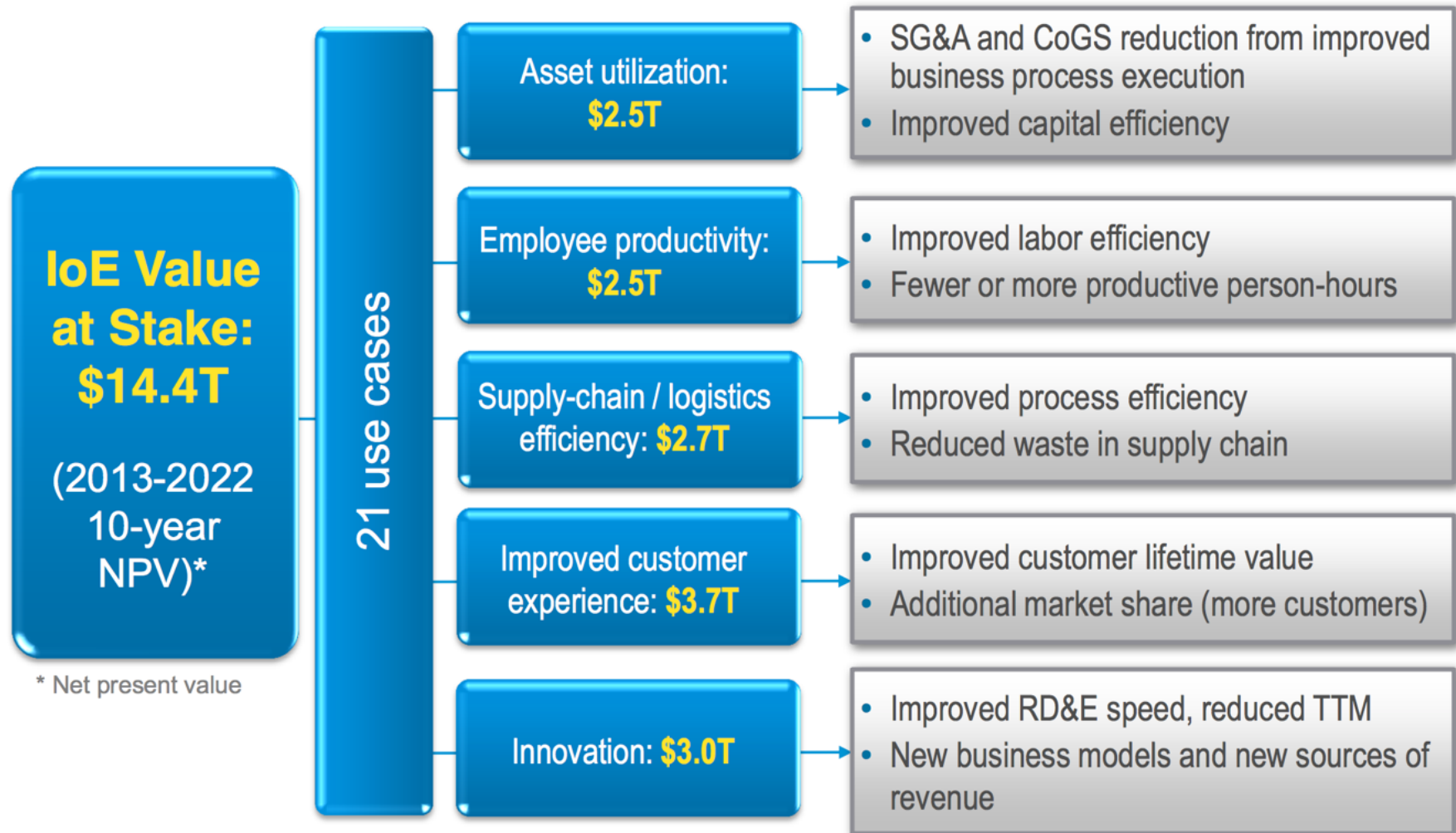


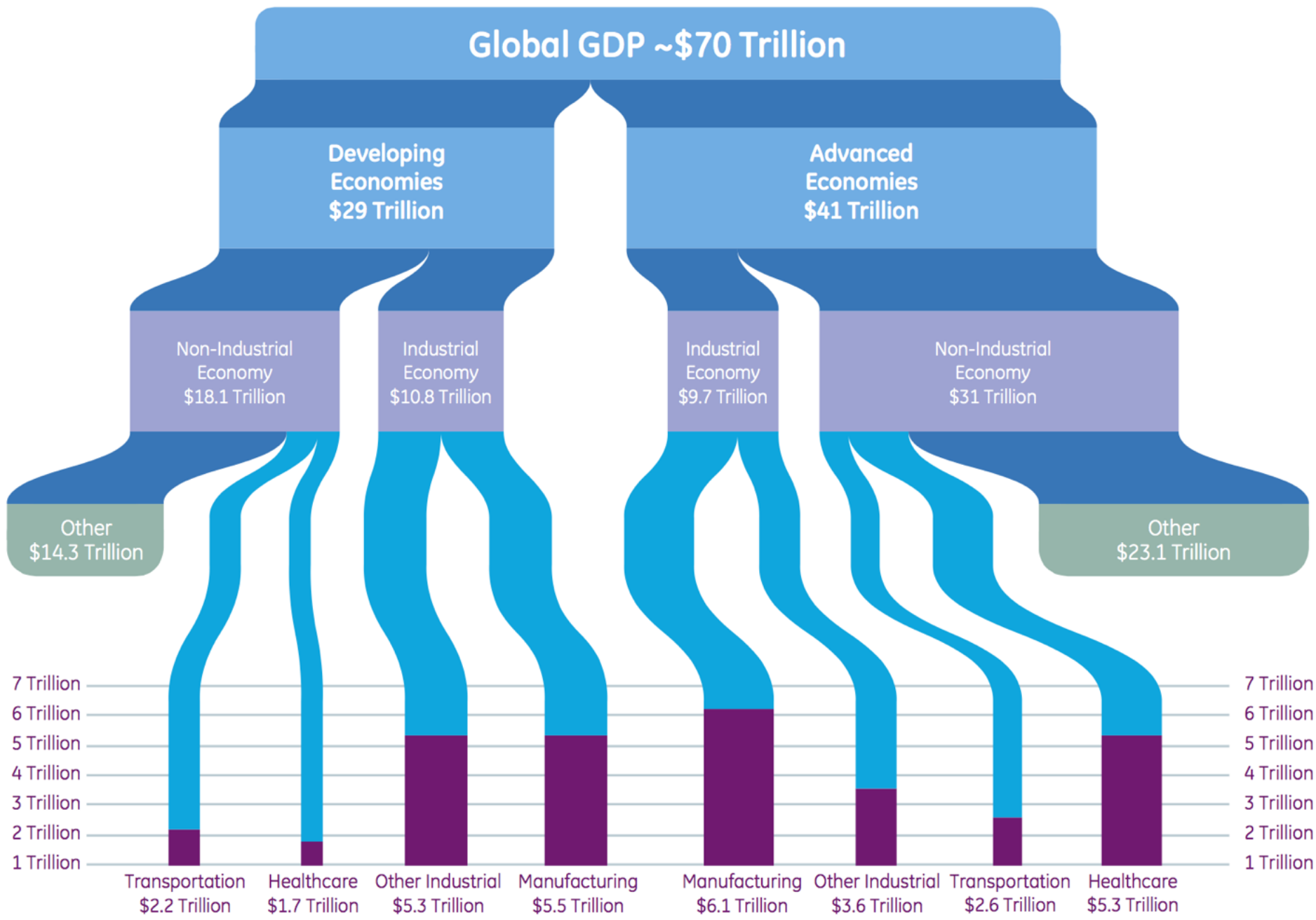
- Value at stake for the next decade (2013) by CISCO
 - 14,4 trillion USD at stake in total
 - 1,95 trillion USD from Smart Factories
- Remember: One Trillion = 10^{12}



