Smart Manufacturing: opportunities and challenges

Paul Clough

PEAK INDICATORS

The University Of Sheffield.

About me

British Telecommunications

- Began working for BT as an apprentice at 16
- Electronics and software engineering

University of Sheffield

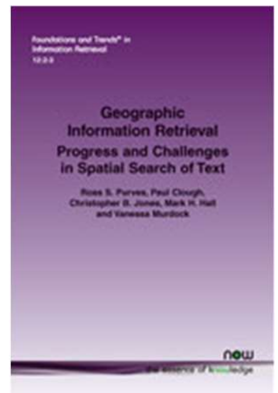
- Started in Department of Computer Science and joined iSchool in 2001
- Professor in Search & Analytics

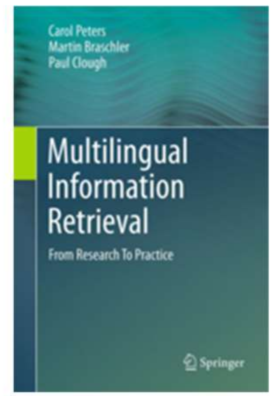
Peak Indicators

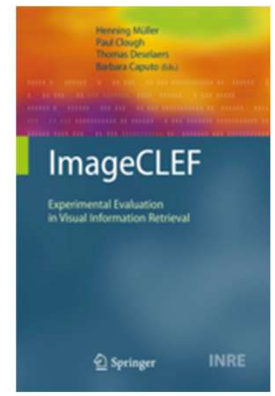
- Joined Peak in 2018
- Head of Data Science

Areas of interest

- Information Access and Retrieval
- Reuse, fabrication and falsification
- Data Science





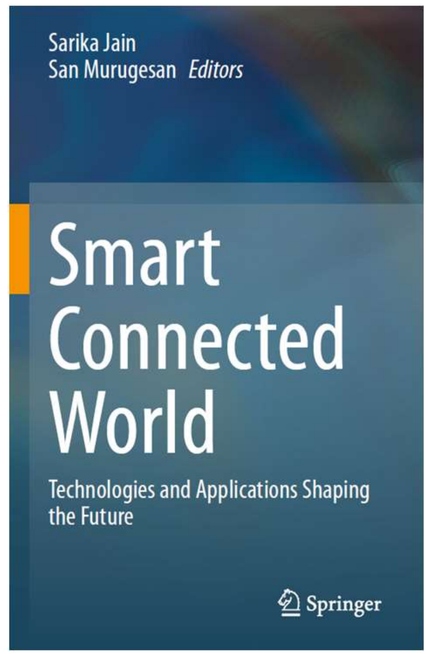


CLEF ASSOCIATION

https://scholar.google.com/citations?hl=en&user=YF03sCUAAAAJ

Outline

- The data revolution
- Smart Manufacturing
- Building blocks
  - Data generation and capture
  - From sensors to business value
  - Beyond the physical world
- Opportunities and challenges



Due: August 26, 2021

The University Of Sheffield.

AMRC Advanced Manufacturing Research Centre

Co-author: Jon Stammers

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https://www.amrc.co.uk/

We have 11 core capabilities:

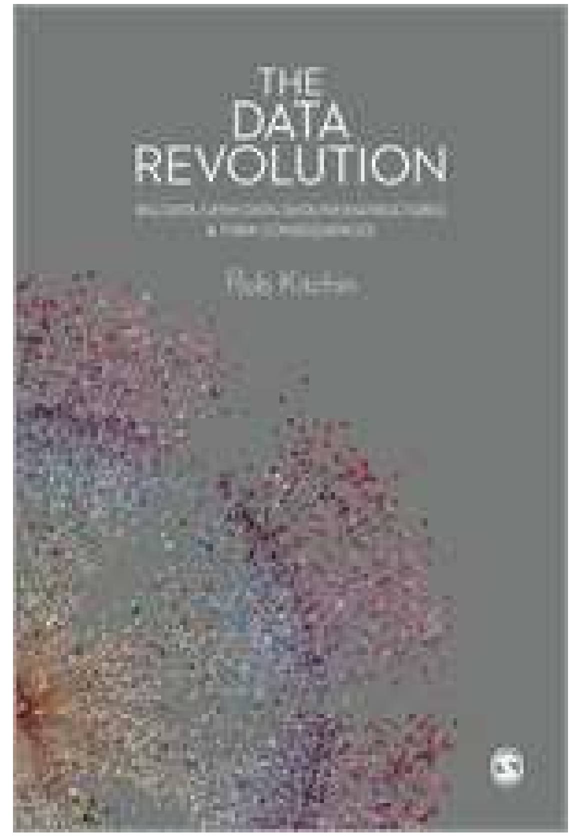
- Machining
- Integrated manufacturing
- Composite Manufacturing
- Castings
- Design & prototyping
- Structural testing
- Medical
- Additive Manufacturing
- Microscopy
- Metrology
- Manufacturing Intelligence

The data revolution

The ‘data revolution’

“Traditionally, data has been a scarce commodity which, given its value, has been either jealously guarded or expensively traded. In recent years, technological developments and political lobbying have turned this position on its head. Data now flow as a deep and wide torrent, are low in cost and supported by robust infrastructures, and are increasingly open and accessible.

A data revolution is underway, one that is already reshaping how knowledge is produced, business conducted, and governance enacted, as well as raising many questions concerning surveillance, privacy, security, profiling, social sorting, and intellectual property rights.



https://thedatarevolutionbook.wordpress.com/

The positive impact of IDTs on the UK economy over the next decade could be as high as £455 billion for UK manufacturing,[3] increasing manufacturing sector growth between 1.5 and 3 percent per annum.[4] The effect: a conservative estimated net gain of 175,000 jobs[5] throughout the economy and a reduction in CO_2 emissions by 4.5 percent.[6] Overall, from the data and evidence collated, we are confident that IDTs can improve industrial productivity by more than 25 percent.

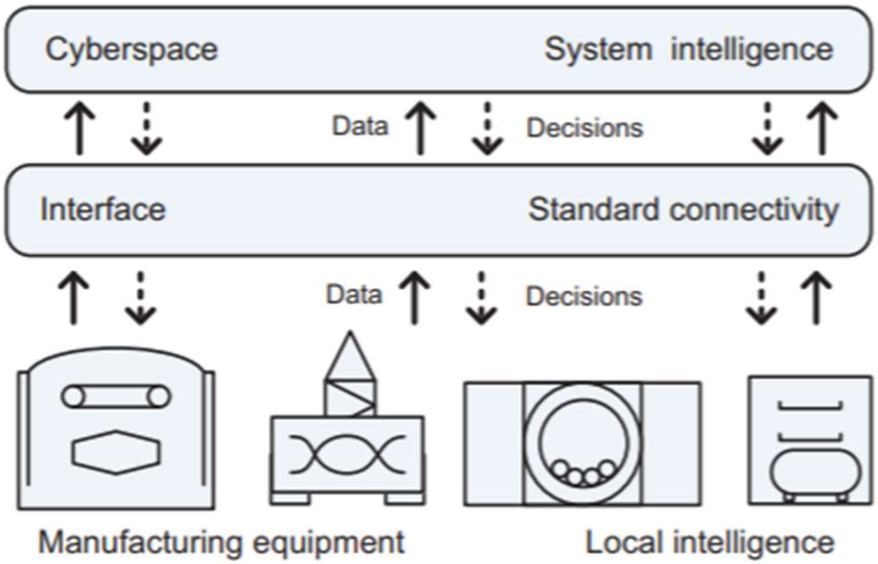
*Industrial Digital Technologies (IDTs)

HM Government

Seizing the data opportunity

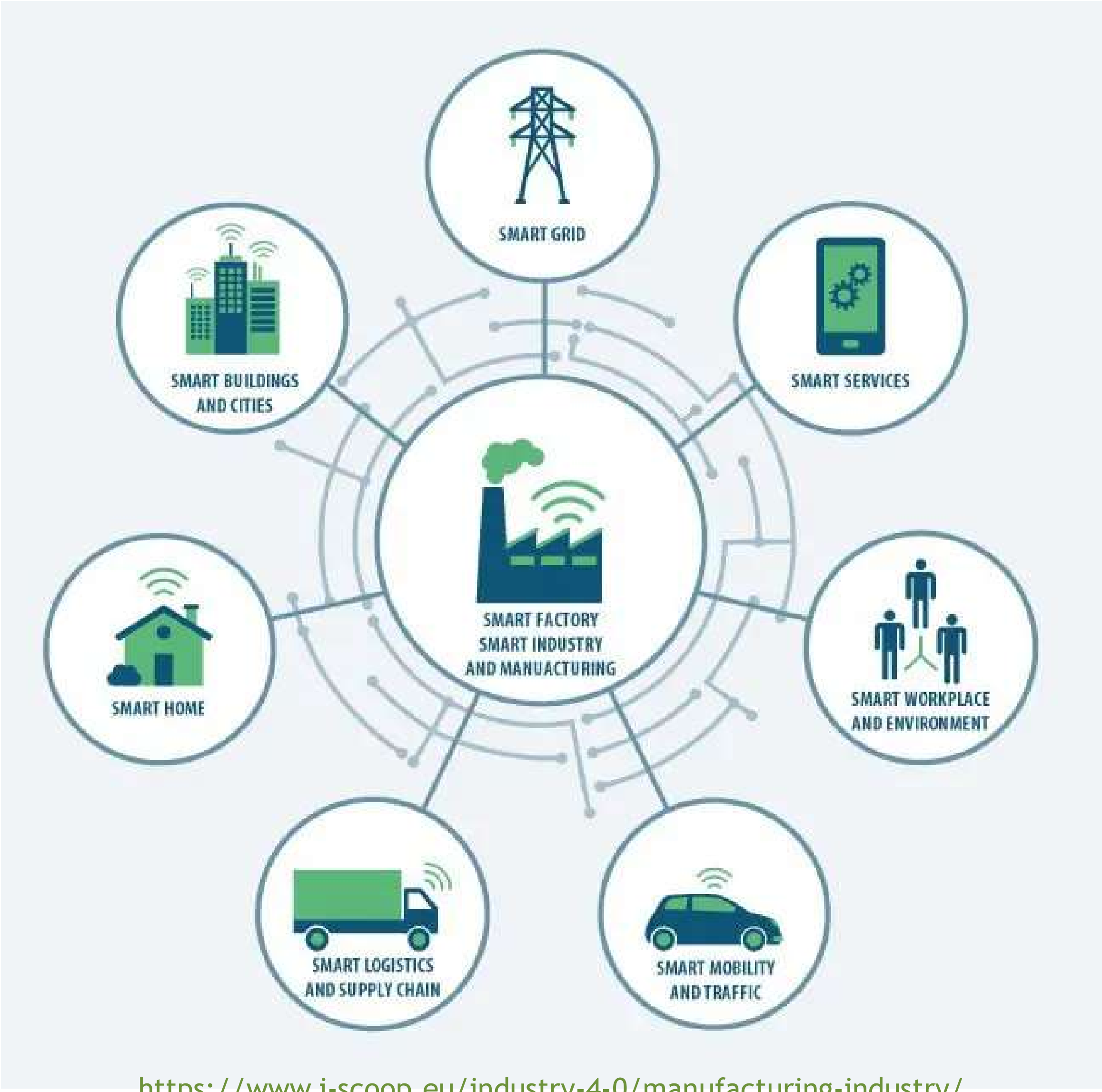
A strategy for UK data capability

Cyber-physical systems



Kusiak, A. (2018). Smart manufacturing. International Journal of Production Research, 56(1-2), 508-517.

- Manufacturers focusing on integration of physical assets with digital/cyberspace to form cyber-physical production systems
- Automation and local intelligence central to Industry 3.0
- System-wide intelligence at heart of smart manufacturing and Industry 4.0



https://www.i-scoop.eu/industry-4-0/manufacturing-industry/

Part of a smart environment

Smart manufacturing

What is Manufacturing?

Manufacturing refers to a large-scale production of goods that converts raw materials, parts, and components into finished merchandise using manual labor and/or machines. The finished goods can be sold directly to consumers, to other manufacturers for the production of more complex products, or to wholesalers who distribute the goods to retailers.

In the US manufacturing represents 15% of its economic output, including automobiles, aerospace, machinery, telecommunications.

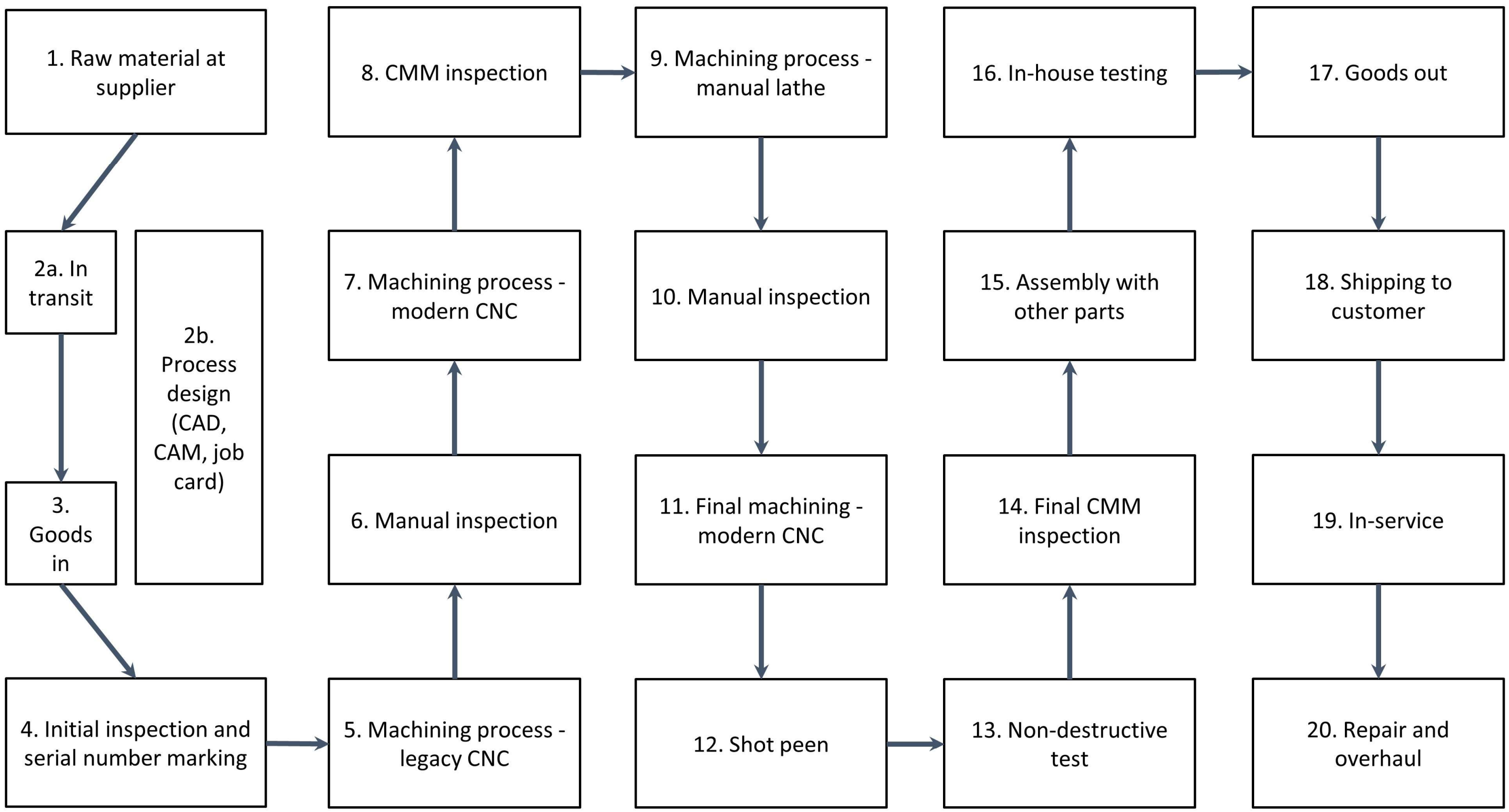
https://www.oberlo.com/ecommerce-wiki/manufacturing

