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Smart Supply Chain Management Towards Industry 4.0

Presentation by

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25th Sep 2019

Agenda

- **Introduction**
- **Industry 4.0**
- **Industry 4.0 design principles**
- **Potential Implications**
- **Supply Chain 4.0**
- **Skills relevant to Industry 4.0**

An introduction of myself

- **Currently:** Professor of Operations and Supply Chain Management and Director of Research and Scholarship, Bristol Business School, University of the West of England, UK

- **Previously:** Lecturer of Management, Dublin City University Business School, Dublin, Republic of Ireland.

- **PhD in Management Studies**, Exeter Business School, University of Exeter, UK

- **Bachelor of Technology (B. Tech)** in Metallurgy and Materials Engineering, National Institute of Foundry and Forge Technology, India

Bristol Business School

UWE Bristol | University of the West of England

150+ academic staff, 3500 students

Academic Disciplines:

Accounting & Finance, Economics, Human Resource Management, Marketing, Organisation Studies, Strategy & Operations Management

Centres of Research & Knowledge Exchange:

Centre for Applied Legal Research, Bristol Centre for Economics and Finance, Bristol Leadership and Change Centre, Applied Marketing Research Group, Human Resources, Work and Employment, Innovation, Operations Management and Supply

New Business School

A recently completed £55m+ Bristol Business School and Bristol Law School building

https://www.youtube.com/watch?v=oNl5CJQBURM

https://www.youtube.com/watch?v=zfJRF3XVTnc

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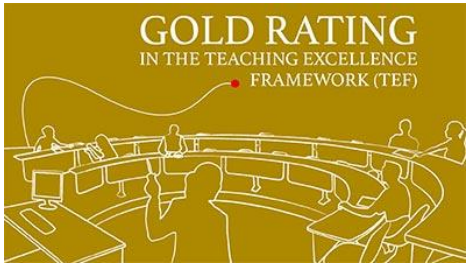
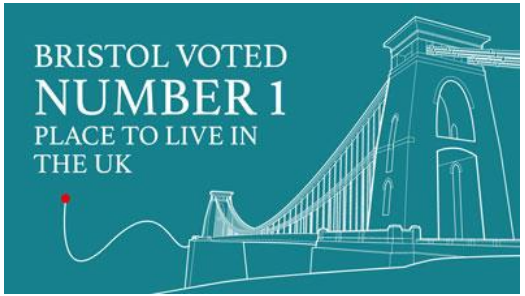


Bristol, UK

Bristol is a city, unitary authority and county in South West England with an estimated population of 437,492 in 2013. It is England's sixth and the United Kingdom's eighth most populous city, and the most populous city in Southern England outside London.

The rich and eventful history of Bristol as a port stretches back over many centuries.

Bristol



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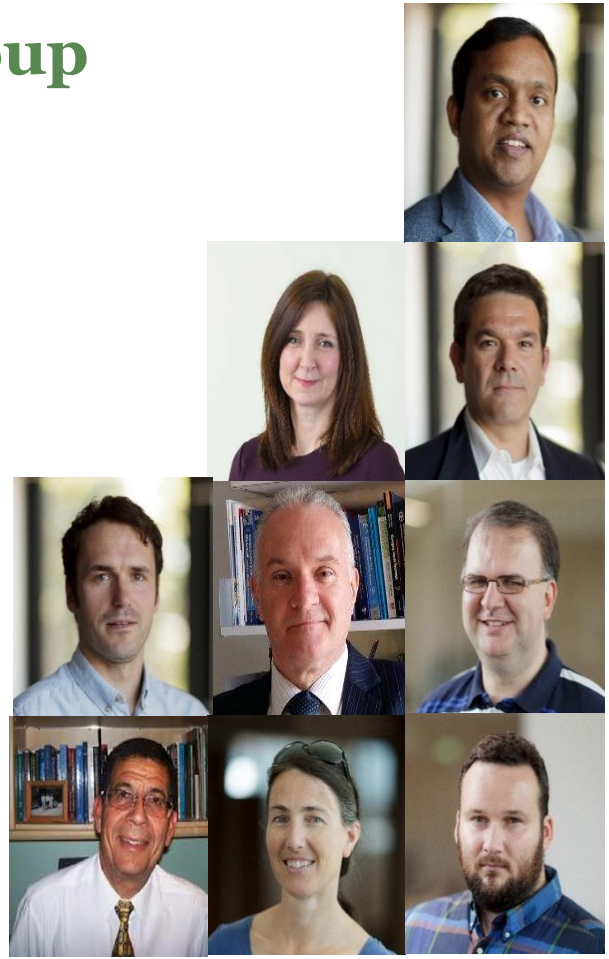
Innovation Operations Management & Supply Group (IOMS)

- Innovations in the Digital Economy
- Service Science
- Sustainability
- Business Models
- Value
- Lean Process Improvement
- Costing & Procurement
- Complex Networks
- Process Modelling
- Supply Chain Management



International Projects

Indonesia

- **Project Title:** Development of Supply Chain FMEA Model for Managing Supply Chain Sustainability Risk in Indonesian Small and Medium Enterprises (SMEs) (2018-2020)