Value Drivers

Source: CISCO, 2013





Industrial Internet opportunity (\$32.3 Trillion) 46% share of global economy today

Source: World Bank, 2011 and General Electric

Case: Automotive



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National (Re-) Industrializing Programs

Siemens, Amberg

- General Electric
 - Industrial Internet Consortium
- Germany
 - Industrie 4.0
- US
 - Smart Manufacturing
- India
 - Make in India
- Netherlands
 - Smart Industries
- Sweden
 - Produktion2030
- Denmark
 - Manufacturing Academy of Denmark (MADE)



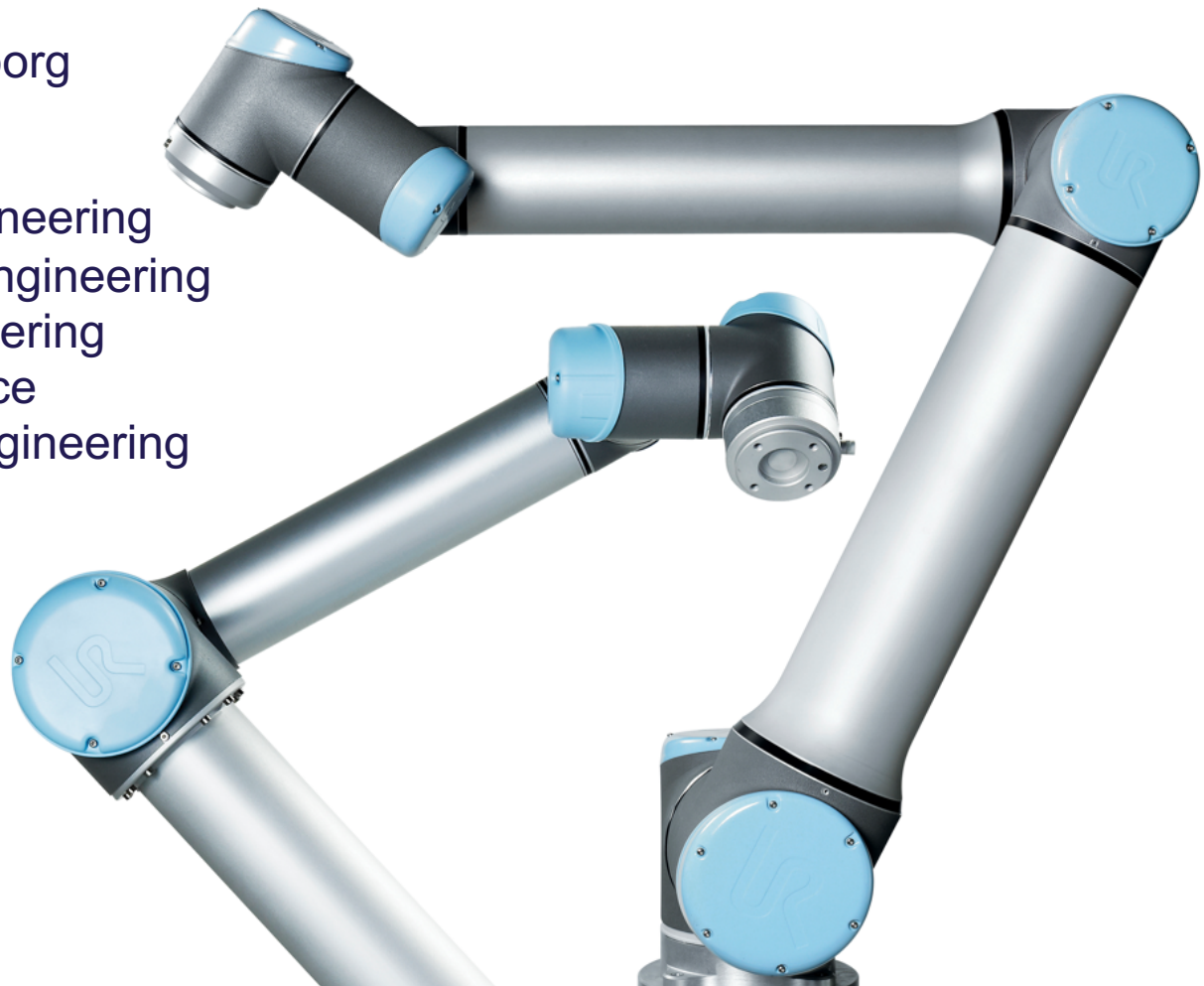
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SAP/Festo Cyber Physical Research and Learning Factory