> *“Manufacturing is more than just putting parts together. It’s coming up with ideas, testing principles and perfecting the engineering, as well as final assembly.*

Manufacturing process

Large-scale manufacturing uses core assets, including assembly line processes and sophisticated technologies for the mass production of goods.

https://corporatefinanceinstitute.com/resources/knowledge/other/manufacturing/



An example manufacturing process of high-value components (e.g. fabrication of metal components and assembly) - includes product life before and after

CNC – Computerised Numerical Control (production equipment controlled by software)
CMM – Coordinate Measuring Machine (inspection and testing)

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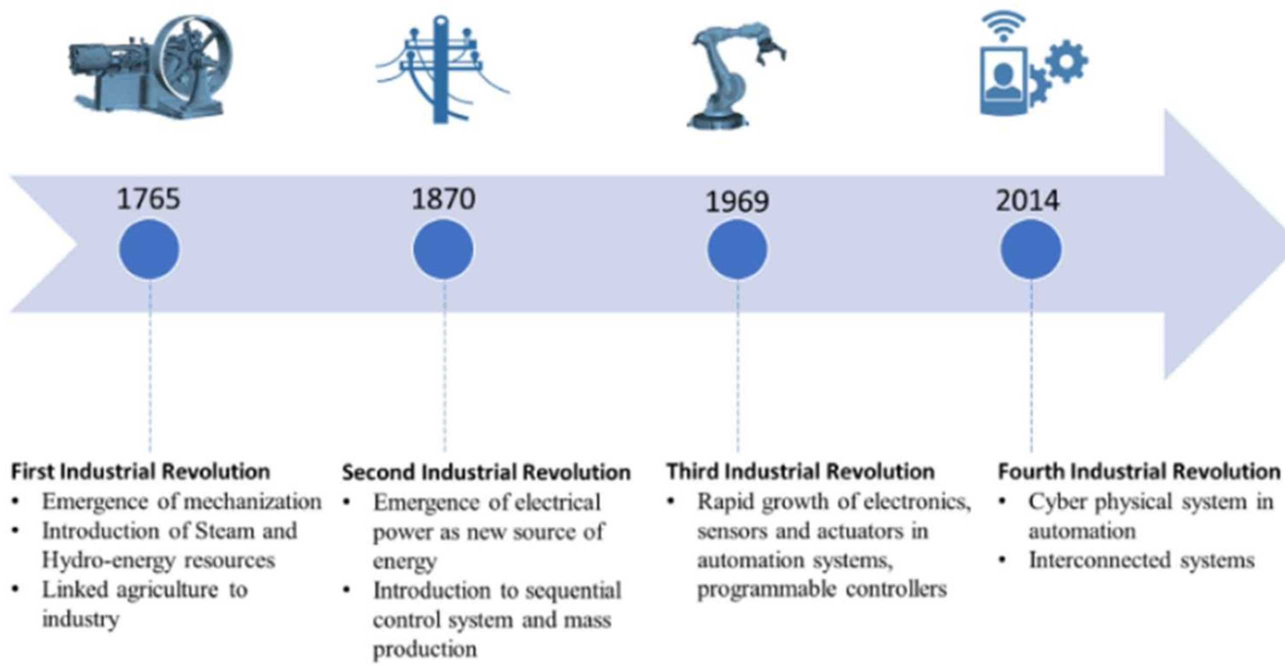
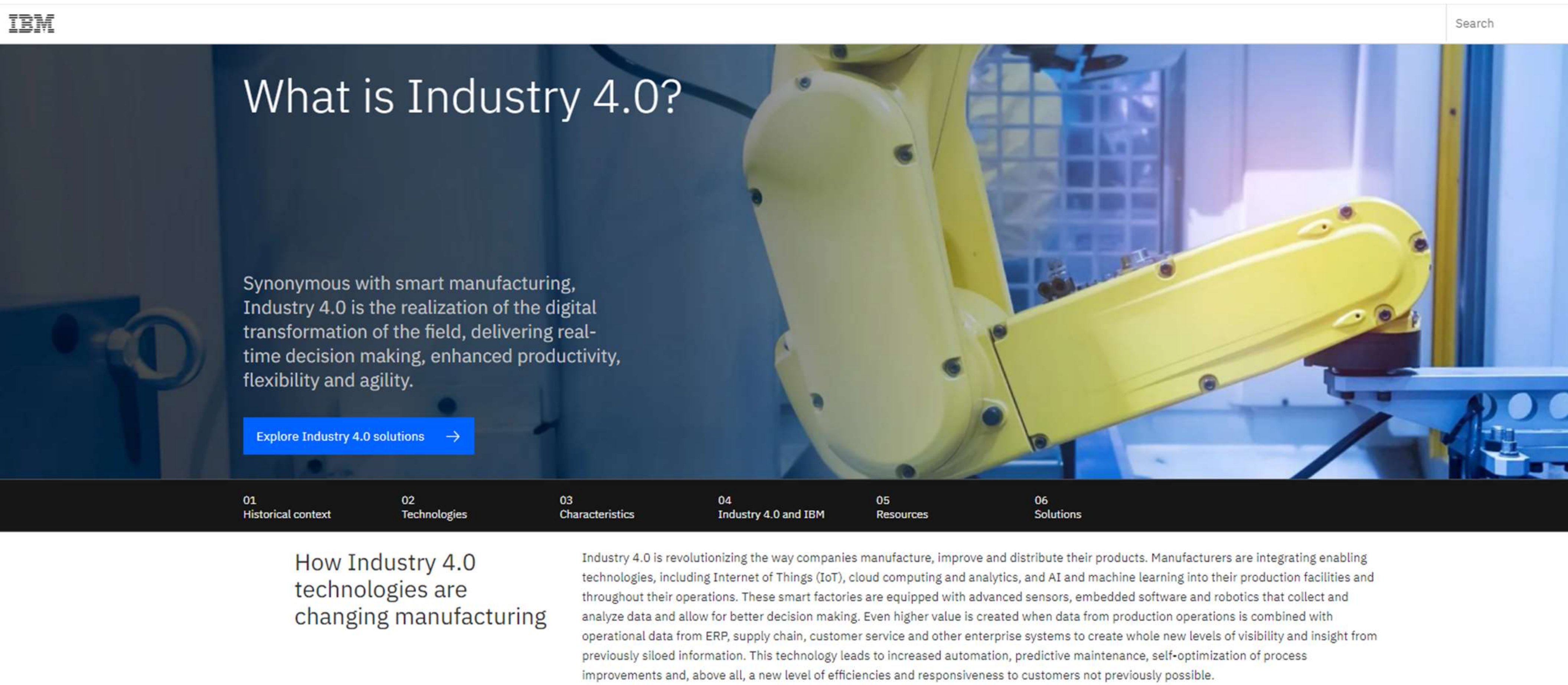
Making manufacturing smarter

- In many ways, manufacturers have always been smart
- ‘Smart’ and ‘intelligent’ were terms used in Industry 3.0
- Move towards data-driven smart manufacturing and Industry 4.0



https://www.sciencedirect.com/science/article/pii/S2666188820300162



IBM

Search

What is Industry 4.0?

Synonymous with smart manufacturing, Industry 4.0 is the realization of the digital transformation of the field, delivering real-time decision making, enhanced productivity, flexibility and agility.

Explore Industry 4.0 solutions →

01 Historical context | 02 Technologies | 03 Characteristics | 04 Industry 4.0 and IBM | 05 Resources | 06 Solutions

How Industry 4.0 technologies are changing manufacturing

Industry 4.0 is revolutionizing the way companies manufacture, improve and distribute their products. Manufacturers are integrating enabling technologies, including Internet of Things (IoT), cloud computing and analytics, and AI and machine learning into their production facilities and throughout their operations. These smart factories are equipped with advanced sensors, embedded software and robotics that collect and analyze data and allow for better decision making. Even higher value is created when data from production operations is combined with operational data from ERP, supply chain, customer service and other enterprise systems to create whole new levels of visibility and insight from previously siloed information. This technology leads to increased automation, predictive maintenance, self-optimization of process improvements and, above all, a new level of efficiencies and responsiveness to customers not previously possible.

https://www.ibm.com/uk-en/topics/industry-4-0

IBM

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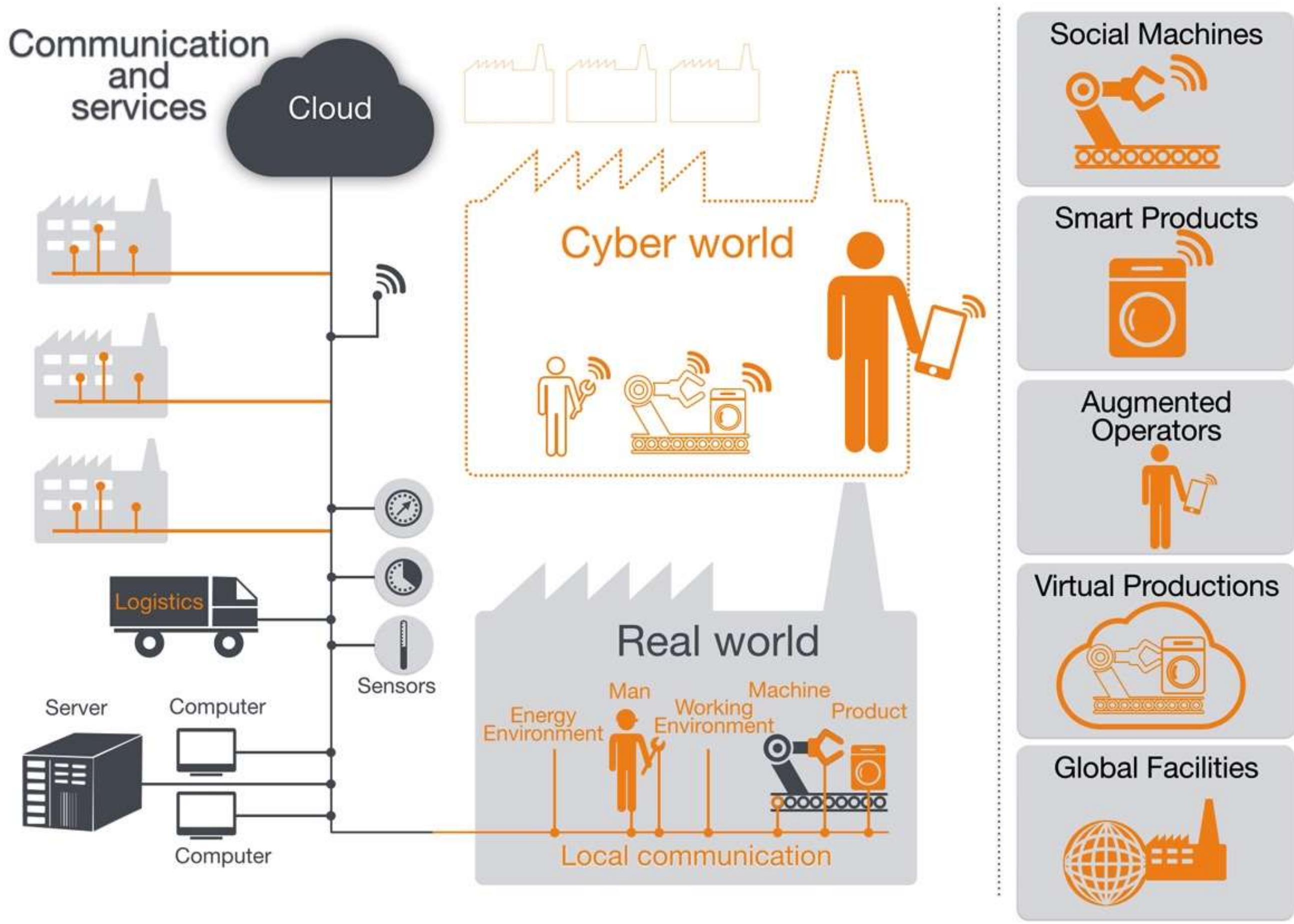
Developing smart factories provides an incredible opportunity for manufacturers entering the fourth industrial revolution. Analyzing the large amounts of data collected from sensors on the factory floor ensures real-time visibility of manufacturing assets and can provide tools for performing predictive maintenance in order to minimize equipment downtime.

https://www.ibm.com/uk-en/topics/industry-4-0

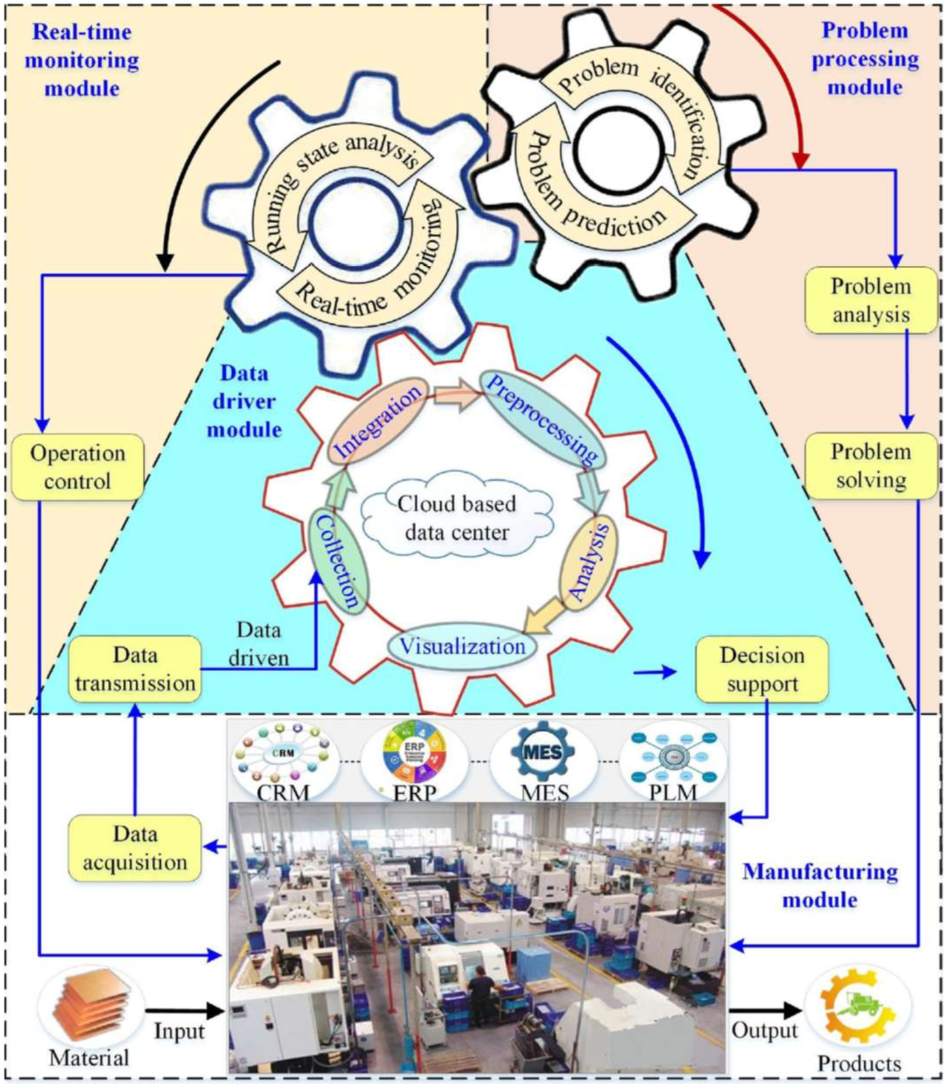


https://ottomotors.com/blog/understanding-industry-4-0

“Smart manufacturing, also known as Industry 4.0, refers to the next generation manufacturing paradigm that makes use of smart sensors, cloud computing infrastructures, AI, machine learning, additive manufacturing, and/or advanced robotics to improve manufacturing productivity and cost efficiency

“Smart manufacturing aims to convert data acquired across the product lifecycle into manufacturing intelligence in order to yield positive impacts on all aspects of manufacturing.

