Robotics and Artificial Intelligence

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Note: Some of the pictures / images are taken from internet. Those are used for academic purposes.

National University of Singapore

What is a Robot – and what is not?

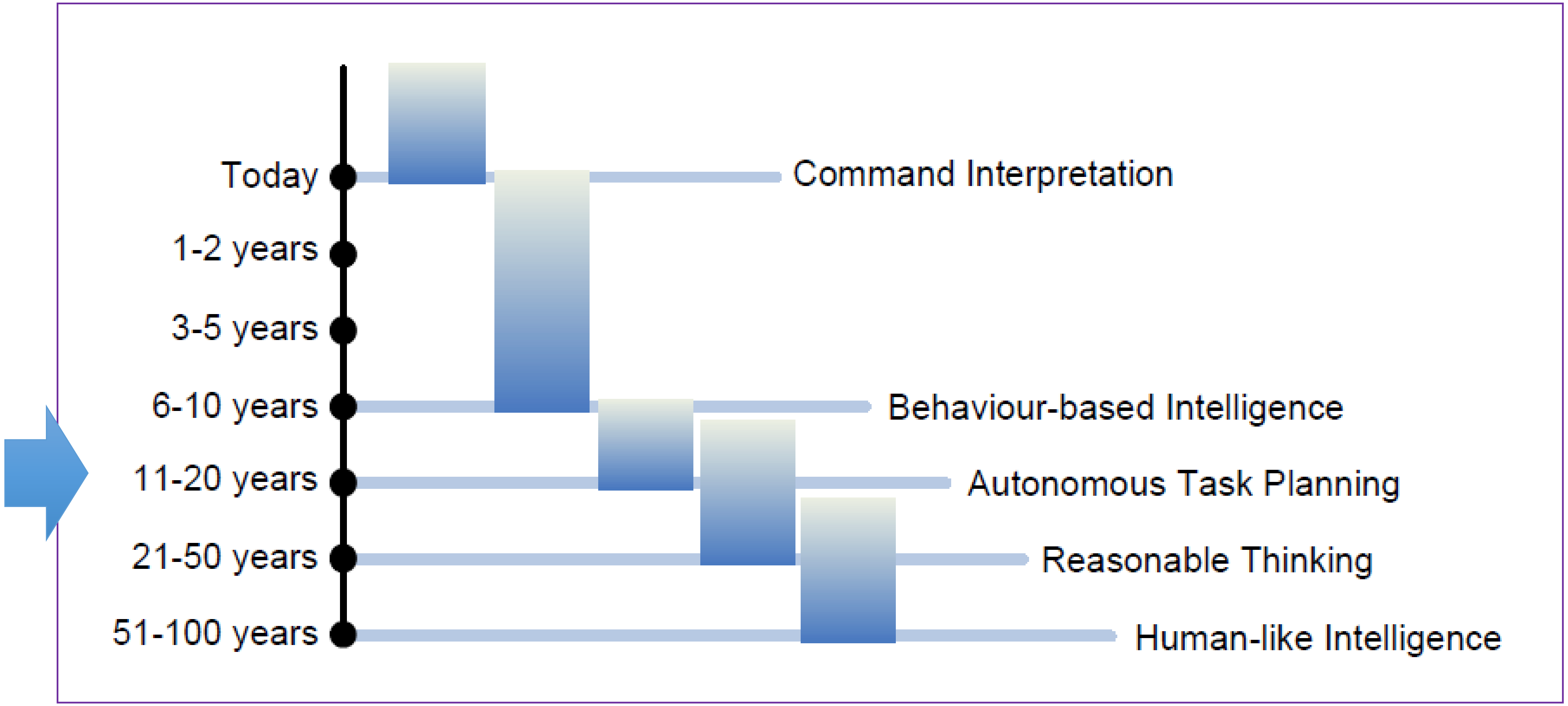
- Robot defined by International Standards Organization ISO
  - Automatically controlled, reprogrammable, multipurpose manipulator, programmable in three or more axes, which can be either fixed in place or mobile for use in industrial automation applications.
- No robots:
  - software (“bots”, AI, Robotic Process Automation-RPA)
  - remote-controlled drones, UAV, UGV, UUV
  - voice assistants
  - autonomous cars
  - ATMs, smart washing machines, etc.