- **Project Partner:** Sam Ratulangi University, Manado, Indonesia

- **Funded by: Royal Academy of Engineering**

ROYAL ACADEMY OF ENGINEERING

THE ROYAL SOCIETY

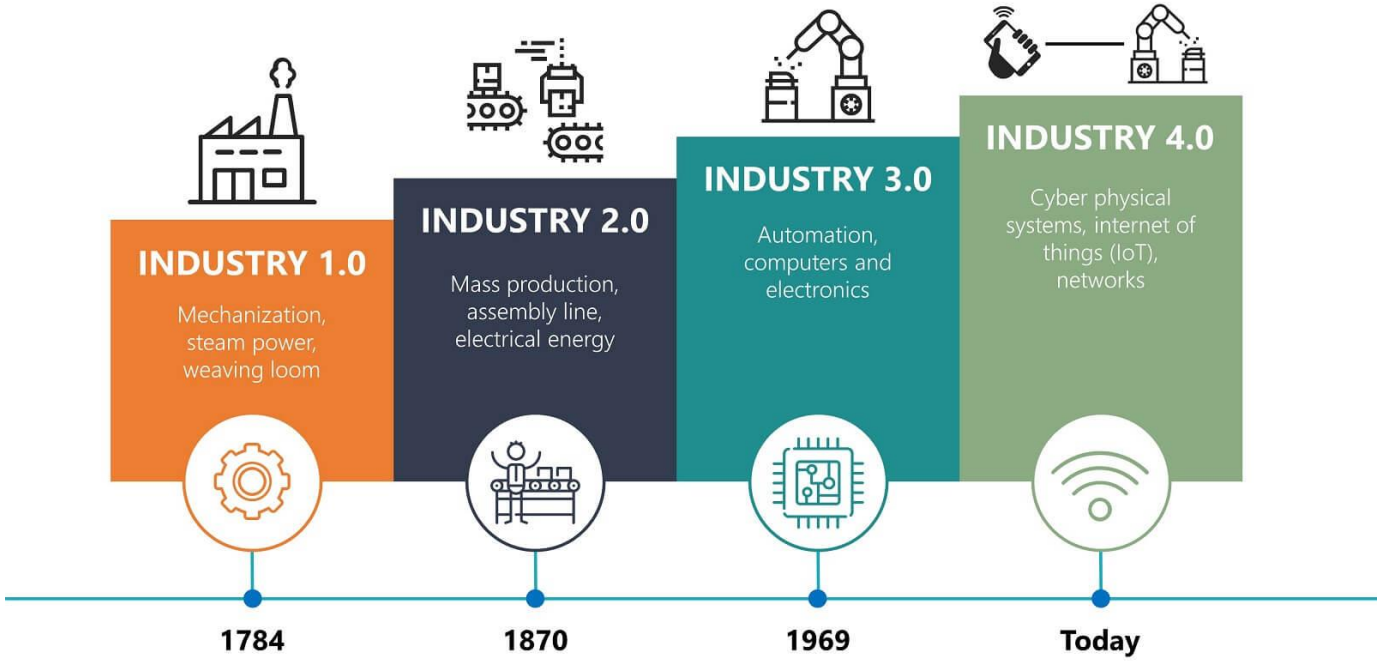
Turkey

- **Project Title:** Smart Supply Chain Management Towards Industry 4.0

- **Project Partner:** Yasar University, Izmir, Turkey (2019-2021)

Funded by: Royal Academy of Engineering /TUBITAK

What is Industry 4.0



Phases of earlier 3 Industrial Revolutions

1. 1760 to 1840 - Ushered in Mechanical production; railways and steam engine
2. 1870 to 1940 - Mass production; electricity and assembly line
3. 1960 to 2010 - Computers; semi conductors, main frame computing, personal devices, internet

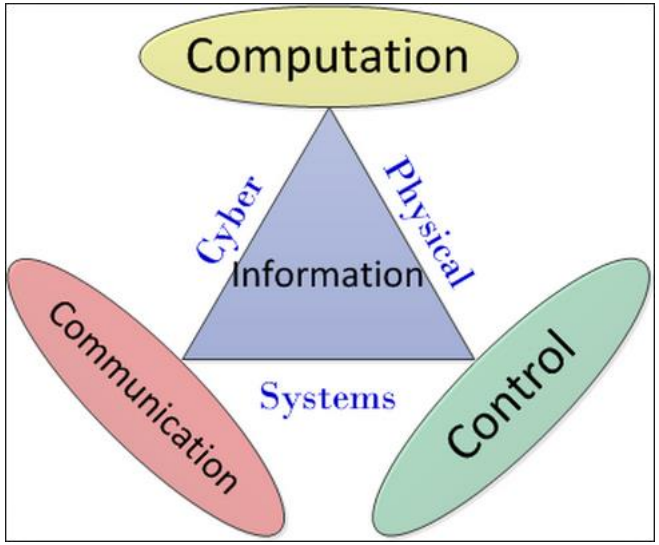
What is Industry 4.0

- Industry 4.0 refers to a new phase in the Industrial Revolution that focuses heavily on interconnectivity, automation, machine learning, and real-time data.

- Industry 4.0 isn't just about investing in new technology and tools to improve manufacturing efficiency—it's about revolutionizing the way your entire business operates and grows.

- Recent figures from KPMG has estimated that the component markets of Industry 4.0 are estimated to be worth more than US$4 trillion by 2020.

- https://www.youtube.com/watch?v=ktcRXyE8SaY#action=share



A **cyber-physical system** (**CPS**) is a system of collaborating computational elements controlling physical entities. CPS are physical and engineered systems whose operations are monitored, coordinated, controlled and integrated by a computing and communication core. They allow us to add capabilities to physical systems by merging computing and communication with physical processes.

Did not exist in 2006

- iPhone
- iPad
- Kindle
- 4G
- Uber
- Airbnb
- Android
- Android
- Oculus
- Instagram
- Snapchat
- Whatsapp

Time to reach 100 Million customers

- Telephone 75 Years
- Web 7 Years
- Facebook 4 Years
- Instagram 2 Years
- Pokemon Go 1 Month

Industry 4.0: Six Design Principles

- **Interoperability**: the ability of **cyber-physical systems** (i.e. work piece carriers, assembly stations and products), humans and Smart Factories to connect and communicate with each other via the **Internet of Things** and the **Internet of Services**
- **Virtualization**: a virtual copy of the Smart Factory which is created by linking sensor data (from monitoring physical processes) with virtual plant models and simulation models
- **Decentralization**: the ability of **cyber-physical systems** within Smart Factories to make decisions on their own
- **Real-Time Capability**: the capability to collect and analyze data and provide the insights immediately
- **Service Orientation**: offering of services (of **cyber-physical systems**, humans and Smart Factories) via the **Internet of Services**
- **Modularity**: flexible adaptation of Smart Factories for changing requirements of individual modules