Example data-driven smart manufacturing infrastructure



CRM: Customer Relationship Management
MES: Manufacturing Execution System
ERP: Enterprise Resource Planning
PLM: Product Lifecycle Management

ELSEVIER
Journal of Manufacturing Systems
Volume 48, Part C, July 2018, Pages 157-169

Data-driven smart manufacturing

Fei Tao [a], Qinglin Qi [a], Ang Liu [b], Andrew Kusiak [c]

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https://doi.org/10.1016/j.jmsy.2018.01.006

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Building blocks

Data generation and connectivity using sensors and Industrial IoT

Industrial Internet of Things (IIoT)

- IoT devices contain embedded technology allowing them to sense and interact with their surroundings
- When applied to industrial systems referred to as Industrial IoT (IIoT)
- Bring opportunities to capture large amounts of data about industrial systems for monitoring and control

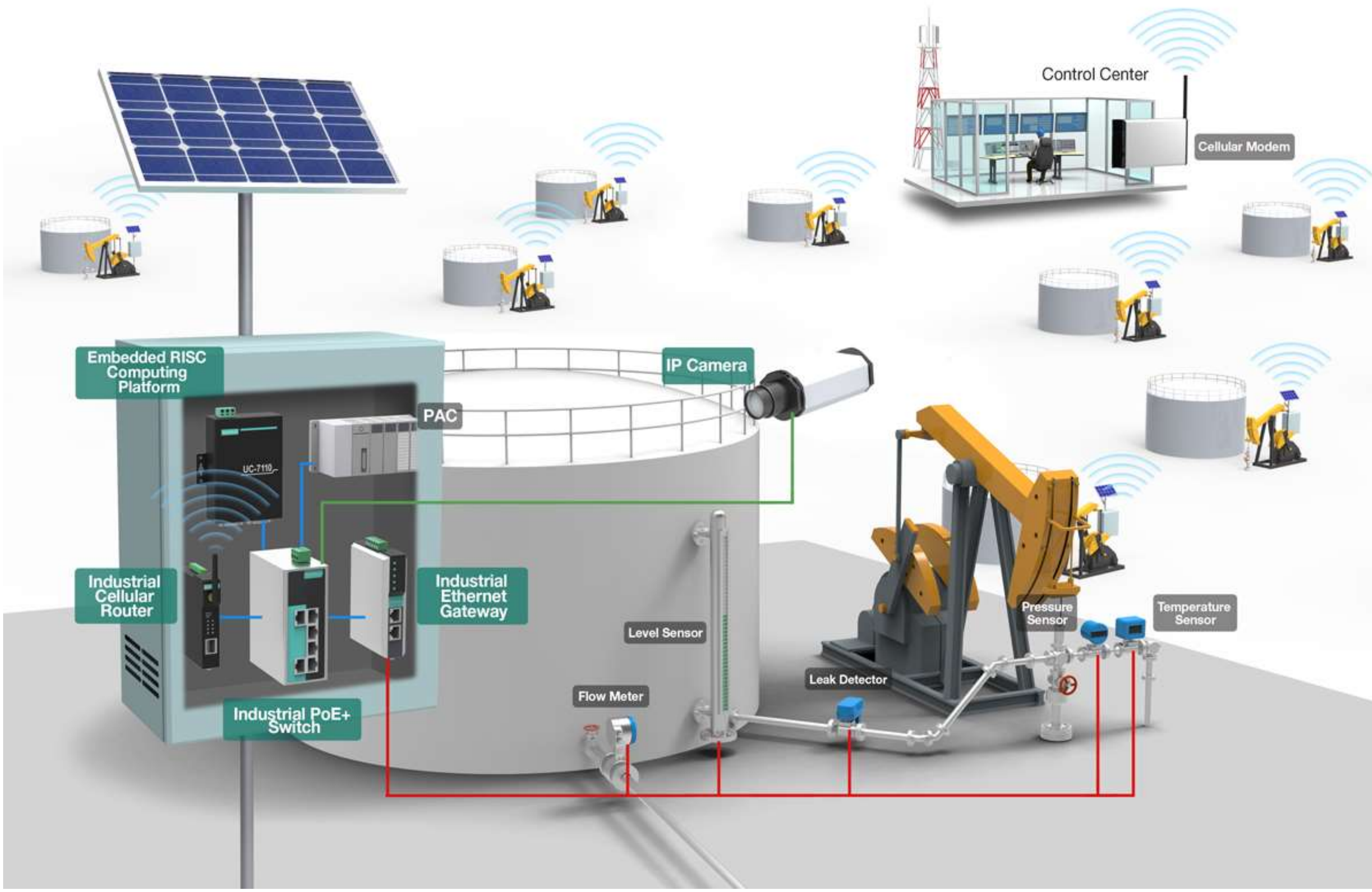
“ *...the network of intelligent and highly connected industrial components that are deployed to achieve high production rate with reduced operational costs through real-time monitoring, efficient management and controlling of industrial processes, assets and operational time.*

ELSEVIER

Computers & Electrical Engineering
Volume 81, January 2020, 106522

Industrial internet of things: Recent advances, enabling technologies and open challenges ☆

W.Z. Khan [a], M.H. Rehman [b], H.M. Zangoti [c], M.K. Afzal [d], N. Armi [a], K. Salah [e]



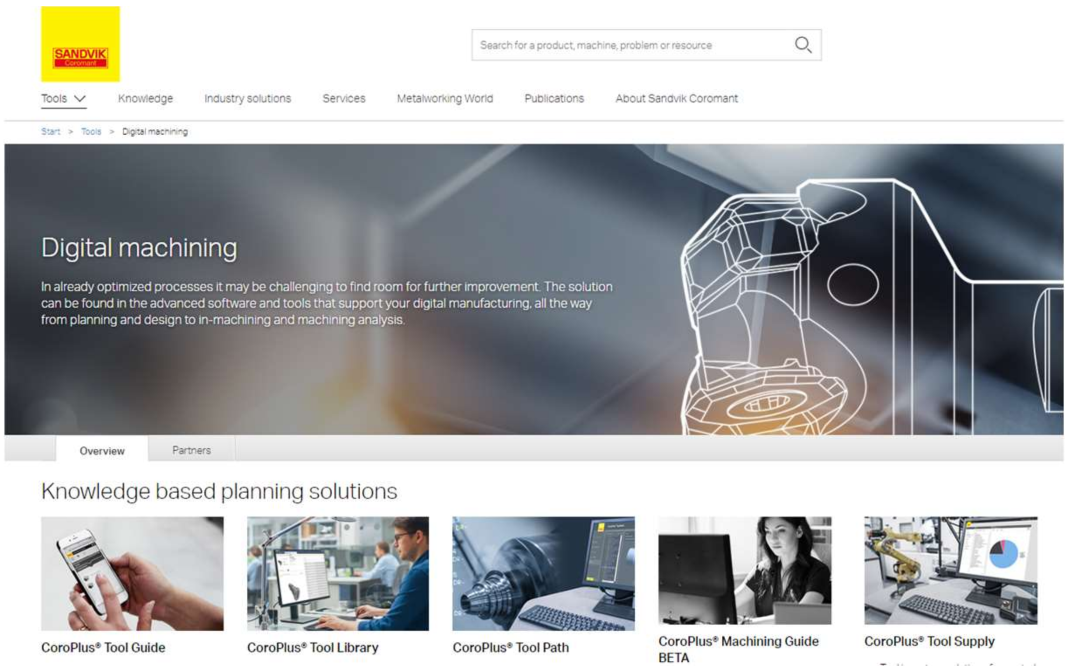
An example of an IIoT system https://medium.com/@jaydev_21091/industrial-internet-of-things-74a4ffb44679

Sensors

Sensor / measurement type	Applications in manufacturing	Frequency
Temperature	Factory environmental conditions, machine tool structure monitoring (potential deformation), cutting tool condition, motor and drive condition, component temperature (growth, shrinkage), additive process assessment.	Typically, low (< 1Hz) High for cutting tool condition (> 1kHz)
Humidity	Factory environmental conditions	Low (< 1 Hz)
Power	Machine tool motor and drive monitoring, building management systems	Low for general energy usage calculations (< 1 Hz) Medium for asset health monitoring (< 1 kHz)
Accelerometer	Machining vibration, spindles and bearings, floor vibration	High (1 kHz - 20 kHz)
Force and torque	Machine tool structure and fixture monitoring, conveyor system monitoring, spindle and bearing monitoring	Low to medium (1 Hz - 1 kHz)
Encoders, proximity	Position of guideways, rotary systems, robot arms, conveyor belt tension, etc.	Medium (< 1 kHz)
Acoustic Emission	Cutting tool condition,	Very high (>50 kHz)
pH, composition, particulates	Fluids condition monitoring (eg. metal working fluids for machining, fluid components in pharma and food)	Low (1 Hz or less)
Vision systems	Part identification, quality monitoring, asset identification and location, asset attendance	N/A

- Sensors are devices that measure something about their surroundings
- Sensor data sent to data acquisition system
- Primary source of data in smart manufacturing systems
- Data acquisition devices (DAQ) and data transfer protocols fundamental to sensor systems

Machine tool health monitoring



https://www.sandvik.coromant.com/

- Machine tools are core of many manufacturing systems and failure can cause both irreparable damage and significant delays
- Monitoring the health of machine tools is a key activity of any smart manufacturing system
- Many different sensors could be used, e.g., bearings can be monitored using vibration, force and deformation sensing
- Application: ongoing monitoring and proactive maintenance activities

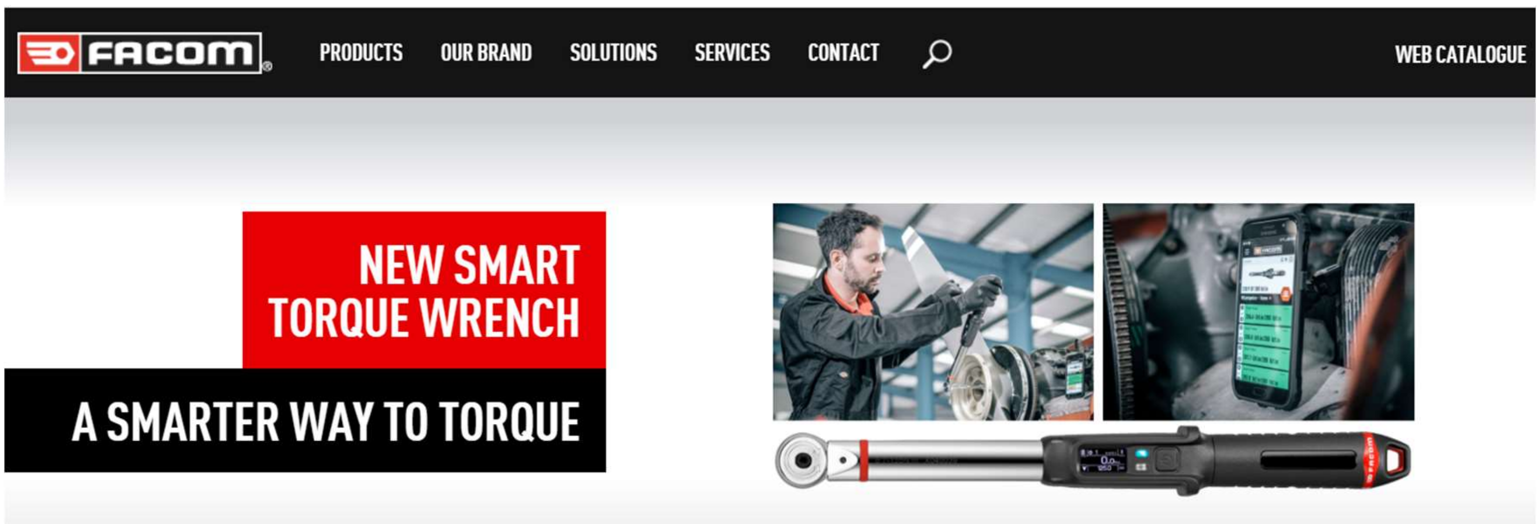
Legacy devices and low-cost sensing

- Many SMEs unable to adopt Industry 4.0 and IIoT due to cost and use of legacy devices
- Can attach low-cost sensing systems to existing equipment to enable real-time monitoring of equipment effectiveness, machine condition, etc.
- Data acquisition can be provided by low-cost devices, such as Raspberry Pi