What is a Robot? – Britannica

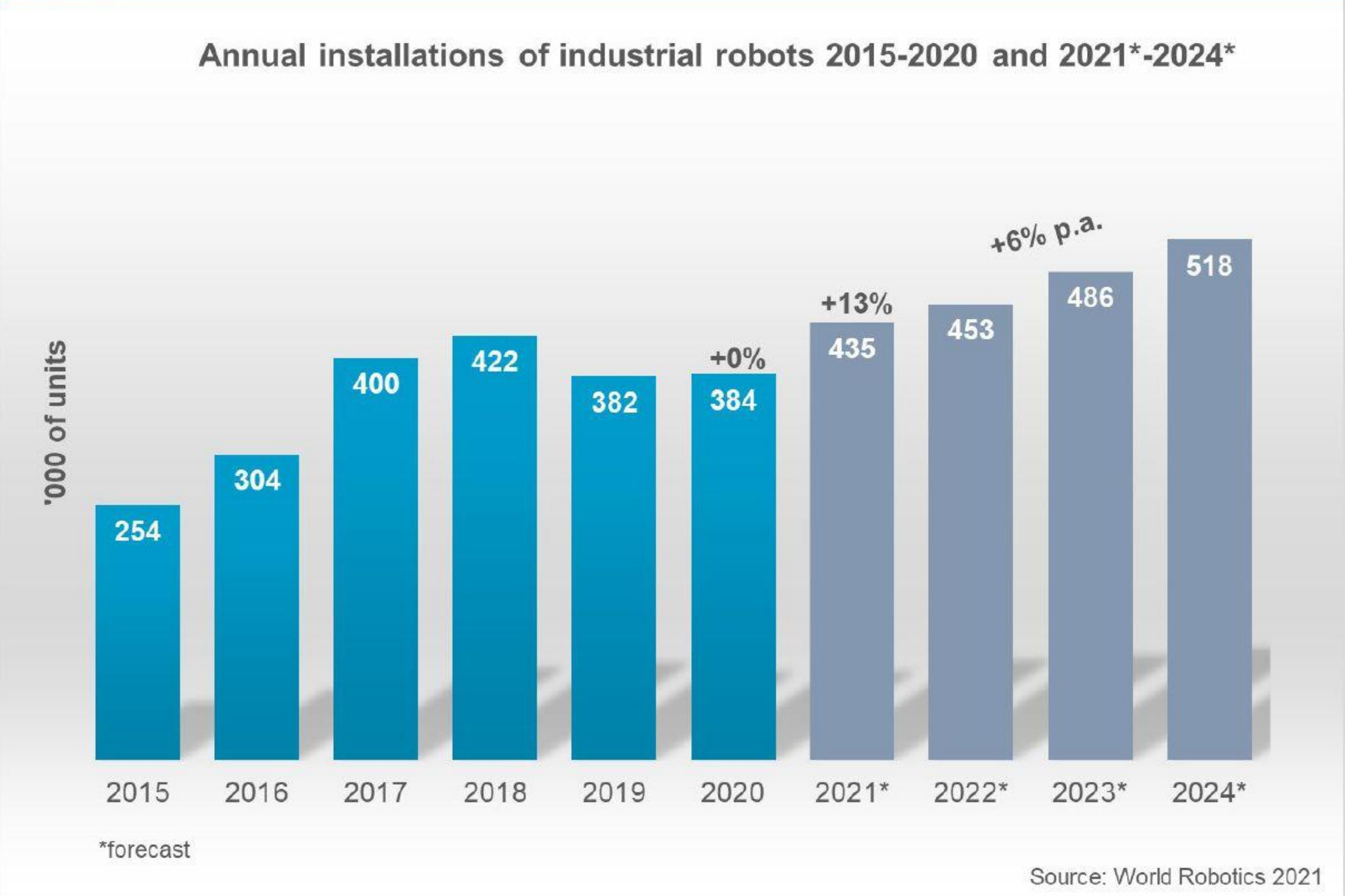
- robot, any automatically operated machine that replaces human effort, though it may not resemble human beings in appearance or perform functions in a humanlike manner. By extension, robotics is the engineering discipline dealing with the design, construction, and operation of robots.

britannica.com

Technology Roadmap for development of Intelligent Systems (courtesy: EURON 2004)



Forecast



IFR International Federation of Robotics

ifr.org


ABB

Robotics Capabilities (Technical know-hows)

- Adaptive manipulation
- Context Awareness
- Human-Robot Interaction (HRI)
- Intuitive Programming
- HRI Safety
- Learning and Adaptation
- Localization and Path Planning
- Mobility in Unstructured Environments
- Multi-robot coordination
- Smart Infrastructure
- Surveillance
- Wearable Systems
- *Robust robot system design*

Robotics – Technology Readiness Levels (TRLs) Technology Readiness Levels assess the maturity level of a particular technology

Level 1 - Basic Principles Observed

Idea: Basic technology research. Document elaborated which describes a product / feature idea and/or potential market requirement: Functional description, customer benefit, ideas for realization.