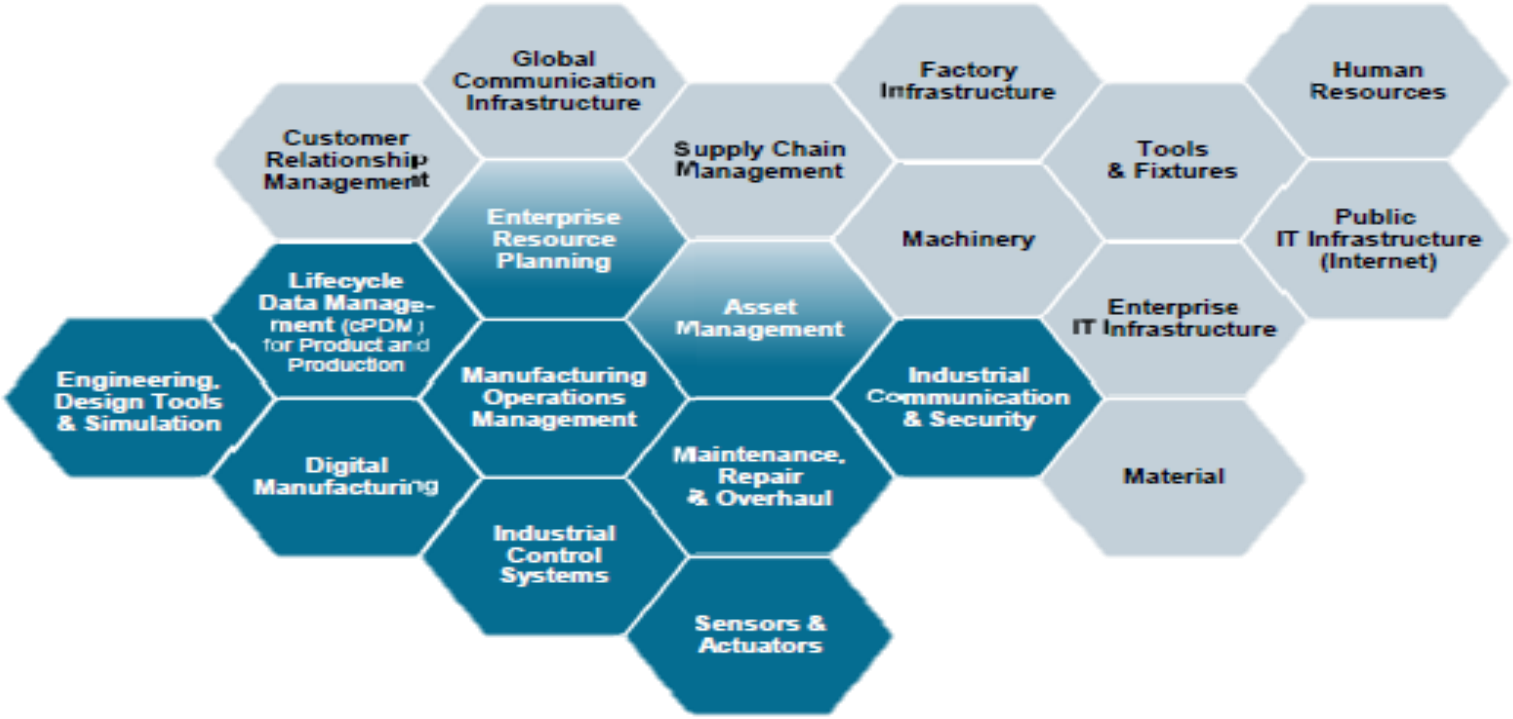
Industry 4.0 Building Blocks

Industry 4.0 refers to the convergence and application of nine digital industrial technologies

1. **Advanced Robotics**
   - Autonomous, cooperating industrial robots
   - Numerous integrated sensors and standardized interfaces
2. **Additive Manufacturing**
   - 3D printing, particularly for spare parts and prototypes
   - Decentralized 3D facilities to reduce transport distances and inventory
3. **Augmented Reality**
   - Augmented reality for maintenance, logistics, and all kinds of SOP
   - Display of supporting information, e.g., through glasses
4. **Simulation**
   - Simulation of value networks
   - Optimization based on real-time data from intelligent systems
5. **Horizontal/ Vertical Integration**
   - Cross-company data integration based on data transfer standards
   - Precondition for a fully automated value chain (from supplier to customer, from management to shop floor)
6. **Industrial Internet**
   - Network of machines and products
   - Multidirectional communication between networked objects
7. **Cloud**
   - Management of huge data volumes in open systems
   - Real-time communication for production systems
8. **Cybersecurity**
   - Operation in networks and open systems
   - High level of networking between intelligent machines, products, and systems
9. **Big Data and Analytics**
   - Full evaluation of available data (e.g., from ERP, SCM, MES, CRM, and machine data)
   - Real-time decision-making support and optimization

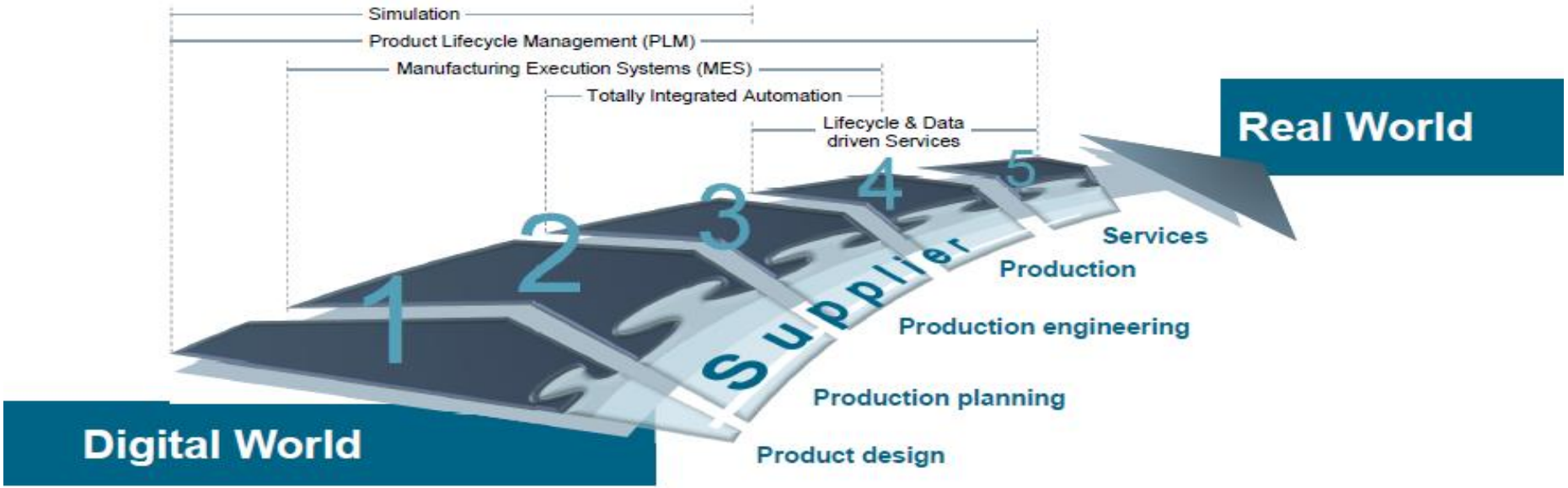
Many application examples already exist for all nine technologies

Impacting all aspect of value chain



Digital Enterprise

Entire value chain is digitized and integrated

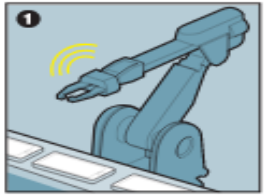


Potential Implications

- Robot Assisted production
- Predictive Maintenance
- Additive manufacturing of complex parts
- Machines as a service
- Big data drive quality control
- Production line simulation
- Smart supply network

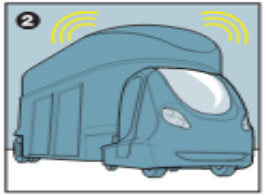
Increased automation is changing global production networks.

Automated production at factory



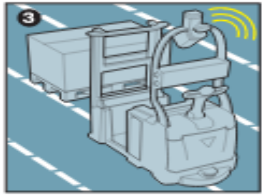
Machines provide constant feedback on production capacity and information on shipment-production status.

Autonomous truck to warehouse



Driverless trucks move goods to warehouses, with live transit-location updates via satellite link.

Automated warehouse

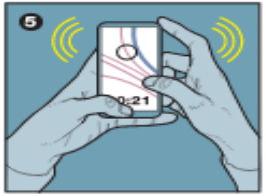


Machines handle all operations, from picking to transporting goods, with continuous information flow on status of goods.

Predictive shipping

Goods are dispatched from warehouses to stores and to online retail supply chains ahead of demand, based on anticipated demand.

Shipment rerouting by customer



Via mobile phone, customer has ability to view order status and input a new delivery destination.