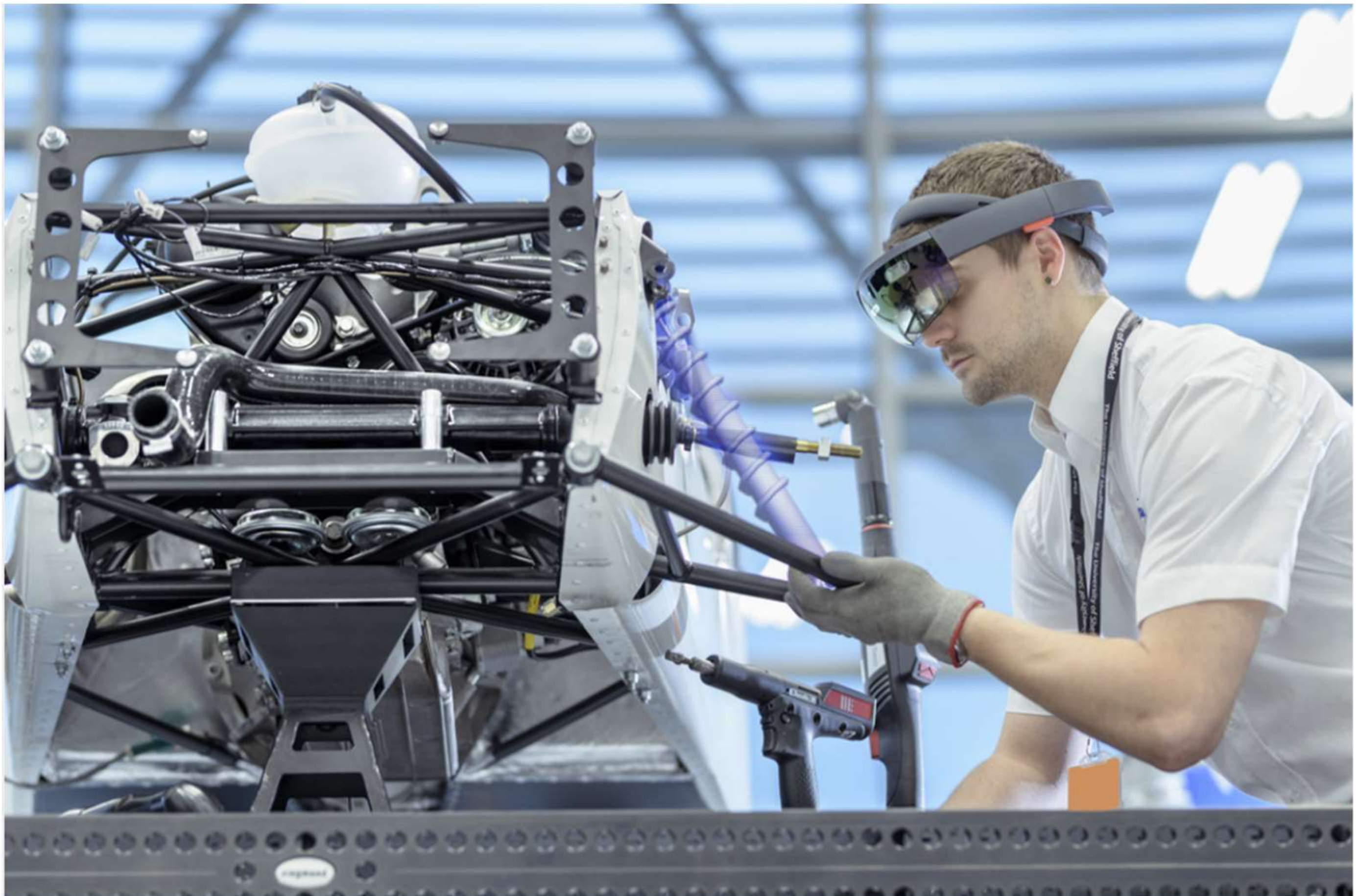
AMRC: Colchester Bantam lathe with a low-cost Industry 4.0 solution

Smart hand tools

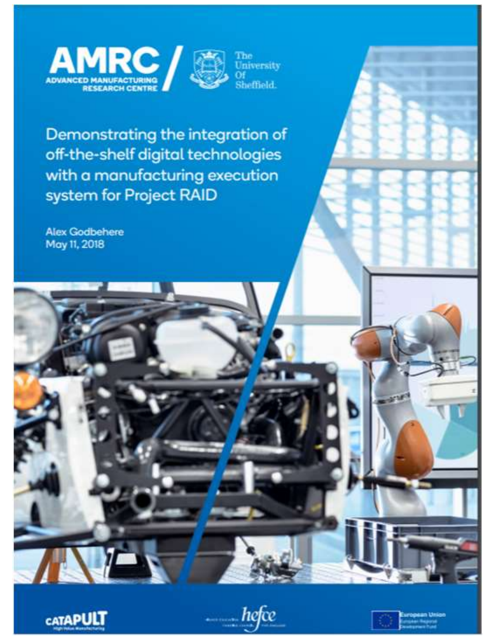
- Although robotics increasingly used, manually operated hand tools still commonplace
- Smart hand tools have elements of sensing and connectivity built in and can be combined with digital work instructions, e.g. intelligent torque wrench



https://www.facom.com/uk/products/Smart-Torque-Description.html



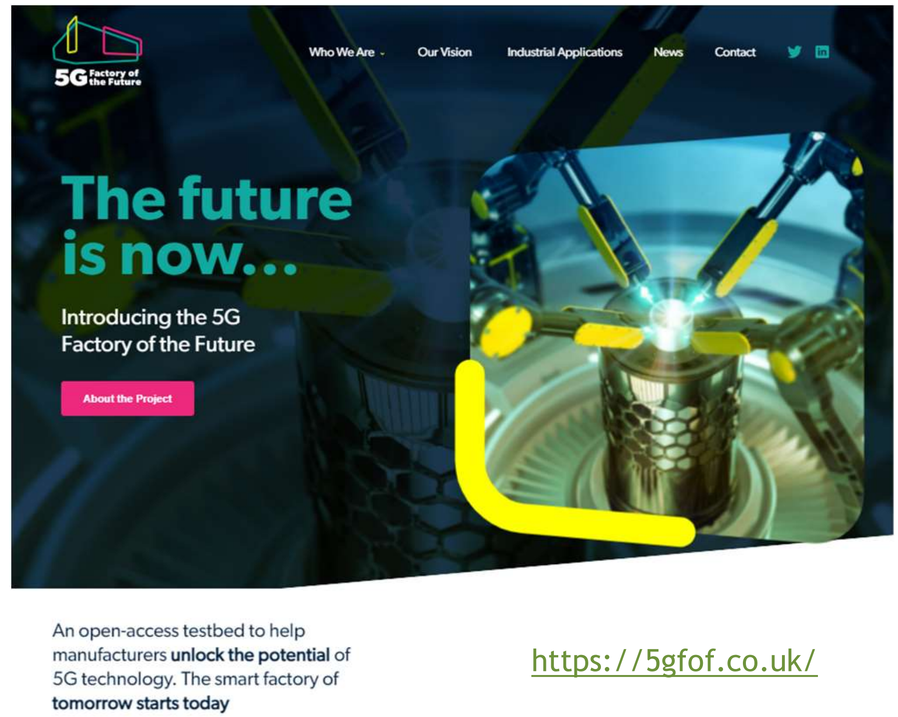
James Lindsay works on the Caterham sports car at the AMRC's Factory 2050.



https://www.amrc.co.uk/files/document/260/1548081041_WHITE_PAPER_AW.pdf

Wireless connectivity

- Further key aspect is connectivity
- Many manufacturing environments still reliant on physical connection between devices, but moving towards wireless networks
- WiFi limited in factories, therefore use of other technologies, such as Low-Power Wide Area Networks and 5th Generation mobile networks
- 5G viewed as more future-looking option

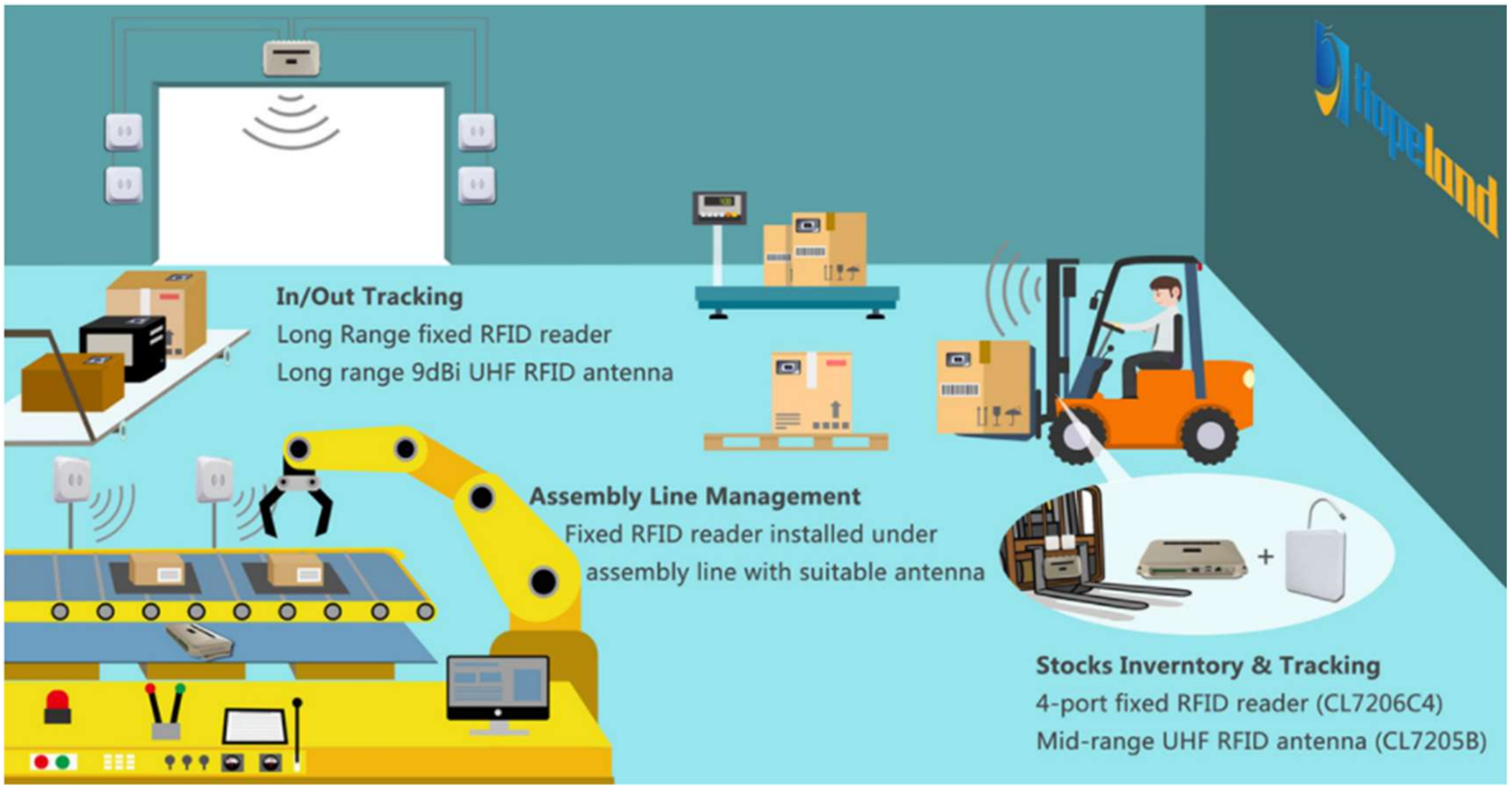


https://5gfof.co.uk/

Location tracking technologies

- Knowing the location of an object in a manufacturing environment can save significant time and cost
- Includes location of a component or part, as well as other assets essential to the manufacturing process
- Tracking technologies allow tracking at local level through to the global level

- Tracking technologies include:
  - Barcodes and Quick Response (QR) codes
  - Radio Frequency Identification (RFID)
  - WiFi
  - Bluetooth
  - Global Positioning System (GPS)

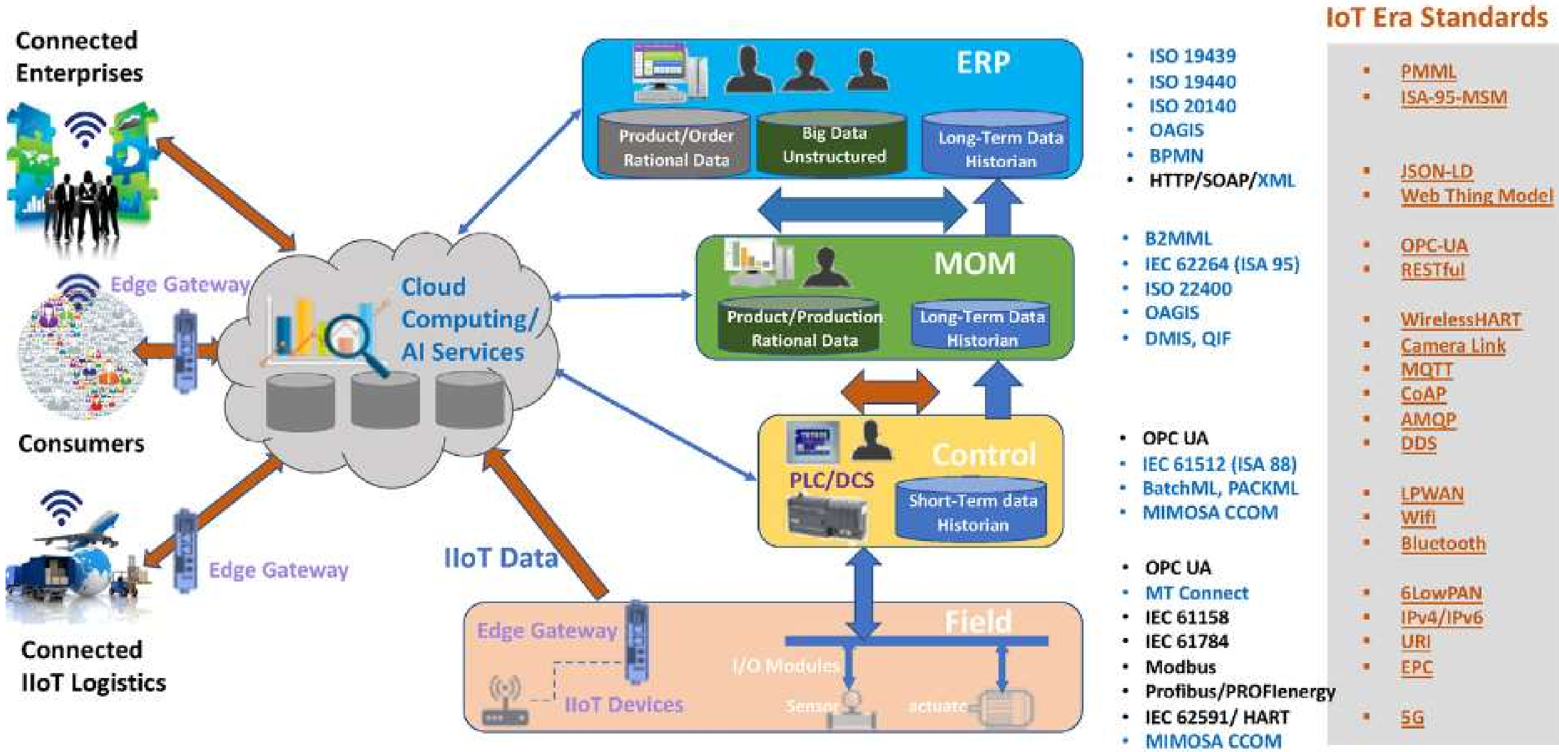


https://www.hopelandrfid.com/industry-4-0-smart-manufacturing_n40

RFID could be used for

- Tracing raw materials and spare parts and updating inventories
- Automatic production control
- Production data collection and analysis
- Product warehousing management within the factory

Standards and interoperability



The IIoT era integration standards landscape (Lu et al., 2020)

Lu, Y., Witherell, P., & Jones, A. (2020). Standard connections for IIoT empowered smart manufacturing. Manufacturing Letters, 26, 17-20.

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The University Of Sheffield. / AMRC   Factory+ Portal   Documentation

Introduction

Specification

About

Messages & Payload

Architecture & Topology

Security

Connectivity

Implementation Guide

What is Factory+?