Level 2 - Technology Concept Formulated

Concept Formation: Basic technology research. Proof of principle developments including algorithm development and simulations. Concept formulated with details on potential development risks, including coarse resource planning.

Level 3 - Experimental Proof of Concept

Experimental Development: Technology development. Realization of parts of the Concept to visualize the product / feature idea; proof of concepts, first components and interfaces developed; lab experiments carried out; future technical scope of work identified.

Level 4 - Technology Validated in Laboratory

Experiment: Technology development. Testing of system or major sub-systems; validation against established benchmarks; Testing of internal and external inter-connectivity. Initial normative testing with trained users possible.

Source : Robotics 2020 Multi-Annual Roadmap For Robotics in Europe, 2014

Robotics – Technology Readiness Levels (TRLs) Technology Readiness Levels assess the maturity level of a particular technology

Level 5 - Technology Validated in Relevant Environment

Lab prototype: Internal technology demonstration. Main functionality of product / feature idea can be demonstrated. Major risks for the realization of a future product / feature have been documented as part of the description of the Demonstrator / realization.

Level 6 - Technology Demonstrated in Relevant Environment

Functional model/First Field Trials: External technology demonstration. Main functionality of a product / feature idea is realized at a degree that selected customers can carry out tests, when accompanied by developers.

Level 7 - System Prototype Demonstration in Operational Environment

Engineering Prototype Development of prototypes with final technology sub-systems or close analogues in a close to complete form factor. All identified functionality is capable of being demonstrated. Customer verification trials (independent of developer support) possible.

Level 8 - System Complete and Qualified Production Prototype

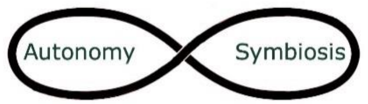
Development of prototypes with final functionality and form factor. Sufficient for end user testing in limited launch markets. Initial batch production of the products.

Level 9 - Actual System Proven in Operational Environment

Series production and sales.