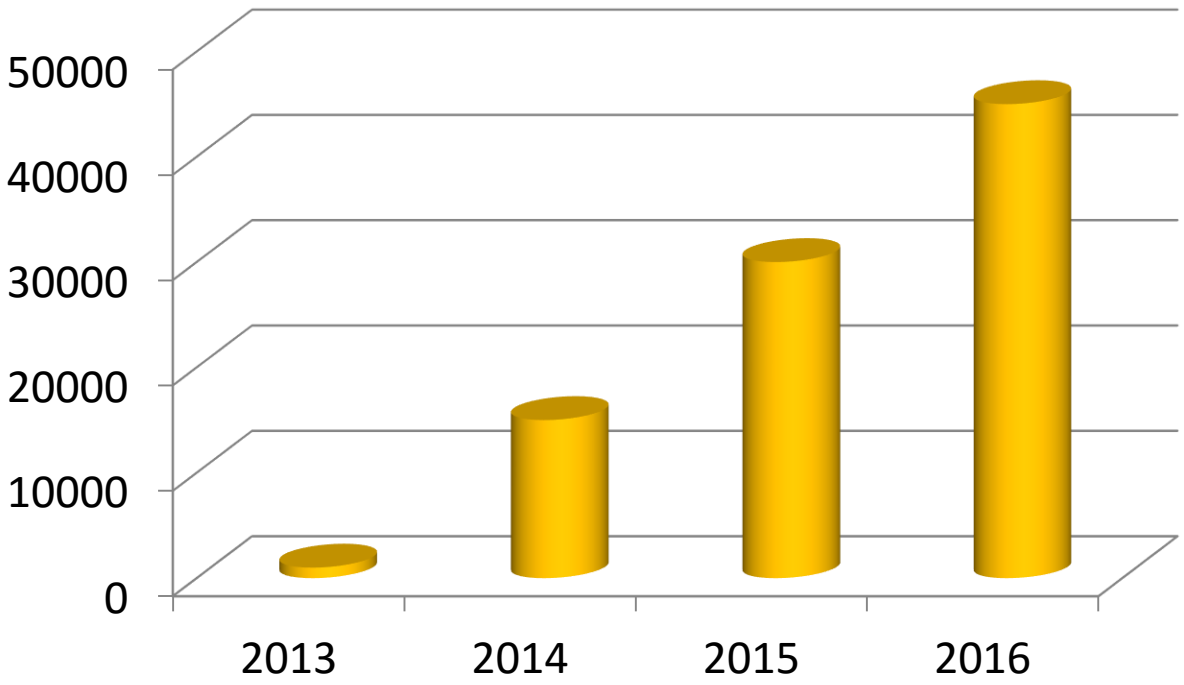
Last-mile delivery

Drones perform last-mile delivery and return pickups.

McKinsey&Company

Self Driving Cars

Robots working in Amazon WH



Examples of Product evolution: Connected and smart products

Philips Lighting

Users can control Philips Lighting hue lightbulbs via smartphone, turning them on and off, programming them to blink if they detect an intruder, or dimming them slowly at night.

Medtronic

Medtronic's implanted digital blood glucose meter connects wirelessly to a monitoring and display device and can alert patients to trends in glucose levels requiring attention.

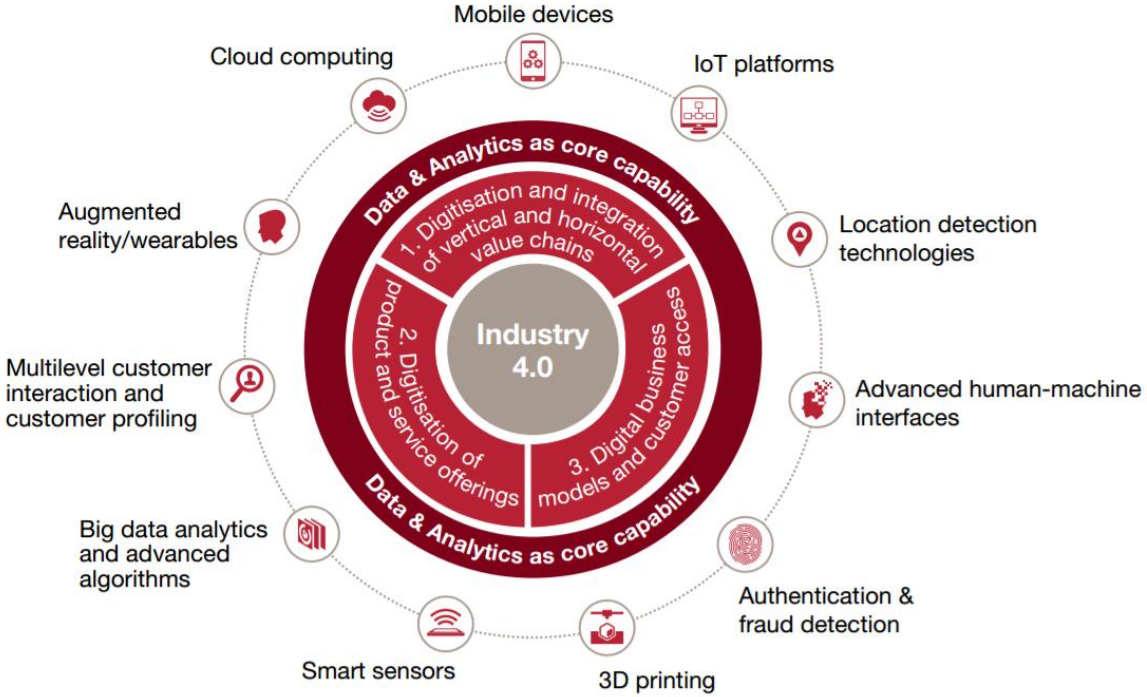
Ralph Lauren

Ralph Lauren's Polo Tech Shirt, available in 2015, streams distance covered, calories burned, movement intensity, heart rate, and other data to the wearer's mobile device.

Babolat

Babolat's Play Pure Drive product system puts sensors and connectivity in the tennis racket handle, allowing users to track and analyze ball speed, spin, and impact location to improve their game.

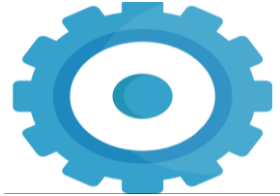
Leveraging Industry 4.0-Challenges & Opportunities



1) An organization can drive both revenue & margin by leveraging Industry 4.0
2) Transformation opportunity: both biz. models and biz. processes
3) Digital maturity-digital intensity & transformation management
4) Enablement on ‘new skills’ fundamental
5) Digital-niche to ‘must have’ skills

IoT will revolutionize the industry

- **Technology**
  - Robotics – Replacing humans on assembly line
  - 3D Printing – Manufacturing customized components
  - Big Data – Collecting performance parameters
  - Analytics – Understanding collected data