Factory+ provides an open framework to standardise and simplify the way that data is extracted, transported, stored, processed, consumed and protected across a manufacturing organisation. By utilising edge-driven, containerised, and event-driven technologies, Factory+ provides the foundations for an Industry 4.0 architecture suitable for use both in a research environment and as an operational testbed/sandbox environment for partners/OEMs to de-risk their Industry 4.0 adoption and try out new technologies.

Motivation

https://factoryplus.app.amrc.co.uk/

Building blocks

Data management and analysis using cloud computing, Big Data and AI

Cloud computing

- Enables businesses to outsource their IT resources
- Everything as a service model (IaaS, PaaS, SaaS)
- Benefits for smart manufacturing:
  - Cost-effective and dynamic access to large amounts of computing power
  - Almost immediate access to hardware resources without upfront capital investments
  - Lower barriers to innovation
  - Easy dynamic scaling of enterprise services
  - Enabling of new classes of applications and services

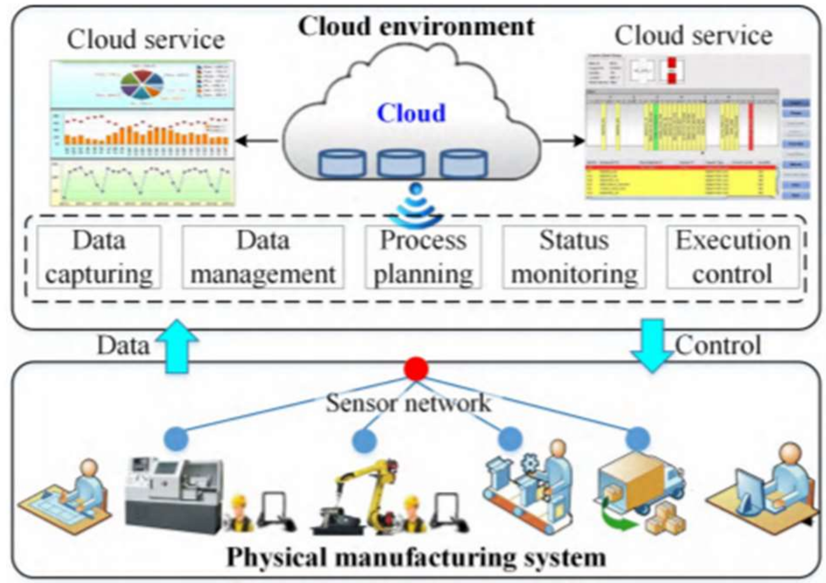


FIGURE 1. The cloud-based manufacturing system architecture.

A Smart Manufacturing Service System Based on Edge Computing, Fog Computing, and Cloud Computing

QINGLIN QI AND FEI TAO, (Senior Member, IEEE)
School of Automation Science and Electrical Engineering, Beihang University, Beijing 100083, China
Corresponding author: Fei Tao (ftao@buaa.edu.cn)

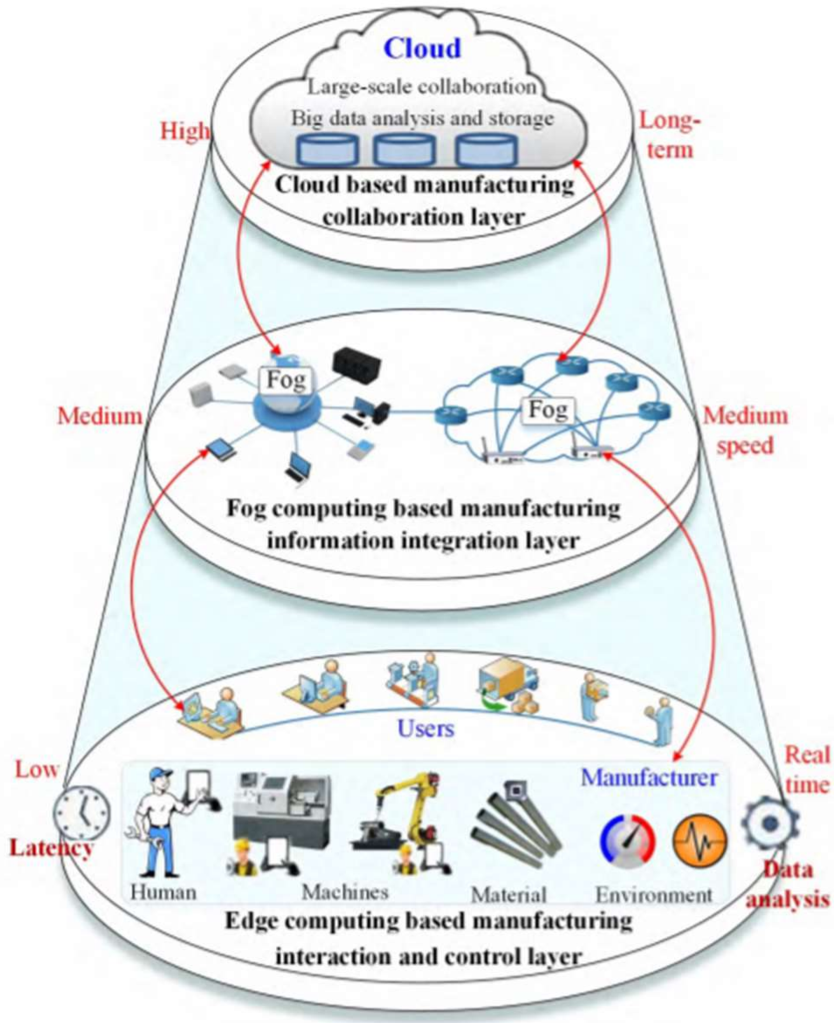
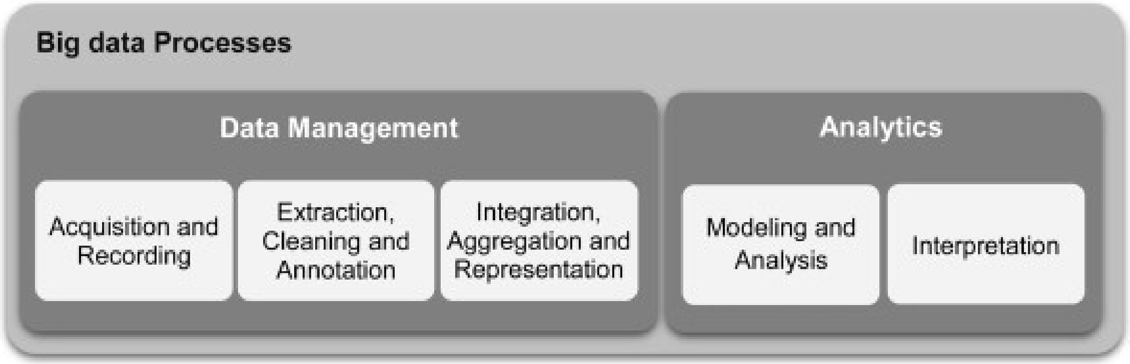


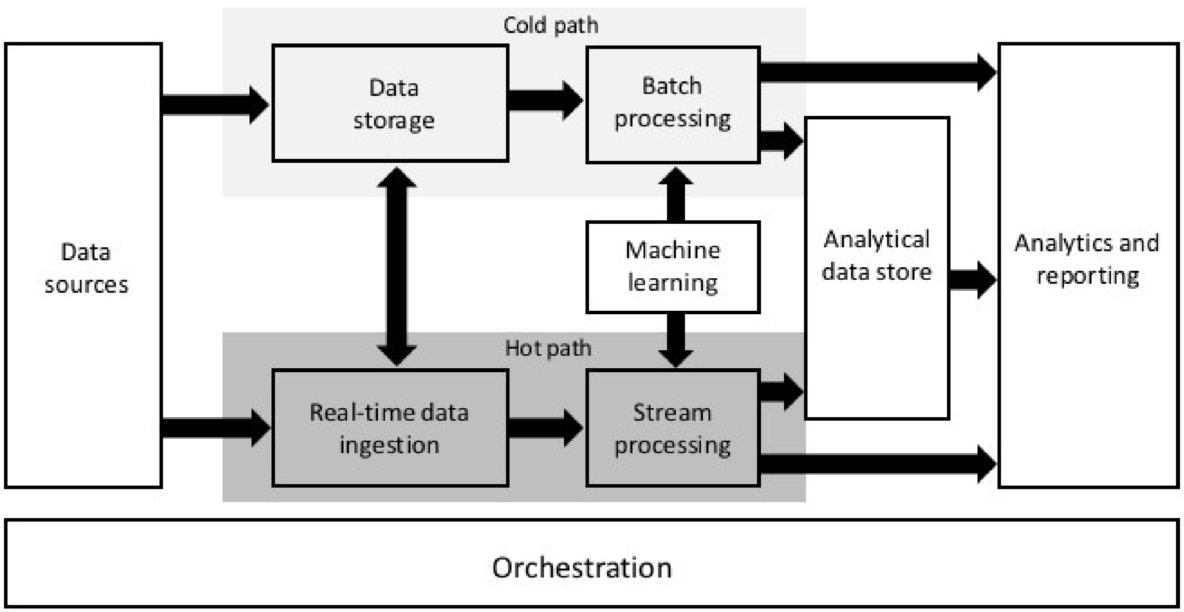
FIGURE 2. **The hierarchy architecture for smart manufacturing based on edge computing, fog computing and cloud computing.**

Fog and edge computing

- Issues with cloud computing can include bottlenecks, network unavailability and latency
- Fog and Edge computing can help by pushing processing and storage nearer to devices and reducing flows of data

Big Data Analytics





https://docs.microsoft.com/en-us/azure/architecture/data-guide/big-data/

“The performance logs from a single works machine can generate around 5 gigabytes (GB) of data per week, and a typical smart factory produces around 5 petabytes (PB) per week – that’s 5 million GB

https://www.techerati.com/the-stack-archive/data-centre/2018/05/14/smart-manufacturing-factory-automation/

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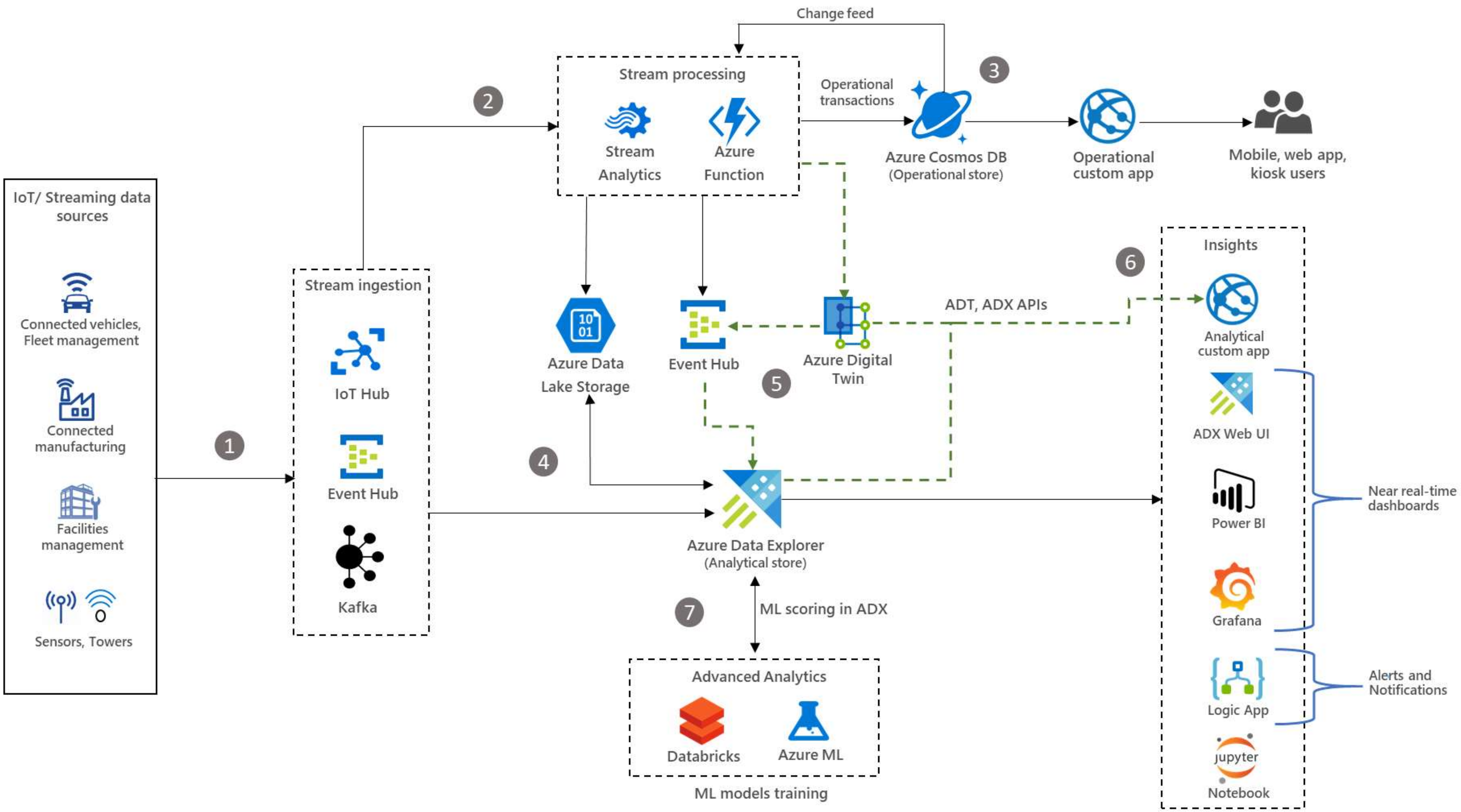

https://docs.microsoft.com/en-us/azure/architecture/solution-ideas/articles/iot-azure-data-explorer