Source : Robotics 2020 Multi-Annual Roadmap For Robotics in Europe, 2014

PROMISING SCENARIOS



Symbiotic human-robot coexistence

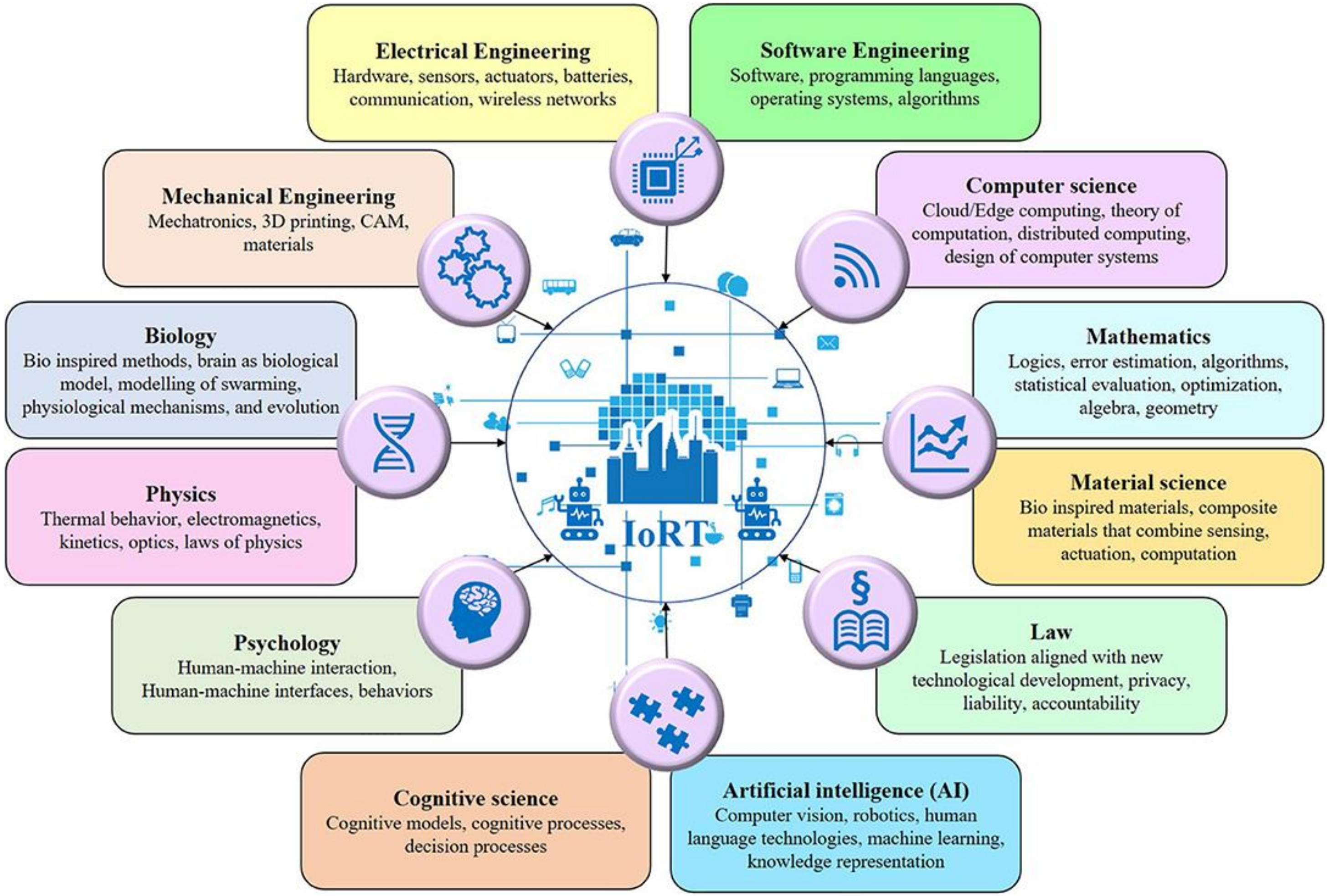
Smart mobility in human environment

Enhanced cognition for autonomy

Internet of Robotic Things

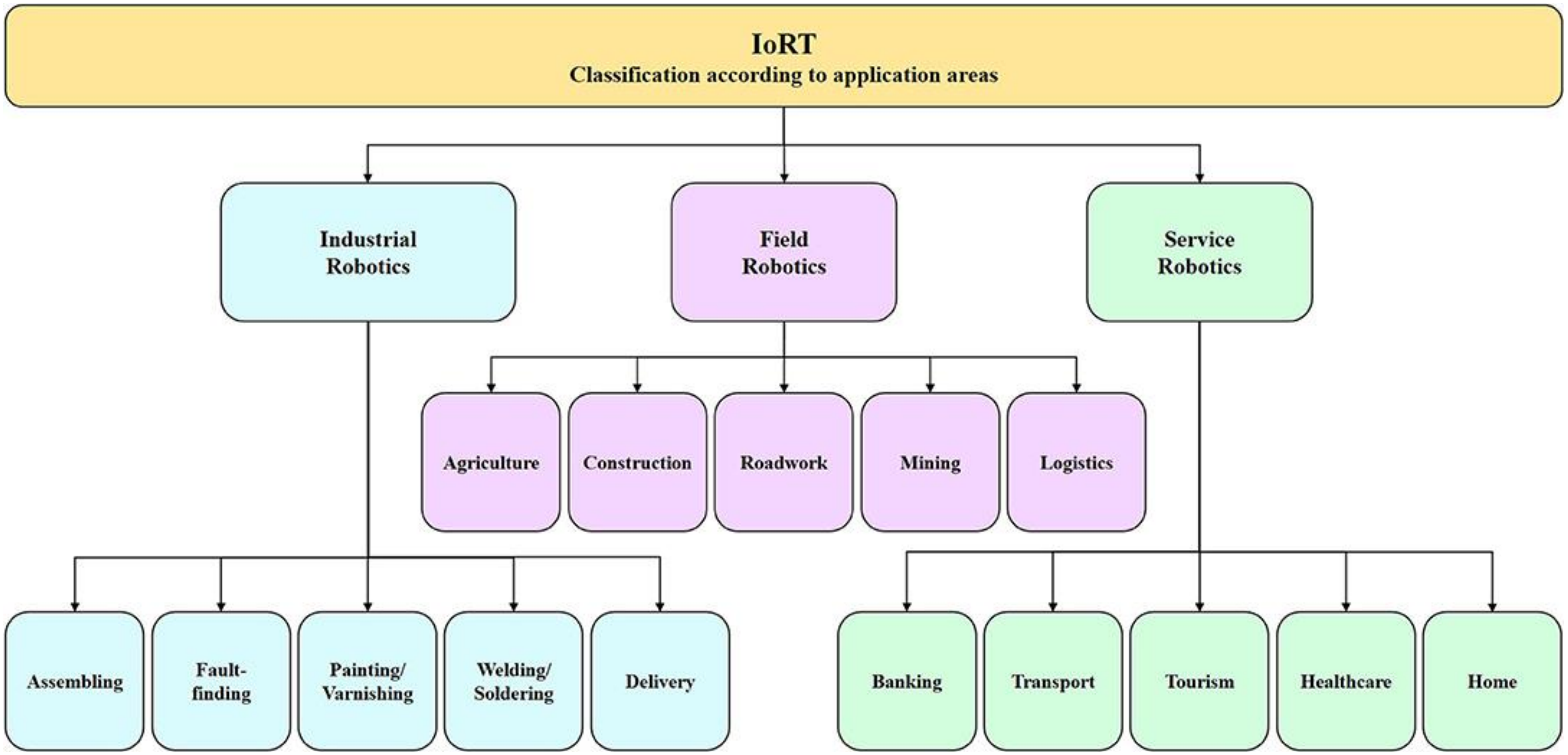
- Robotic things are capable of recognizing events and changes in their surroundings while autonomously acting and reacting appropriately.
- These capabilities enable the convergence of the real, digital, virtual, cyber attributes of robotic things, and the creation of smart environments that make robotic things in the energy, mobility, buildings, manufacturing, and other sectors more intelligent.

frontiersin.org/articles/10.3389/frobt.2020.00104/full



IoRT - An interdisciplinary branch of engineering and science

IoRT classification according to application areas



IoRT functional blocks

Processing	Cognition and Intelligence	Planning	Decision and Control	Propulsion	Connectivity	Data storage and Memory	Energy storage and Source
Energy Speed Code size	Generating information Combining information with other input Developing collaborative intelligence and collective cognition	Plan actions based on mission Plan actions based on other Robotic Thing Plan actions based on humans, animals, environment	Generate trajectory Provide energy management based on task context Diagnose and manage faults	Perform tasks Provide energy management based on task context Planned trajectory steering, braking, stabilization	Connected anytime, anything, anyone Through different paths, network and services Capacity to build and take decisions considering collective exchange of info	Storing necessary data locally Storing necessary data remotely Storing necessary energy needed for propulsion etc.	Pre-charged batteries Self-charging batteries Other energy sources (solar, etc.)

Operating Systems

HW/SW IoRT Platforms

frontiersin.org

IoT revolutionizes 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

In the future, complex production systems will function as artificial intelligence-driven self-organizing Internets-of-Things