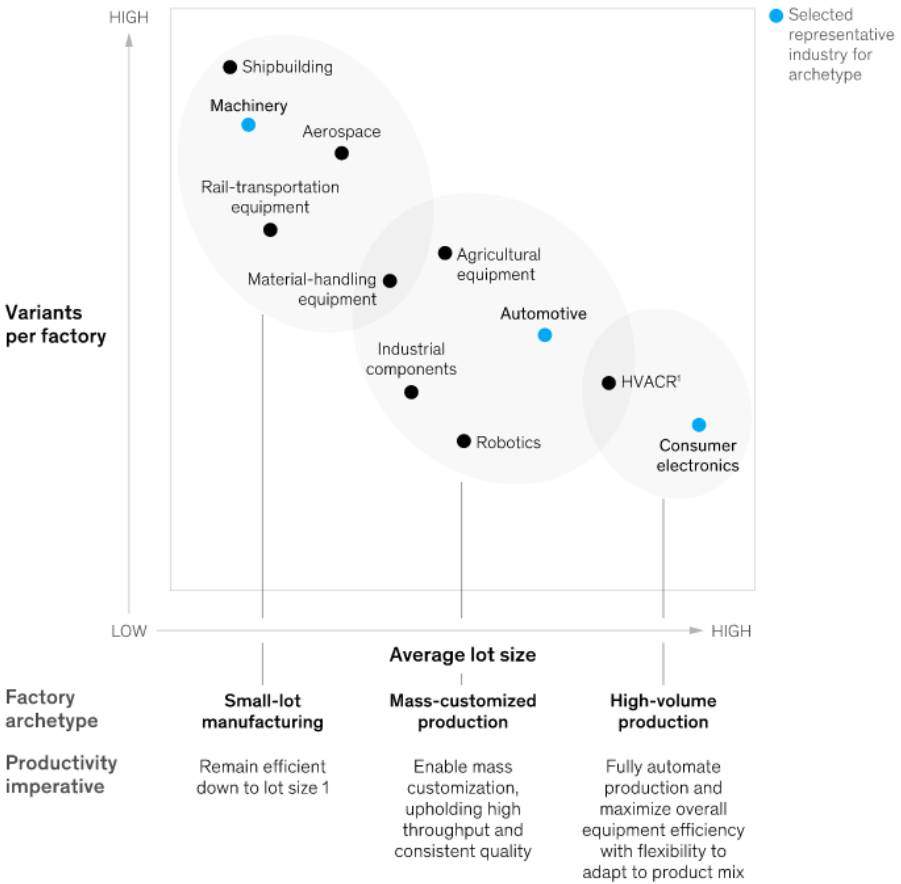


- **Process**
  - Constant communication – Data exchange between components
  - Decentralized decision making – Routine decisions
  - Standardization – Ease of customization
  - Smart Transport System - Automated transportation of raw material / final products

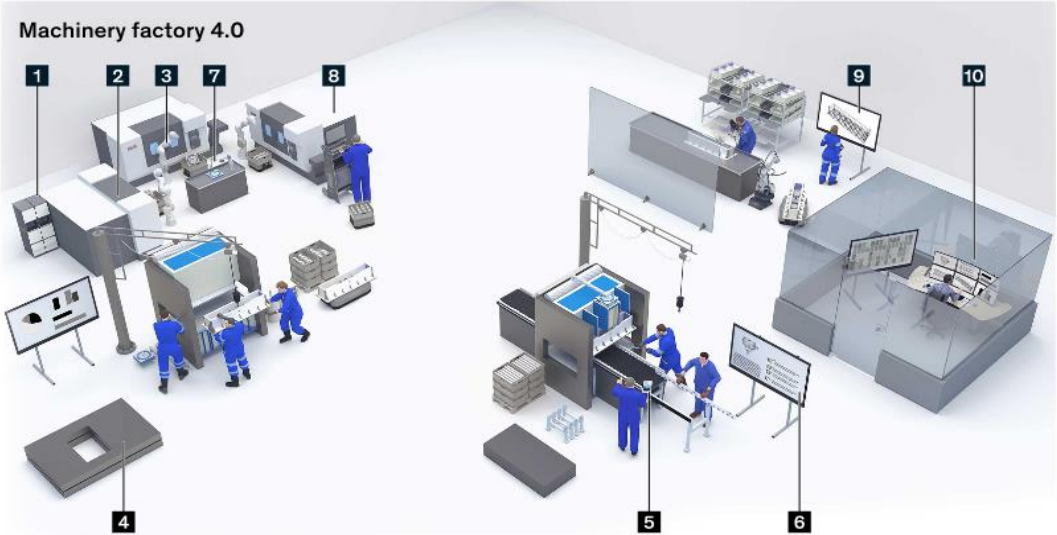
- **People**
  - Increased efficiency – Reduction in labor per unit
  - Skill Development – Up-skilling, Re-skilling, Continuous learning & Mindset change
  - Only to handle disruptions – Monitoring and corrective actions

Factory archetypes and industry 4.0 specific key value drivers

Overview of the 3 factory archetypes in discrete manufacturing, their productivity imperatives, and representative industries.



In the machinery factory of the future, an integrated product data model, digital enablement of workers, and OEE optimization are especially relevant.



Data-driven overall equipment effectiveness (OEE) optimization

1. Manufacturing IT integration for digital performance management for critical bottle-neck machinery

2. Digital process optimization based on machine and quality data

3. Automated machine setup and feeding

Digital enablement of workers

4. Real-time tracking of assembly times per step and progress

5. Digital documentation, drawings, troubleshooting guides, and checklists

6. Digital work orders containing detailed task description and sequence

Integrated product data model from engineering to commissioning

7. Integration of quality data into digital tool chain

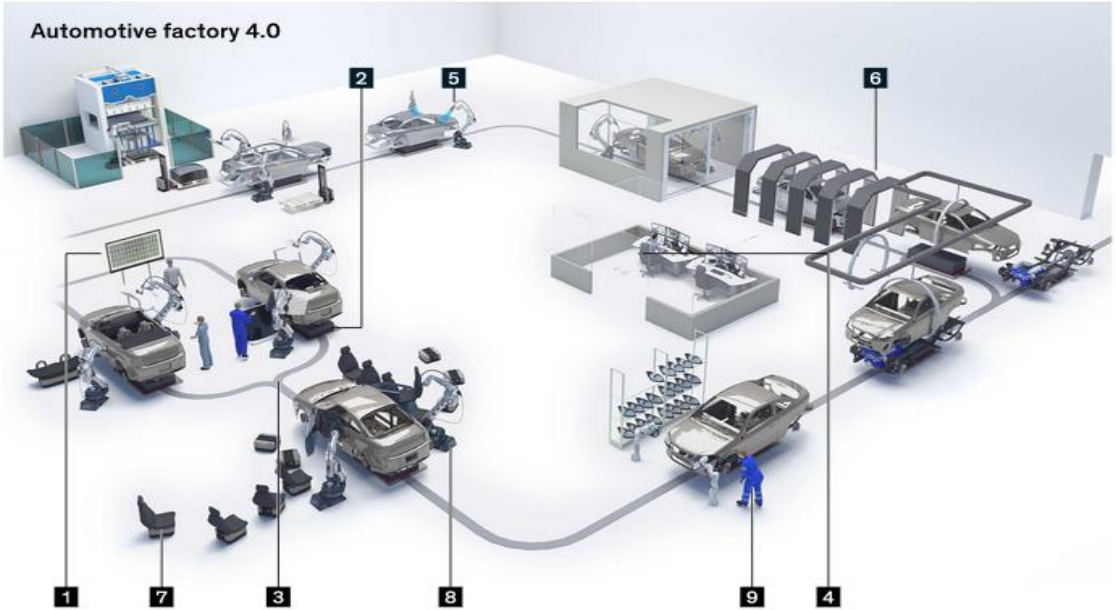
8. CAD/CAM[1] tool chain allowing offline NC[2] programming parallel to machining

9. Engineering and design software supplying latest information to shop floor

10. Virtual commissioning allowing for direct commissioning at customer site, eliminating prior in-house build-up, quality testing, and disassembly

[1]Computer-aided design and manufacturing.
[2]Numerical control.