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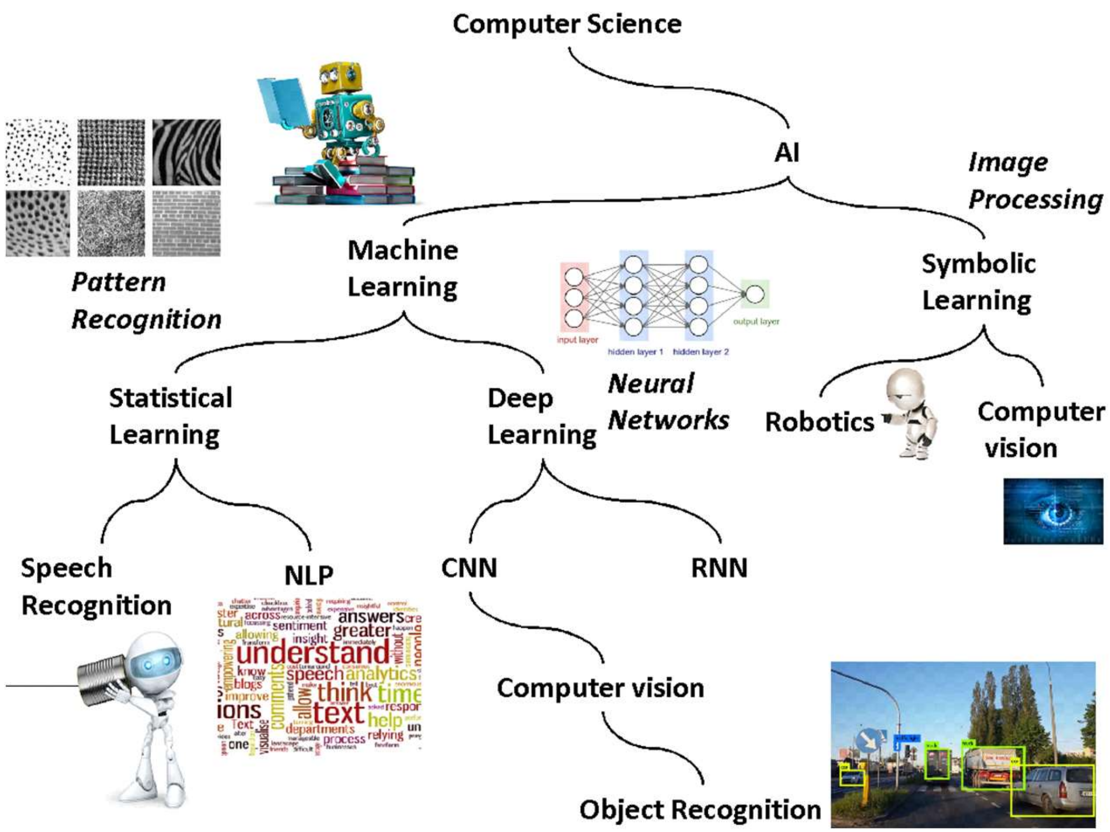
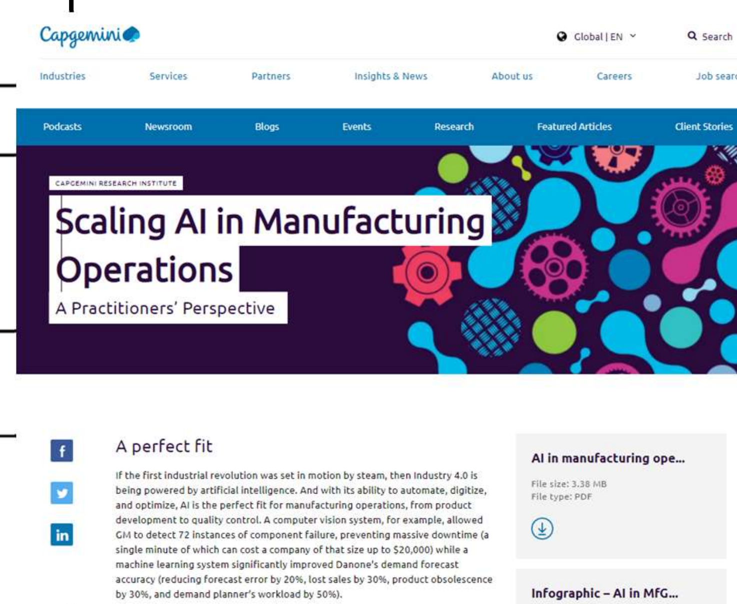


https://www.aitimejournal.com/@premlatha.kr/what-is-ai-in-a-simple-way

Artificial Intelligence

> *"The McKinsey Global Institute has found that robotics and AI technologies such as machine learning (which gives computers the ability to learn without explicit programming) have advanced to the point where it would be possible to automate at least 30 percent of activities in about 60 percent of occupations in both the United States and Germany*
>
> (Breunig et al., 2017).

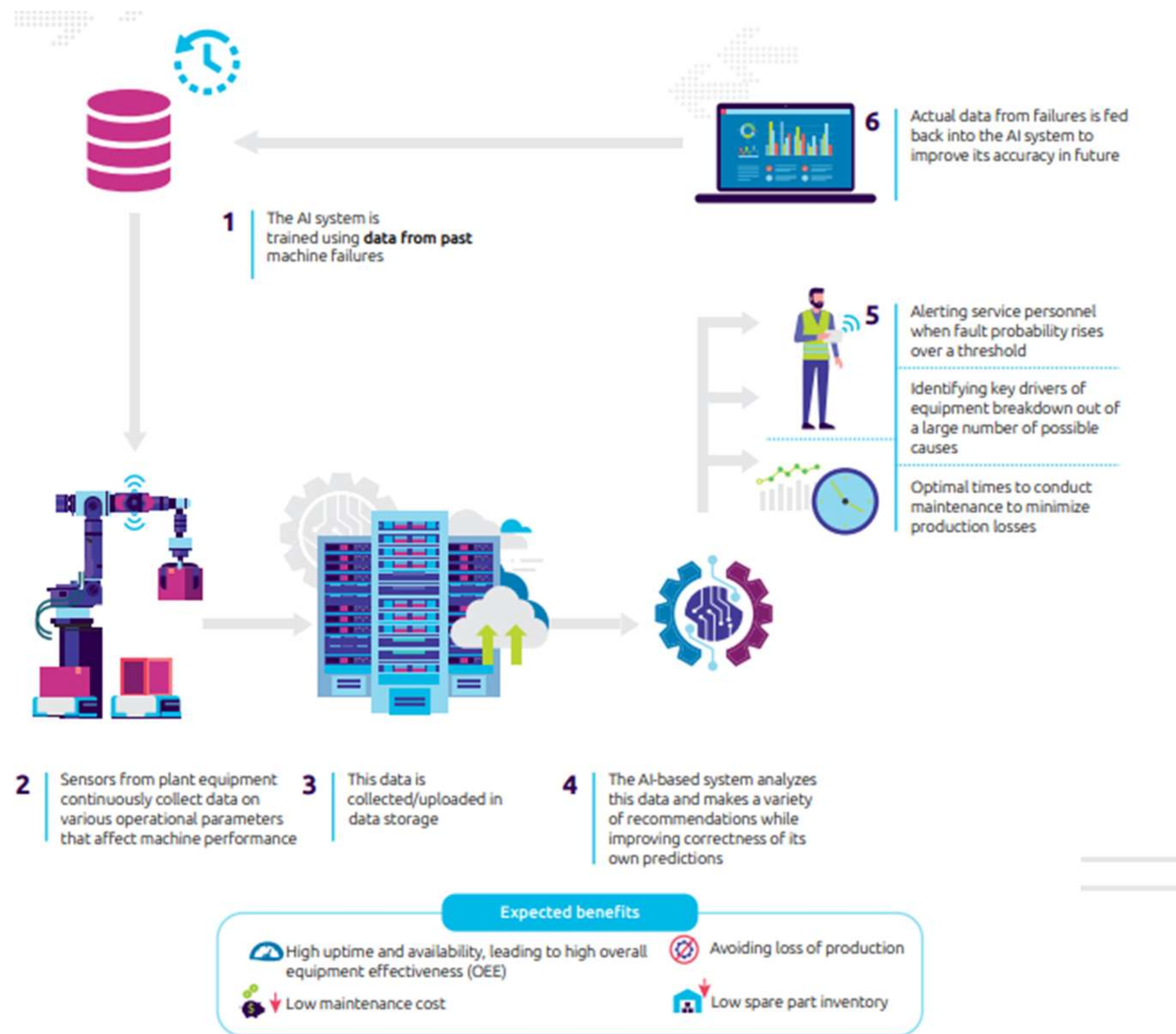
Function	Use cases
Product development / R&D	• New product development • Product validation in R&D • Product enhancement
Demand planning	• Demand planning / forecasting
Inventory management	• Order optimisation • Standardised communications with suppliers using Natural Language Processing (NLP) • Inventory planning
Process control	• Real-time optimisation of process parameters • Optimise equipment changeover
Production	• Optimising overall productivity in production line • Reduction in Takt time • Computer vision for product identification • Layout planning • Collaborative robots (cobots)
Quality control	• Product quality inspection • Predicting final product quality
Maintenance	• Intelligent maintenance • Energy management • Spotting anomalies in communication network • Worker safety • Scrap/wastage reduction • Increasing equipment efficiency



https://www.capgemini.com/research/scaling-ai-in-manufacturing-operations/

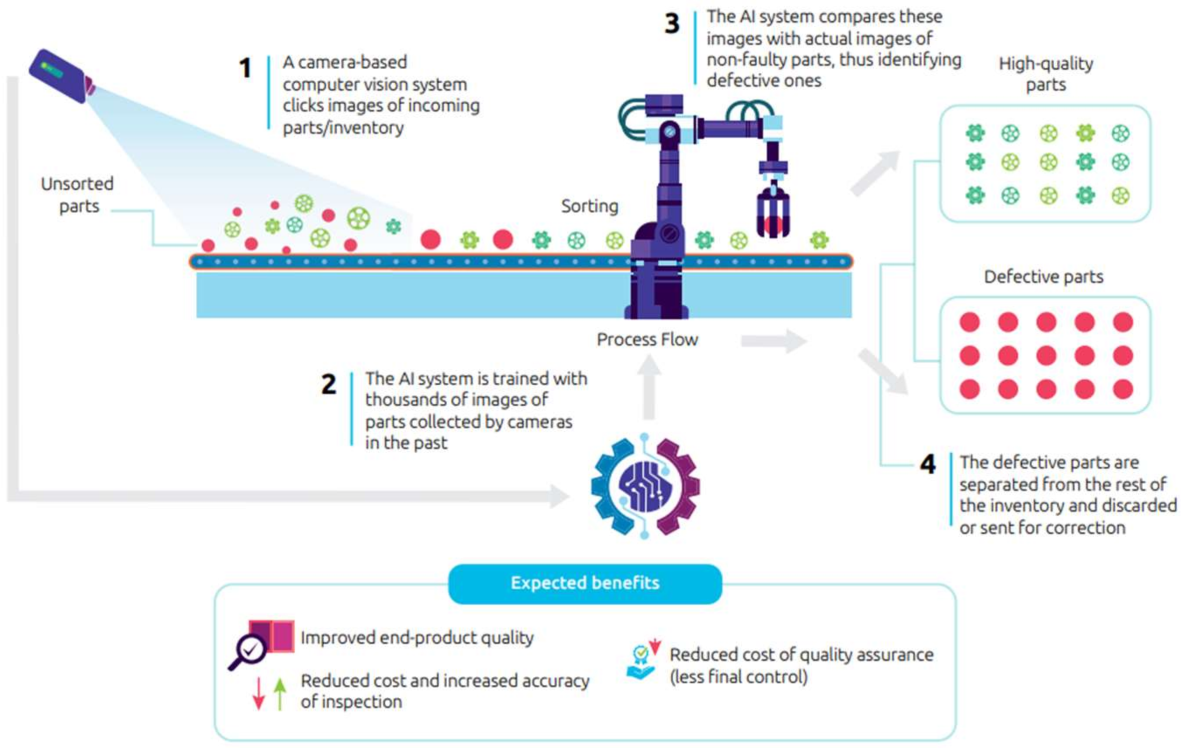
Predictive maintenance

- Predictive Maintenance (PdM) seen as a top use case for AI as: *"the impact of maintenance represents a total of 15 to 60% of the total costs of operating all manufacturing"*
- Allows proactive rather than reactive maintenance
- AI can be used to support common maintenance tasks, such as
  - Fault diagnosis
  - Predicting mechanical failures and Remaining Useful Life (RUL)
  - Maintenance scheduling to support planned Equipment downtime



Source: Capgemini Research Institute analysis.

Identifying defects and quality control



Source: Capgemini Research Institute analysis.

- Drive in manufacturing for high quality processes and products
- Detecting subtle process parameters can help predict and prevent quality issues
- In-line visual inspection methods commonly used
- Widespread availability of high-resolution cameras, coupled with powerful image recognition technology, has dramatically cut the cost of real time in-line inspection

Robots

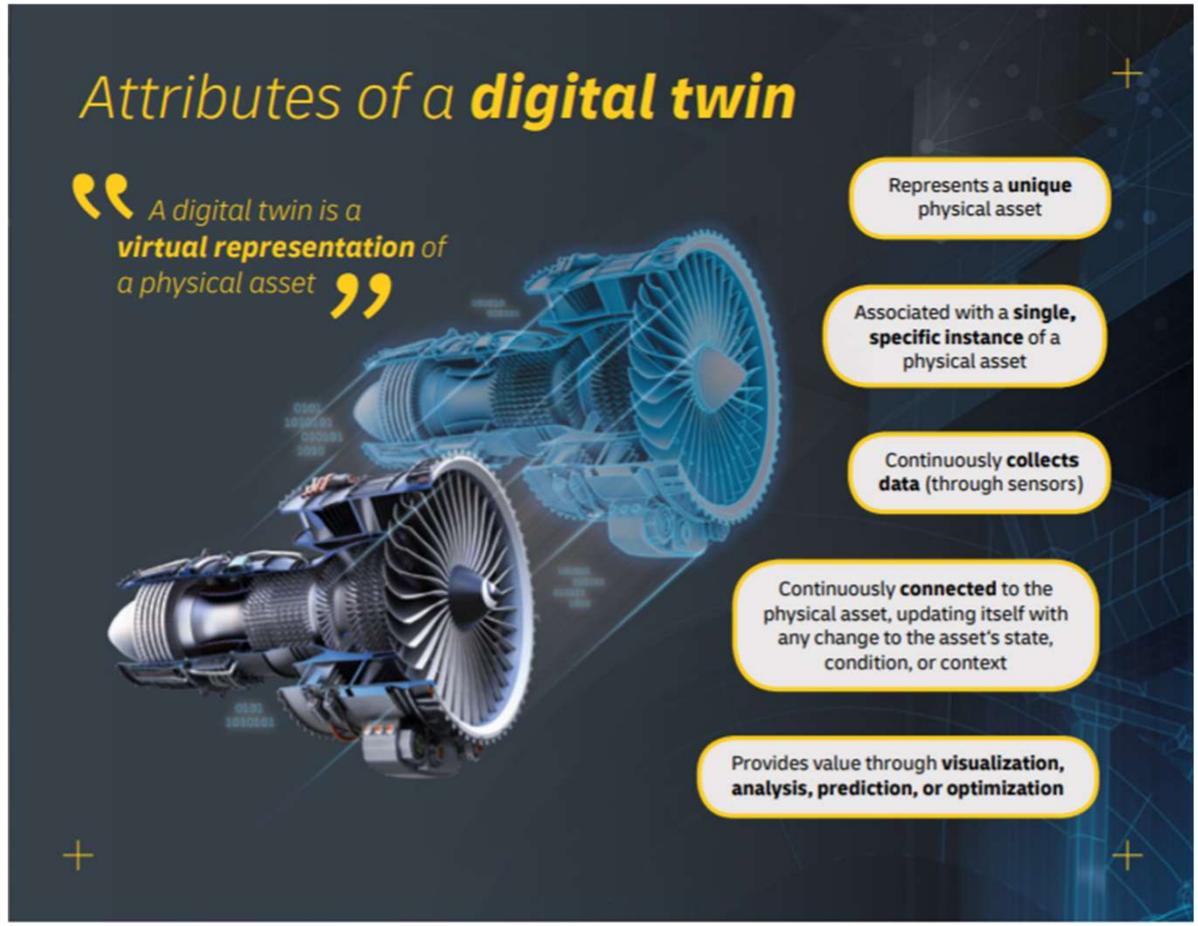
- Advances in mechatronics, computing and communication technologies driving modern robotics and autonomous systems
- Standalone industrial robots first appeared in 1960s
- Recent advances include collaborative robots ('cobots') and mobile robots / automated guided vehicles