Robotics – Application Sectors –Singapore

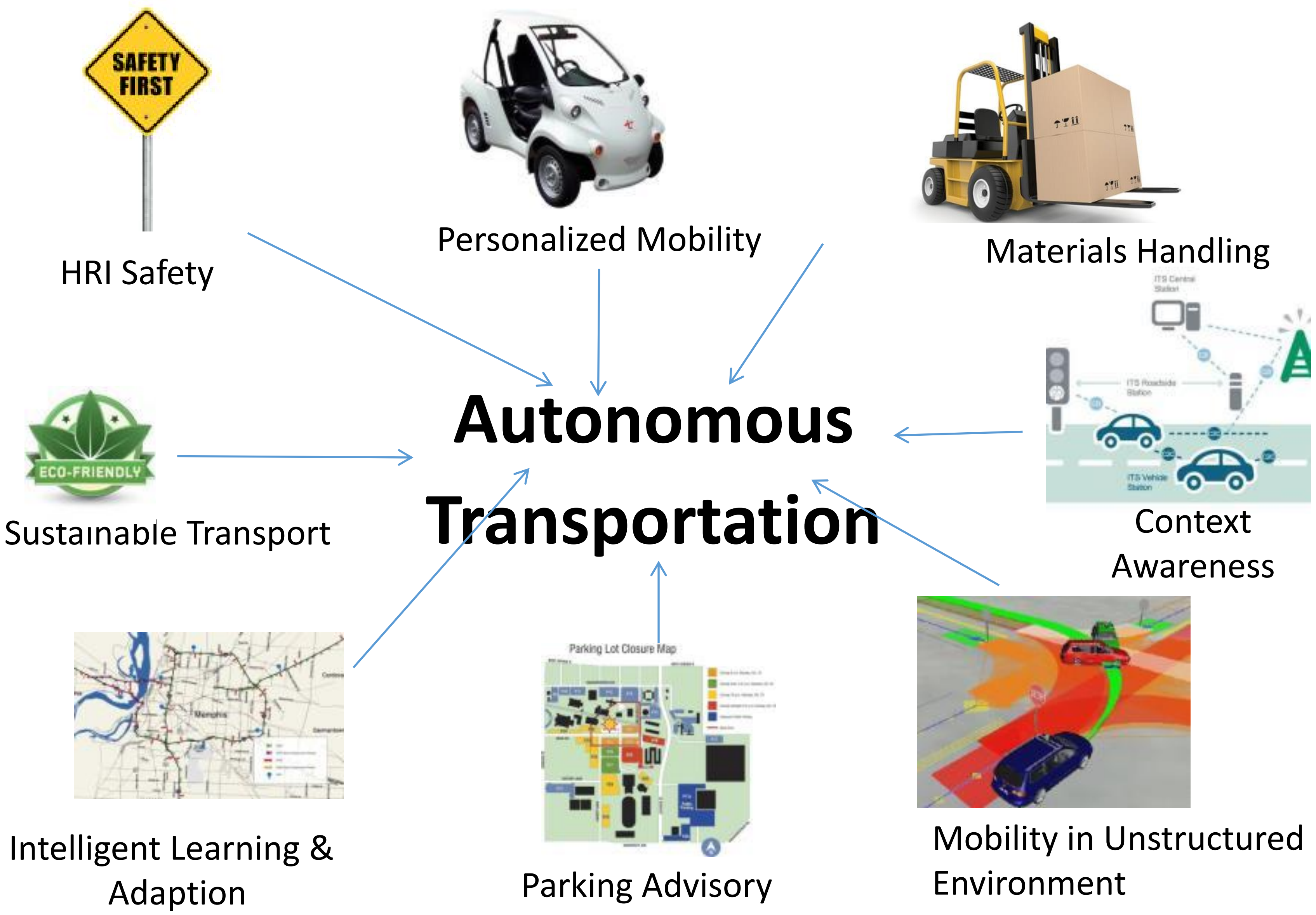
Autonomous Transportation
People Mover, Logistics & Material Handling

Healthcare
Medical, Rehabilitation, Assistive

Manufacturing
HMLV, Collaborative

Services
Professional & Domestic, Security, Social, Education

Autonomous Transportation (people mover, logistics & material handling)


SAFETY FIRST
HRI Safety
Personalized Mobility
Materials Handling
ECO-FRIENDLY
Sustainable Transport
Autonomous Transportation
Context Awareness
Intelligent Learning & Adaption
Parking Lot Closure Map
Parking Advisory
Mobility in Unstructured Environment

Manufacturing (HMLV, collaborative)

State of the art Robots in Manufacturing

Manipulators with all-joint force sensing: UR, KUKA LWR

Omni-directional mobile manipulator: Kuka

Dual-arm robots: Baxter, Kawada, ABB

High-Mix Low-Volume (HMLV) Manufacturing

Assembly

MRO

MRO

Job shop

Medium size structure - Machining

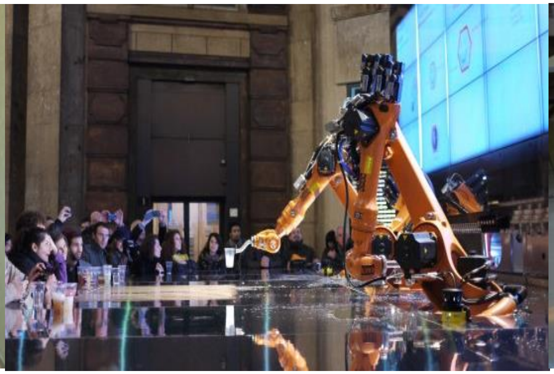
Large structure – sand blasting

Large structure - construction

Wafer fab – wafer handling

Services (professional and domestic, security, social, education)