In the automotive factory of the future, flexible routing, closed control loops, and automation could drive impact at scale.



Flexible routing, scheduling, load balancing, and performance management

1. Artificial intelligence (AI)-based optimized scheduling (eg, matching of skills, experience)

2. Primary material flow through AGV[1] platforms

3. AI-supported load balancing, based on realtime and historical data

4. Digital performance management based on near real-time data

Closed control loops through sensor-based in-line quality inspection

5. Early detection of process parameter deviation and rapid correction, reducing scrap (eg, using scanner-based body shop inspection)

6. Camera-based quality inspection improves defect identification and enables targeted rework

Extension of automation to final and pre-assembly

7. Automated line replenishments and parts delivery through AGVs

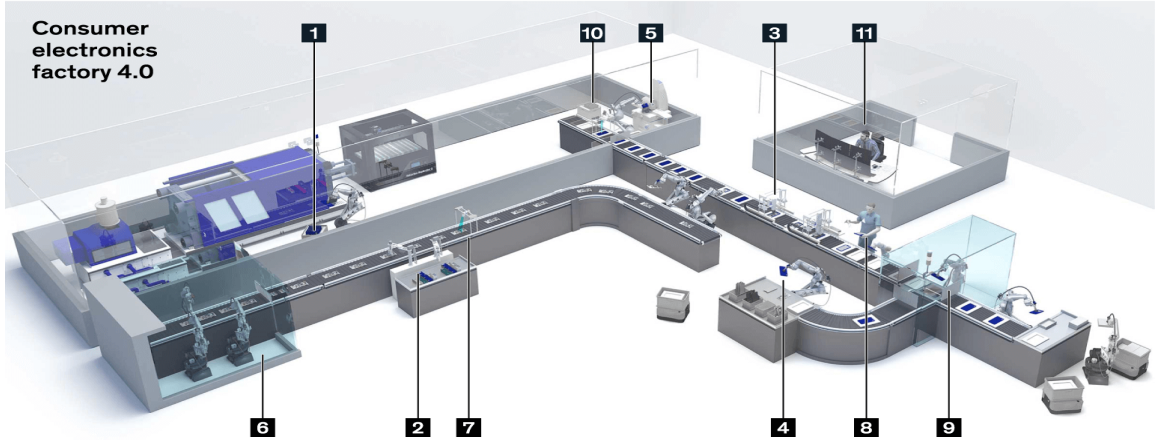
8. Extended use of industrial robots (eg, through machine vision guidance)

9. Collaborative unfenced in-line robots

Additional value drivers

Value capture typically only for selected areas: predictive maintenance for production machines and tools, warehouse automation, automated high capacity battery cell and pack handling

In the consumer-electronics factory of the future, automation, closed control loops, and traceability will be key value drivers.



Manual labor conquered through automation

1. AGV[1] material transport for line replenishment and selected primary material transport

2. Robot-supported component assembly on circuit boards

3. Robotic discrete assembly, micro-screw tightening, and adhesive joining

4. Robot-supported product dismantling and recycling

5. Automated component treatment and preparation (eg, case polishing)

Closed quality loops through sensor-based in-line quality inspection

6. Automated process parameter adjustment and optimization based on quality data

7. Enhanced in-line quality inspection for early defect detection (eg, 3D scanning of PCB[2] assemblies)

8. Quality assurance of discrete assembly (eg, with vision-equipped robots capable of inspecting and correcting misaligned parts)

9. Fully automated end-of-line functional hardware and software testing and quality assurance

Traceability

10. Serialization of components and parts and tracking throughout the production process

11. Tracking of products, components, and materials throughout the value chain

Additional value drivers

Value capture typically only for selected areas: digital performance management

[1]Automated guided vehicles.
[2]Printed circuit board.

McKinsey & Company

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Manufacturers need to overcome major implementation barriers, of which some are more relevant for advanced players

Top 5 barriers mentioned by manufacturers with no/limited progress in Industry 4.0

- **Difficulty in coordinating actions** across different organizational units
- **Lack of courage** to push through radical transformation
- **Lack of necessary talent,** e.g., data scientists
- **Concerns about cybersecurity** when working with third-party providers
- **Lack of a clear business case** that justifies **investments** in the underlying IT architecture

+

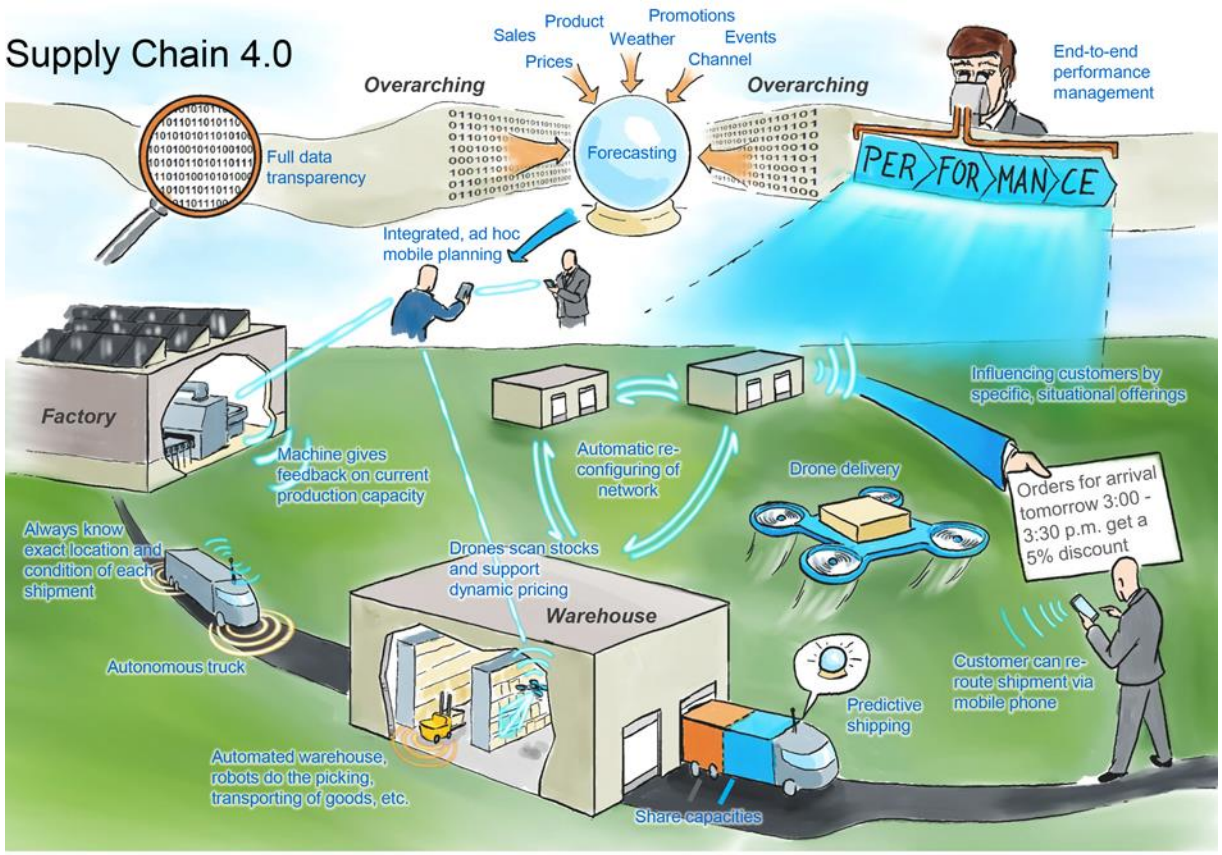
Additional top barriers mentioned by more advanced manufacturers