Building blocks

Beyond the physical world

Digital Twins

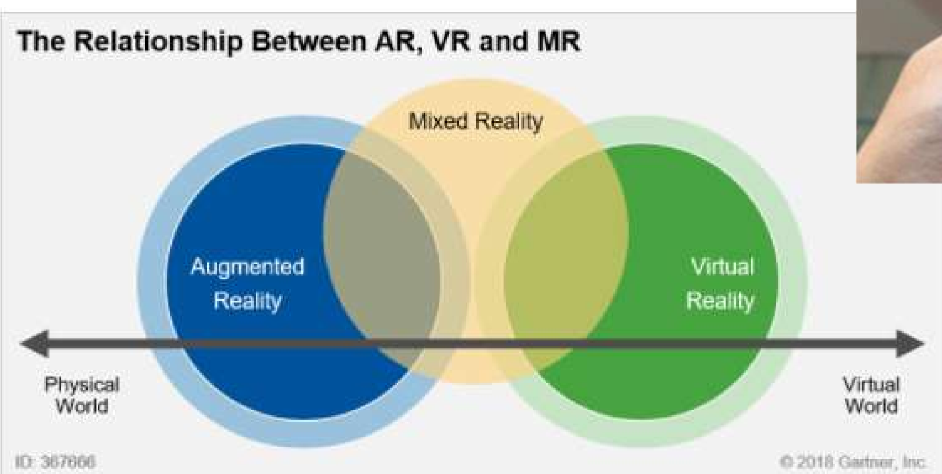
“A live digital coupling of the state of a physical asset or process to a virtual representation with a functional output.



https://www.dhl.com/content/dam/dhl/global/core/documents/pdf/glo-core-digital-twins-in-logistics.pdf

Extended reality

- Virtual reality provides fully immersive digital environment
- Augmented reality uses digital overlays of information onto the physical world
- Mixed reality combination VR and AR



https://blog.thomasnet.com/augmented-reality-manufacturing

Simulation

- Simulation in manufacturing can mean many things (Mourtzis, 2020)
  - Simulating stresses on a part design
  - Simulating an assembly
  - Simulating how the tooth of a tool interacts with the material being cut
  - Simulating complete product production flow in a factory
  - Simulating supply chain and logistics

Mourtzis, D. (2020). Simulation in the design and operation of manufacturing systems: state of the art and new trends. International Journal of Production Research, 58(7), 1927-1949.

AMRC ADVANCED MANUFACTURING RESEARCH CENTRE / The University Of Sheffield.

Manufacturing Intelligence Case Study

Virtual simulation of new Boeing facility based in Sheffield

Off-line resource planning and optimisation becomes possible in the virtual world.

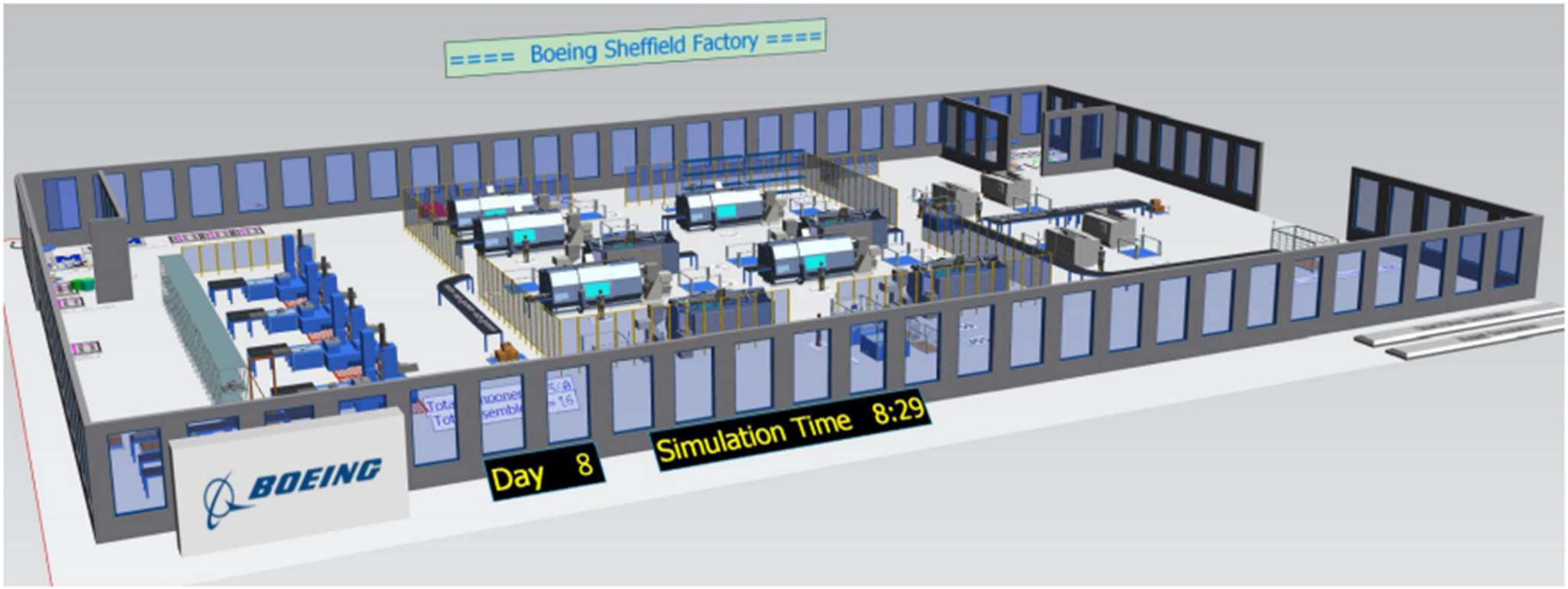
The University of Sheffield Advanced Manufacturing Research Centre (AMRC) has developed a virtual simulation model of the new Boeing Sheffield facility. The model will help to validate the opportunities Boeing has to increase productivity by up to 50 per cent.

As part of the Smart Factory research project, the AMRC are working on for Boeing, its Manufacturing Intelligence Group has worked closely with the Boeing team to create a virtual simulation model using Discrete Event Simulation (DES) techniques to examine the potential capabilities of their new factory and to validate opportunities for increasing productivity.

The key benefits of using simulation for factory floor planning are:

- Optimising factory flow to improve productivity
- Examine the impacts of uncertainties
- Validate new technology introduction

https://www.amrc.co.uk/files/document/241/1542814525_AMRC_BOEING_case_study.pdf



Boeing's first production facility in Europe simulated within a DES model.

A simulation model was created in Siemens Tecnomatix Plant Simulation, a discrete event simulation software package allowing events and what-if scenarios to be run without interrupting existing production systems or processes.

The software is used to produce layouts of factory floors and add in data for machines, processes, production targets and materials, allowing a simulation model to be created which mimicked production flow on the new workshop floor at Boeing Sheffield.

The virtual model and the factory simulation validated the impact of Boeing Sheffield's planned production processes and showed where they had spare production capacity, to assist with future optimisation of production schedules.

Opportunities and Challenges

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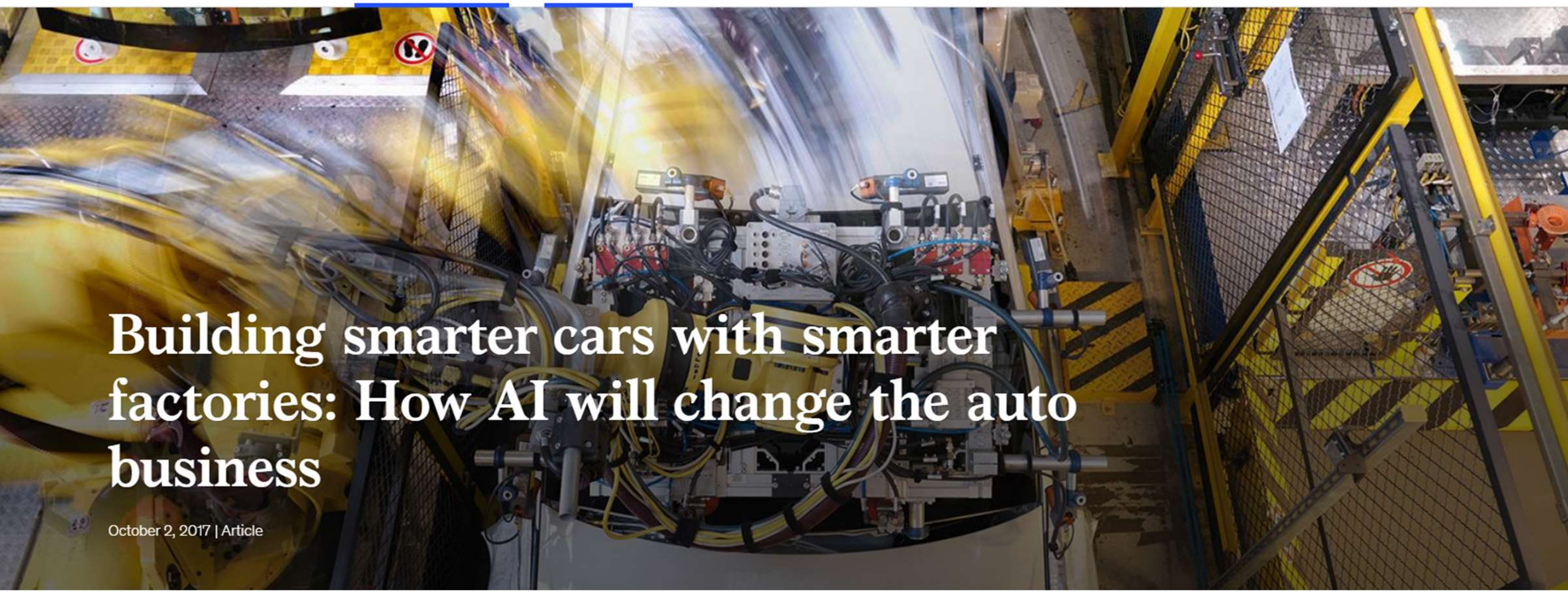
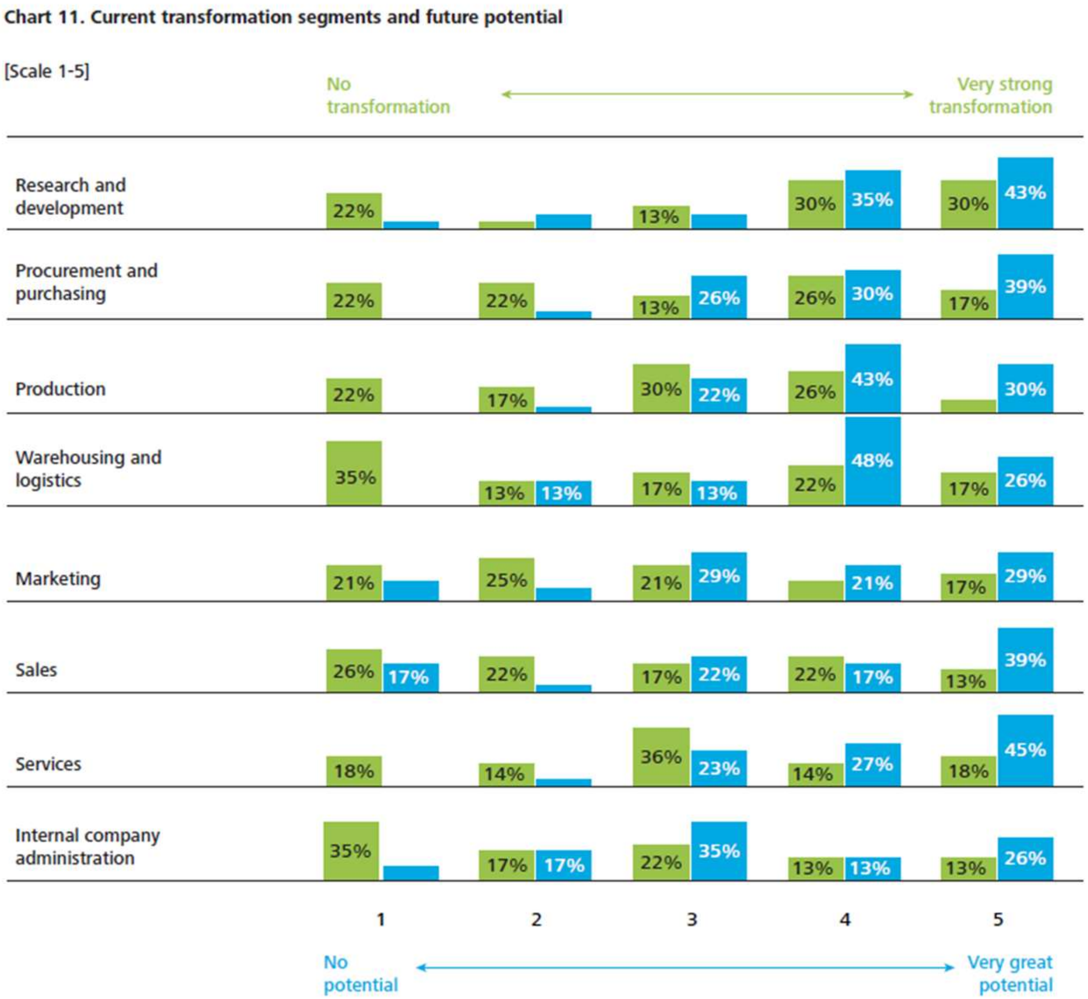


PEAK INDICATORS

Manufacturing *is* changing



Question: Which business segments in your company have undergone the most and the least transformation as part of industry 4.0?

Question: Which business segments within your company have the greatest potential to benefit from the digital transformation to industry 4.0?