State of the art Robots in Services






Facade & public toilet cleaning

Robotic vacuum cleaners: Available

Facade cleaning (commercial): None
(prototypes for uniform vertical walls)

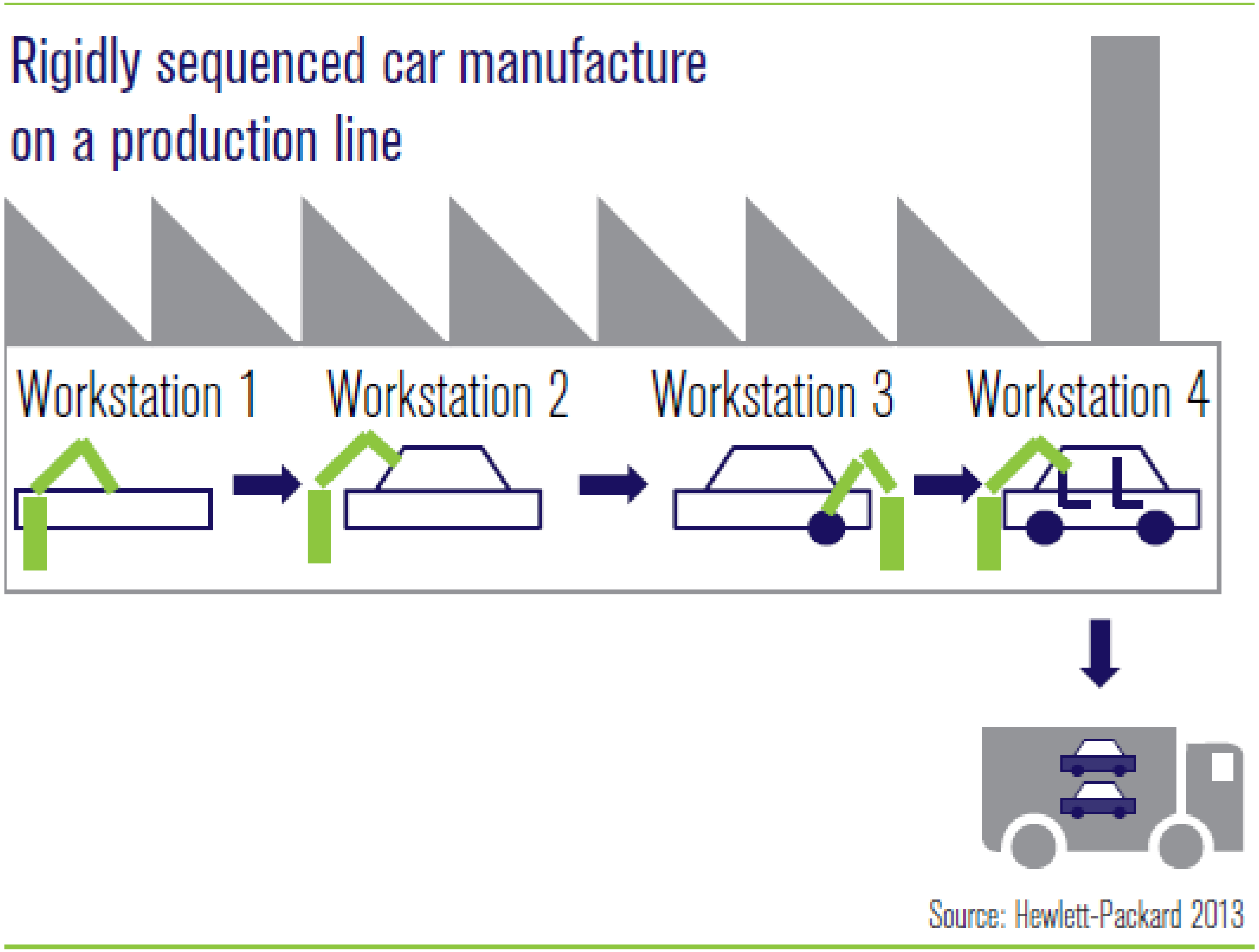
Public toilet cleaning: NUS Startup

Changying Precision Technology Company (Smart phone manufacturer)