The AAU/MADE Roadmap

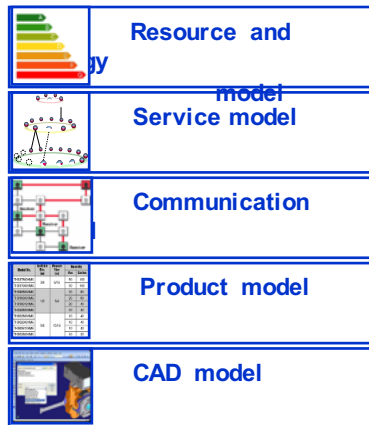
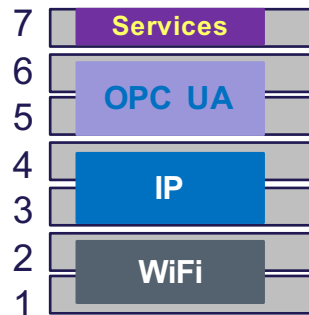
- Create a sandbox at Aalborg Universities for
 - Researchers
 - Mechanical Engineering
 - Manufacturing Engineering
 - Electrical Engineering
 - Computer Science
 - Management Engineering
 - Students
 - Vendors
 - End-users
- Create laboratory and live demonstrators
 - SME
 - Reference models...



Future products, processes and supply chains must...

Source: Adapted from Zülke, 2013

...have a standardized network interface



...be described by models

...have a unique identity and memory (by birth)

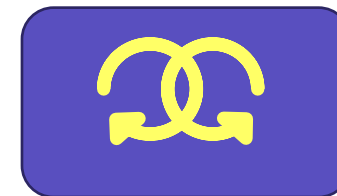


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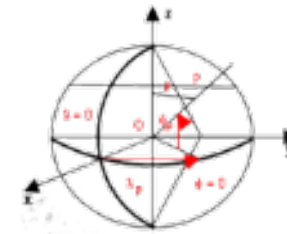