PEAK INDICATORS

Opportunities *and* challenges

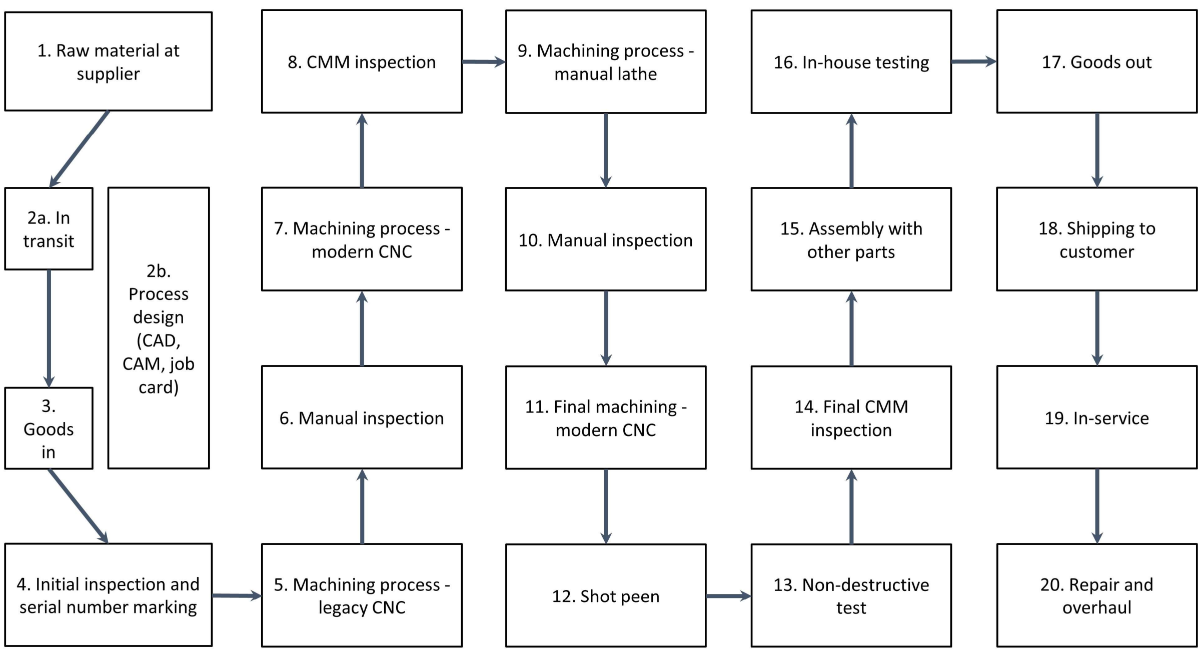
THE UK OPPORTUNITY FROM INDUSTRIAL DIGITALISATION

Digital technologies are transforming industry. In a 2017 report, the World Economic Forum identified a $100 trillion opportunity for both industry and society through the adoption of these technologies.[1] Each day, around five million devices link up with each other, with the internet, or with both. There are around 6.4 billion data-communicating objects in the world today. And by 2020, this number is forecast to explode to around 20 billion.[2]

> In summary, industrial digitalisation is a massive opportunity for UK industry – and the wider economy. But the technologies that underpin it are also highly disruptive, requiring business to be innovative, agile and adaptable. Industry and government will need to work in partnership to provide the infrastructure and ecosystems that can enable manufacturing businesses and their supply chains to maximise these opportunities and be competitive. Get it wrong, and we risk further de-industrialising our economy, and becoming ever more reliant on imports. Get it right, and we will have found the key to rebalancing and strengthening our economy, creating many new, exciting, and well-paid jobs, and leading a renaissance for the UK as a true nation of creators and makers.

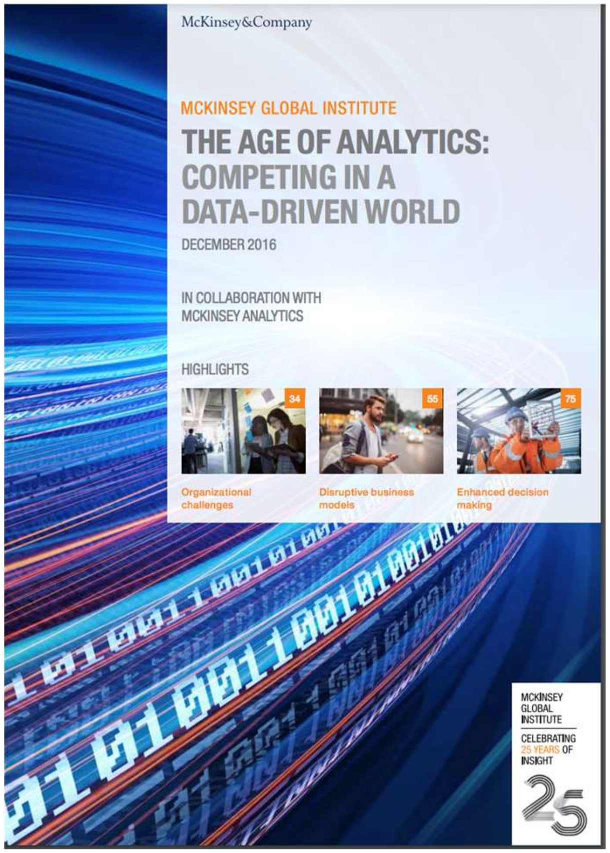
Opportunities

"Manufacturing systems must be made more "smart" to achieve the all-round monitoring, simulation and optimization of production activities" Tao et al. (2018)



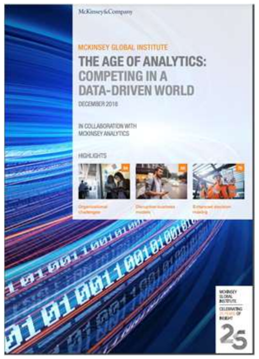
- Smart planning and process
- Smart product design
- Smart equipment maintenance
- Product quality control
- Manufacturing process monitoring
- Material distribution and tracking

PEAK INDICATORS

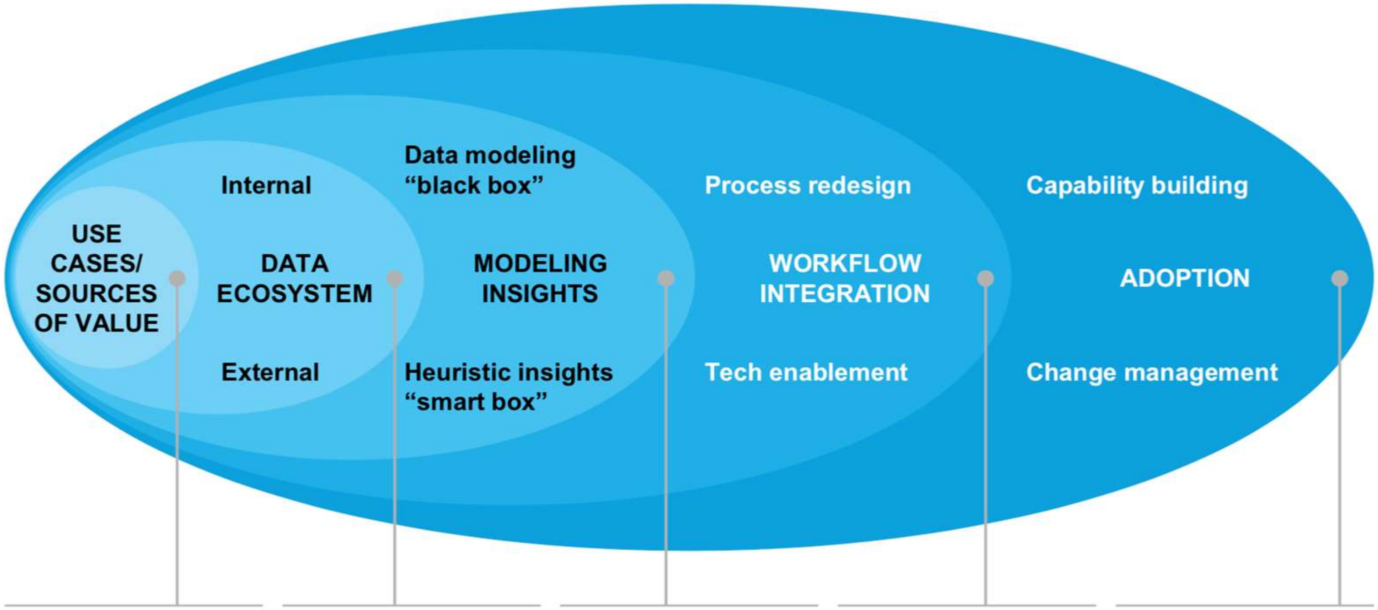


Challenges

“As we take stock of the progress that has been made over the past five years, we see that companies are placing big bets on data and analytics. But adapting to an era of more data-driven decision making has not always proven to be a simple proposition for people or organizations. Many are struggling to develop talent, business processes, and organizational muscle to capture real value from analytics. This is becoming a matter of urgency, since analytics prowess is increasingly the basis of industry competition, and the leaders are staking out large advantages. Meanwhile, the technology itself is taking major leaps forward—and the next generation of technologies promises to be even more disruptive. Machine learning and deep learning capabilities have an enormous variety of applications that stretch deep into sectors of the economy that have largely stayed on the sidelines thus far.



Successful data and analytics transformation requires focusing on five elements



- Clearly articulating the business need and projected impact
- Outlining a clear vision of how the business would use the solution

- Gathering data from internal systems and external sources
- Appending key external data
- Creating an analytic "sandbox"
- Enhancing data (deriving new predictor variables)

- Applying linear and nonlinear modeling to derive new insights
- Codifying and testing heuristics across the organization (informing predictor variables)

- Redesigning processes
- Developing an intuitive user interface that is integrated into day-to-day workflow
- Automating workflows

- Building frontline and management capabilities
- Proactively managing change and tracking adoption with performance indicators

SOURCE: McKinsey Analytics; McKinsey Global Institute analysis

Challenges

Exploding quantities of data have the potential to fuel a new era of fact-based innovation in corporations, backing up new ideas with solid evidence. Buoyed by hopes of better satisfying customers, streamlining operations, and clarifying strategy, firms have for the past decade amassed data, invested in technologies, and paid handsomely for analytical talent. Yet for many companies a strong, data-driven culture remains elusive, and data are rarely the universal basis for decision making.

Why is it so hard?

Our work in a range of industries indicates that the biggest obstacles to creating data-based businesses aren't technical; they're cultural. It is simple enough to describe how to inject data into a decision-making process. It is far harder to make this normal, even automatic, for employees — a shift in mindset that presents a daunting challenge. So we've distilled 10 data commandments to help create and sustain a culture with data at its core.

Harvard Business Review

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Data

10 Steps to Creating a Data-Driven Culture

by David Waller

February 06, 2020

Steve Bronstein/Getty Images

https://hbr.org/2020/02/10-steps-to-creating-a-data-driven-culture

Challenges - being realistic

MIT Technology Review

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Artificial intelligence / Machine learning

AI is not "magic dust" for your company, says Google's Cloud AI boss

Andrew Moore says getting the technology to work in businesses is a huge challenge.

by **Will Knight**

November 8, 2018

Photo of Andrew Moore
COURTESY OF ANDREW MOORE

"

How big of a technology shift is this for businesses?

It's like electrification. And it took about two or three decades for electrification to pretty much change the way the world was. Sometimes I meet very senior people with big responsibilities who have been led to believe that artificial intelligence is some kind of "magic dust" that you sprinkle on an organization and it just gets smarter. ***In fact, implementing artificial intelligence successfully is a slog.***

Global manufacturing challenges

- Adoption of advanced manufacturing technologies
- Growing importance of manufacturing of high value-added products
- Utilising advanced knowledge, information management, and AI systems
- Sustainable manufacturing (processes) and products
- Agile and flexible enterprise capabilities and supply chains
- Innovation in products, services, and processes.
- Close collaboration between industry and research to adopt new technologies
- New manufacturing management paradigms

Barriers to becoming data-driven

Survey respondents report that strategic, leadership, and organizational hurdles often determine the degree to which they can use data and analytics effectively

Which of these have been among the TOP 3 most significant challenges to your organization's pursuit of its data and analytics objectives?

High · Moderate · Low

	Barriers	Overall %	High tech and telecom	Retail	Manu-facturing	Public sector	Health care
Strategy, leadership, and talent	Constructing a strategy	30	High	Moderate	Moderate	Low	Moderate
	Ensuring senior management involvement	42	Low	High	High	High	High
	Securing internal leadership for data and analytics projects	33	High	High	Low	Low	Low
	Attracting and/or retaining appropriate talent (both functional and technical)	21	Moderate	Moderate	Moderate	Low	Low
Organi-zational structure and processes	Tracking the business impact of data and analytics activities	23	Low	Low	Moderate	High	Moderate
	Designing an appropriate organizational structure to support data and analytics activities	45	Moderate	Low	High	High	High
	Creating flexibility in existing processes to take advantage of data-driven insights	13	Low	Low	Moderate	Low	Low
IT infra-structure	Providing business functions with access to support	14	Low	Moderate	Low	Low	Low
	Investing at scale	17	Moderate	High	Low	Low	Moderate
	Designing effective data architecture and technology infrastructure	36	Low	Moderate	High	High	High

SOURCE: McKinsey Global Institute analysis

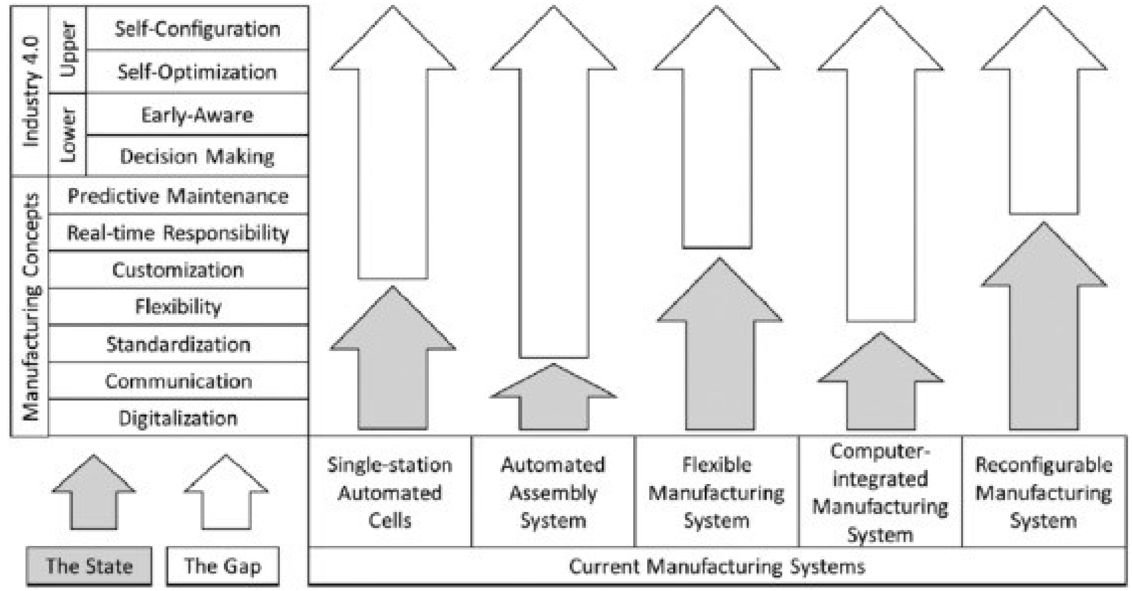
Challenges

- Acceptance and change
- Integration
- Security
- Data infrastructure
- Re-skilling

"The biggest challenge of the digital transformation is going to be guaranteeing that different systems communicate with each other."
Marcel Wenzin, agta record ag, Head of Supply Chain Management

Hot topics

- Legacy connectivity
- Standardisation of data models
- Digital twins
- Upskilling the workforce
- Data sharing and security
- Digital passport and certification
- Connected supply chain
- Human, cyber, physical collaboration



Engineering Science and Technology, an International Journal
Volume 22, Issue 3, June 2019, Pages 899-919

Review

Scanning the Industry 4.0: A Literature Review on Technologies for Manufacturing Systems

V. Alcácer [a, c], V. Cruz-Machado [a, b]

Future research - AI

- Deployment of AI (MLOps)
- Self-supervised and transfer learning
- Generating synthetic training data
- Learning on smaller datasets
- Explainable AI and trust
- Adoption and acceptance of AI

AMRC AI lead: Rikki Coles

IndustryWeek

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Technology and IIoT

TECHNOLOGY AND IIOT

The Dawn of the Smart Factory

"This is nothing less than a paradigm shift in industry: the real manufacturing world is converging with the digital manufacturing world to enable organizations to digitally plan and project the entire lifecycle of products and production facilities." - Helmuth Ludwig, CEO, Siemens Industry Sector, North America.

Thank You

PEAK INDICATORS