- **Concerns about data ownership** when working with third-party providers
- **Uncertainty about in- vs. outsourcing** and lack of knowledge about **providers**
- **Challenges with integrating data** from disparate sources in order to enable Industry 4.0 applications

Level of progress in Industry 4.0

SOURCE: McKinsey Industry 4.0 Global Expert Survey 2016

Supply Chain 4.0



SOURCE: McKinsey

Key Determinants

- Key determinants of the success of any Supply Chain 4.0 initiative are;
  - IT infrastructure
  - HR and Organizational Skills
  - Coordination
  - Leadership Support
  - Awareness
  - Strategic Vision
  - Compliance

Top 10 Skills to be relevant in Industry 4.0

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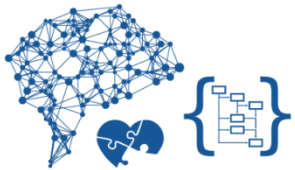
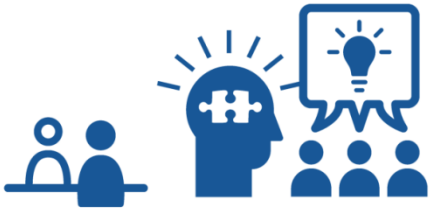
in 2020

1. Complex Problem Solving
2. Critical Thinking
3. Creativity
4. People Management
5. Coordinating with Others
6. Emotional Intelligence
7. Judgment and Decision Making
8. Service Orientation
9. Negotiation
10. Cognitive Flexibility

in 2015

1. Complex Problem Solving
2. Coordinating with Others
3. People Management
4. Critical Thinking
5. Negotiation
6. Quality Control
7. Service Orientation
8. Judgment and Decision Making
9. Active Listening
10. Creativity