...be treated as abstract objects

...offer autonomy

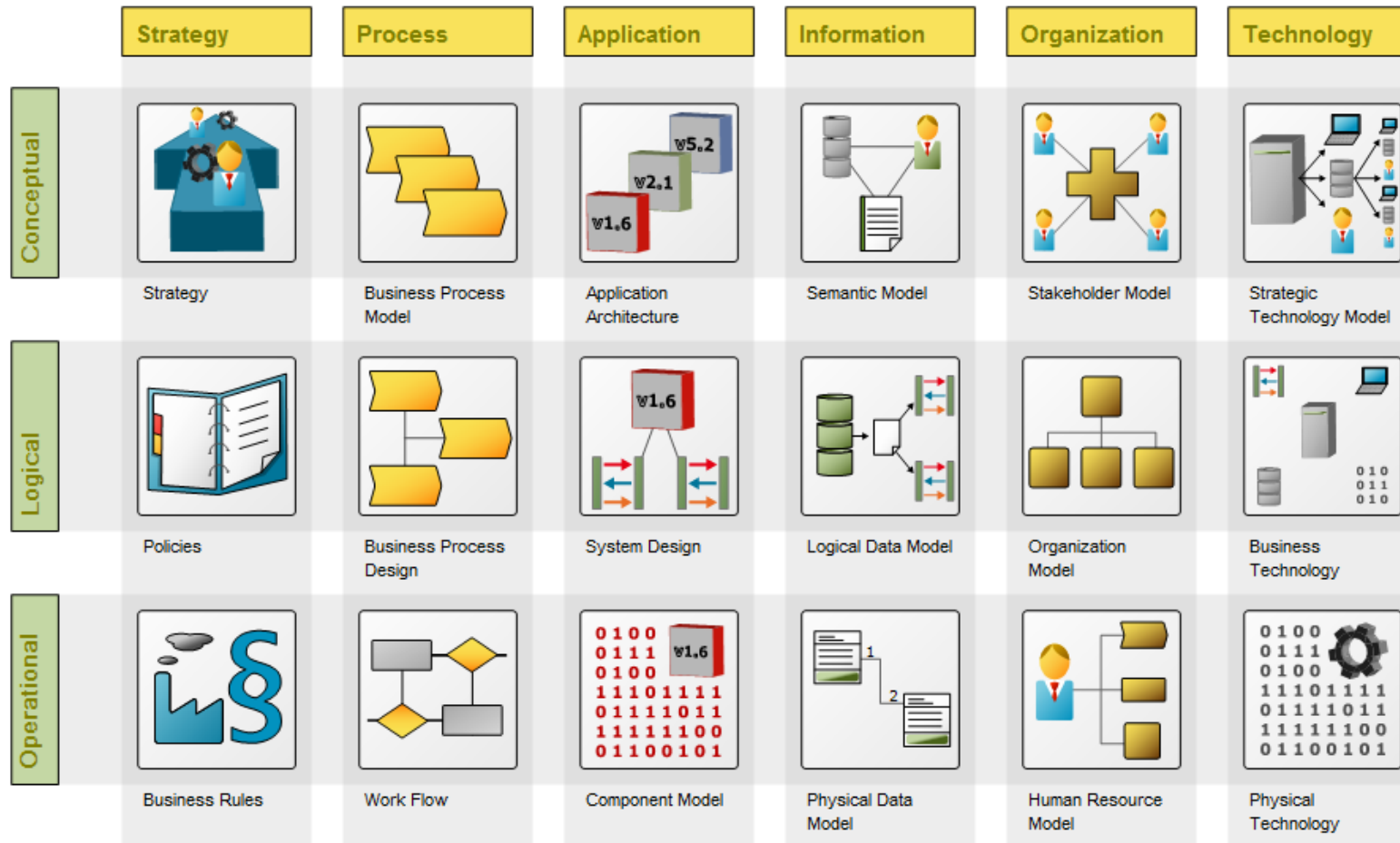


...be locatable at all times



Digitalization and EA

Source: Qualiware



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Vision: Digital Transformation

Kagermann, Wahlster & Helbig, 2013

- The journey towards the future of digital manufacturing will be an **evolutionary process**
- Current basic technologies and experience will have to be **adapted** to the specific requirements of manufacturing engineering and **innovative solutions** for new locations and new markets will have to be **explored**
- Achieving the benefits from digital manufacturing is a long-term endeavor and will involve a gradual experimental learning process involving both **technology, systems** and **management** processes
- For a company it will be key to ensure that the value of existing manufacturing systems is **preserved**
- At the same time, it will be necessary to come up with migration strategies that **deliver benefits and productivity** from an early stage.



Reflections from the back of the theater



- We don't want to talk about
 - Failed IT projects
 - Security and trust
 - And of course over-engineering
 - ...



Thanks for your Attention



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