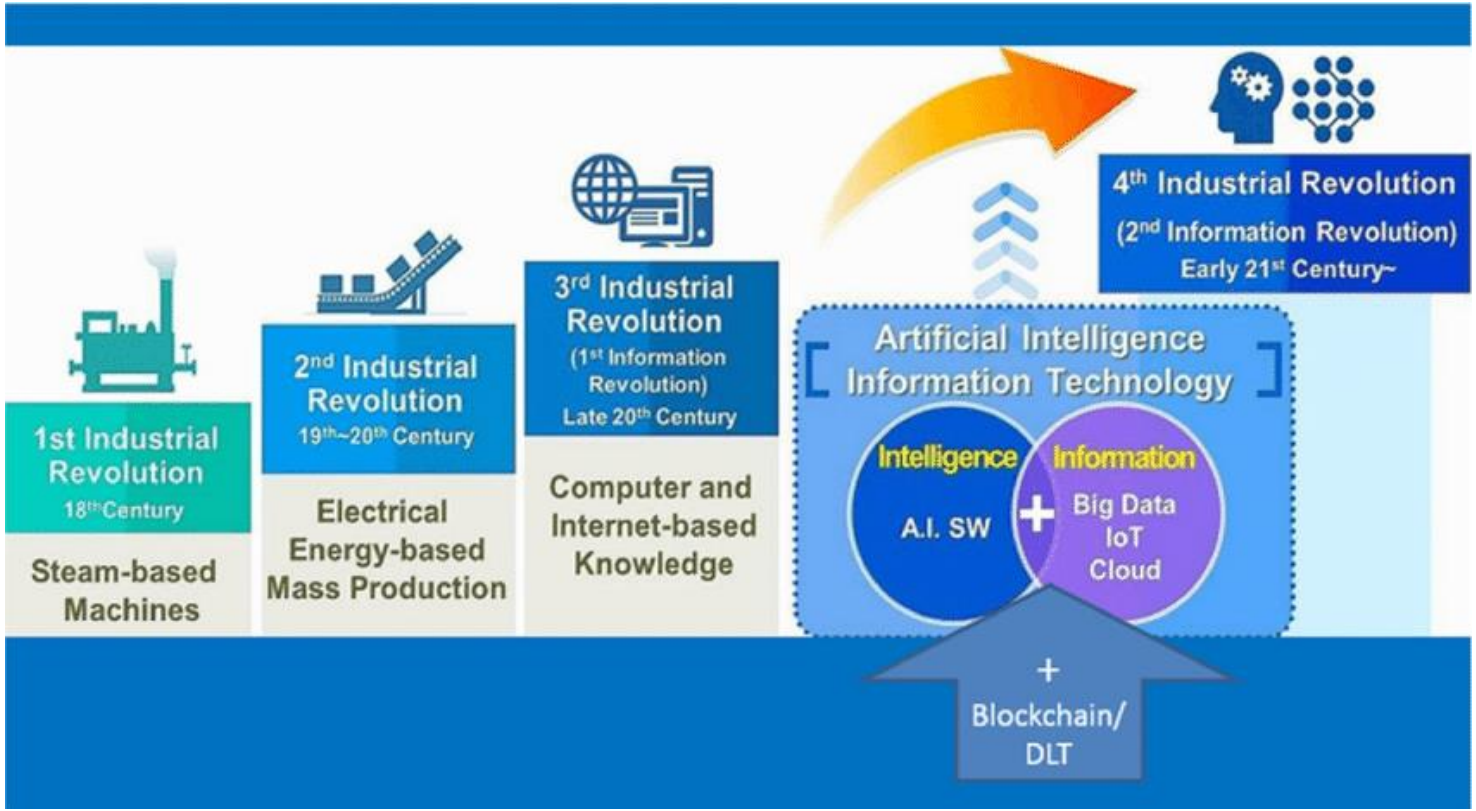




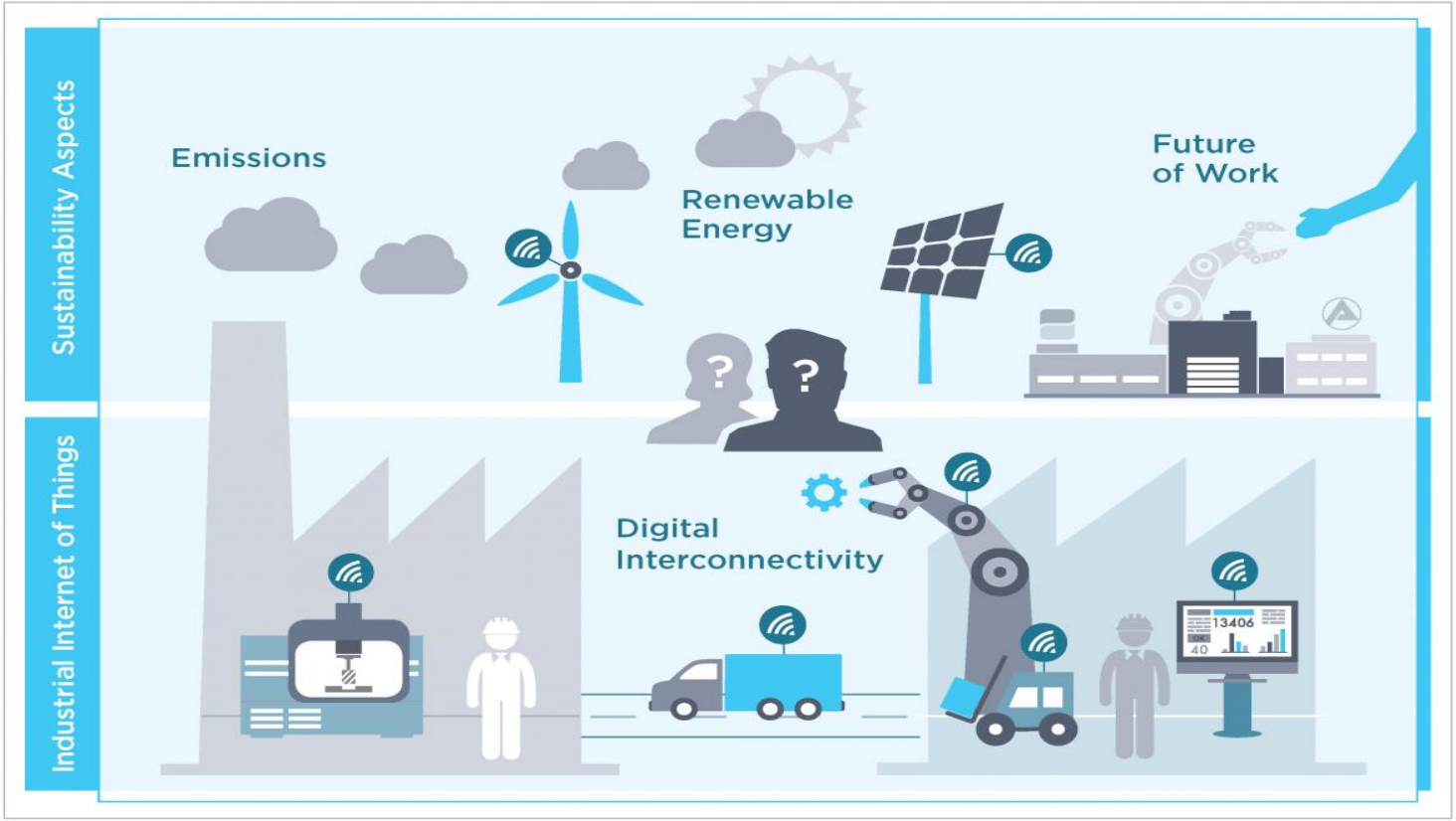
Source: Future of Jobs Report, World Economic Forum

We have some big goals….

Industry 4.0 to tackle Major Global Challenges

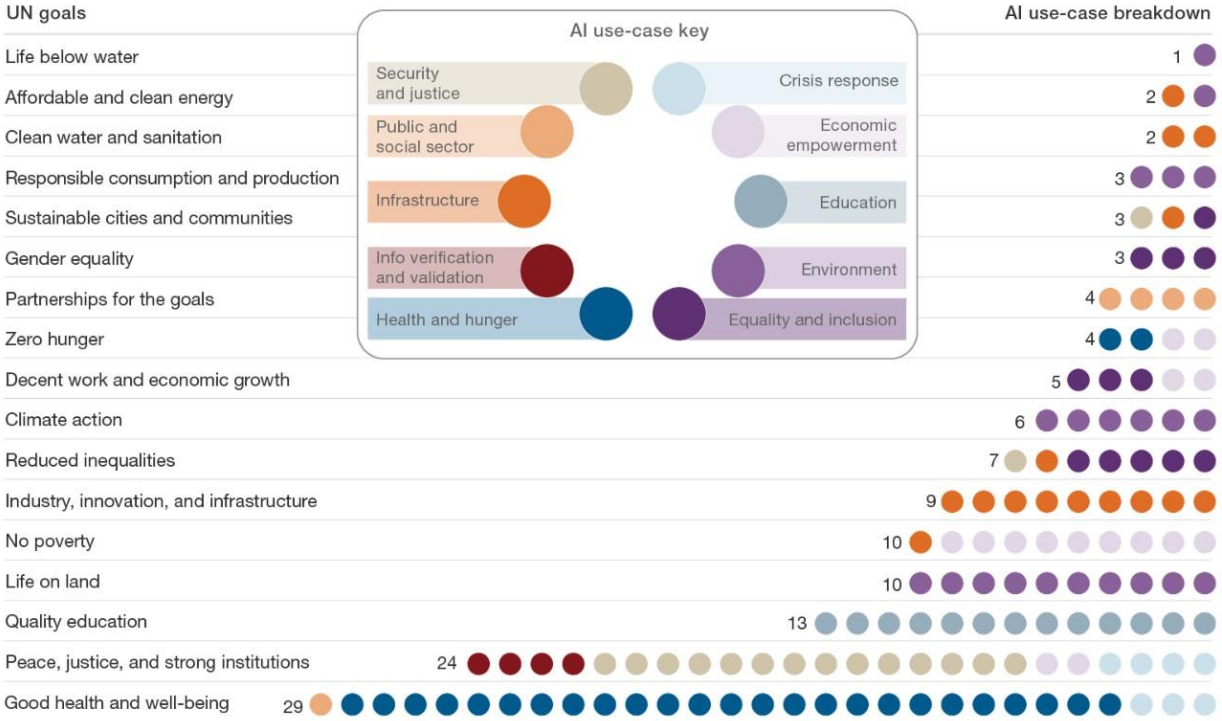


Industry 4.0 to Accelerate Transition towards Sustainable Energies



Many artificial-intelligence (AI) use cases support the most frequently cited societal challenges.

Where AI use cases fall within the UN's sustainable-development goals,[1] number



Note: This chart reflects the number and distribution of use cases and should not be read as a comprehensive evaluation of AI's potential for each sustainable-development goal (SDG); if an SDG has a low number of cases, that is a reflection of our library rather than of AI's applicability to that SDG. The chart also does not reflect all use cases in the library, more than 20 of which do not map to any SDG. These mainly focus on effective management in the public and social sectors, or belong to the issue types of disaster response and search and rescue in the crisis-response domain.
[1]Chart is a partial list of use cases, as 21 of the 156 identified use cases do not target any of the UN's sustainable-development goals.

McKinsey&Company | **Source:** McKinsey Global Institute analysis

Sustainable future commercial mobility

- https://www.mckinsey.com/Videos/video?vid=5589034460001&plyrid=HkOJqCPWdb