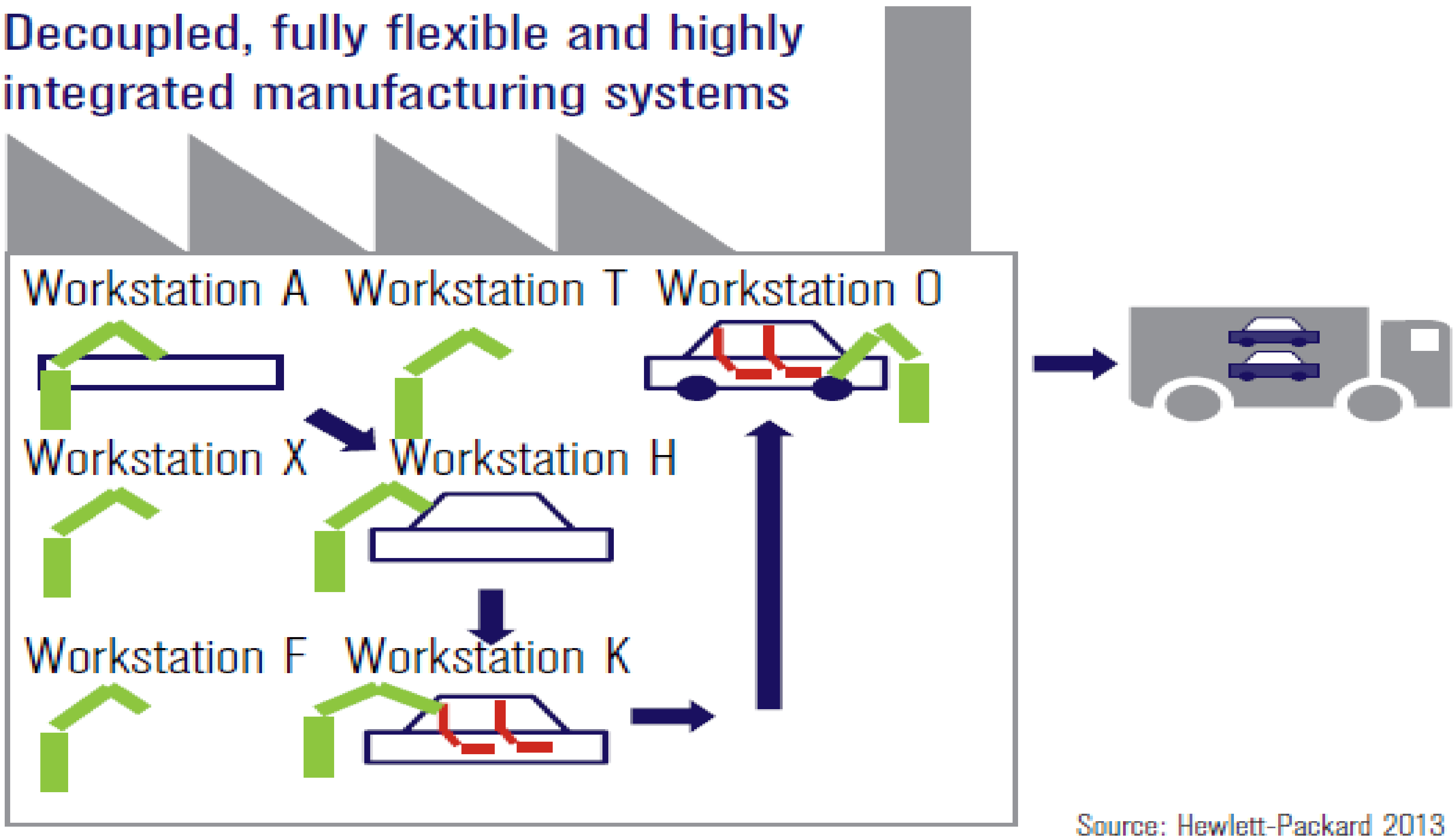
	Before	After
Number of employees	650	60 (90% reduction)
Number of robots	0	65
Defects (%)	25%	Below 5% (80% reduction)
Production per person	8000	21000 (more than 2.6 times)

https://www.roboticsbusinessreview.com/manufacturing/dont-wait-standards-before-adopting-smart-manufacturing/

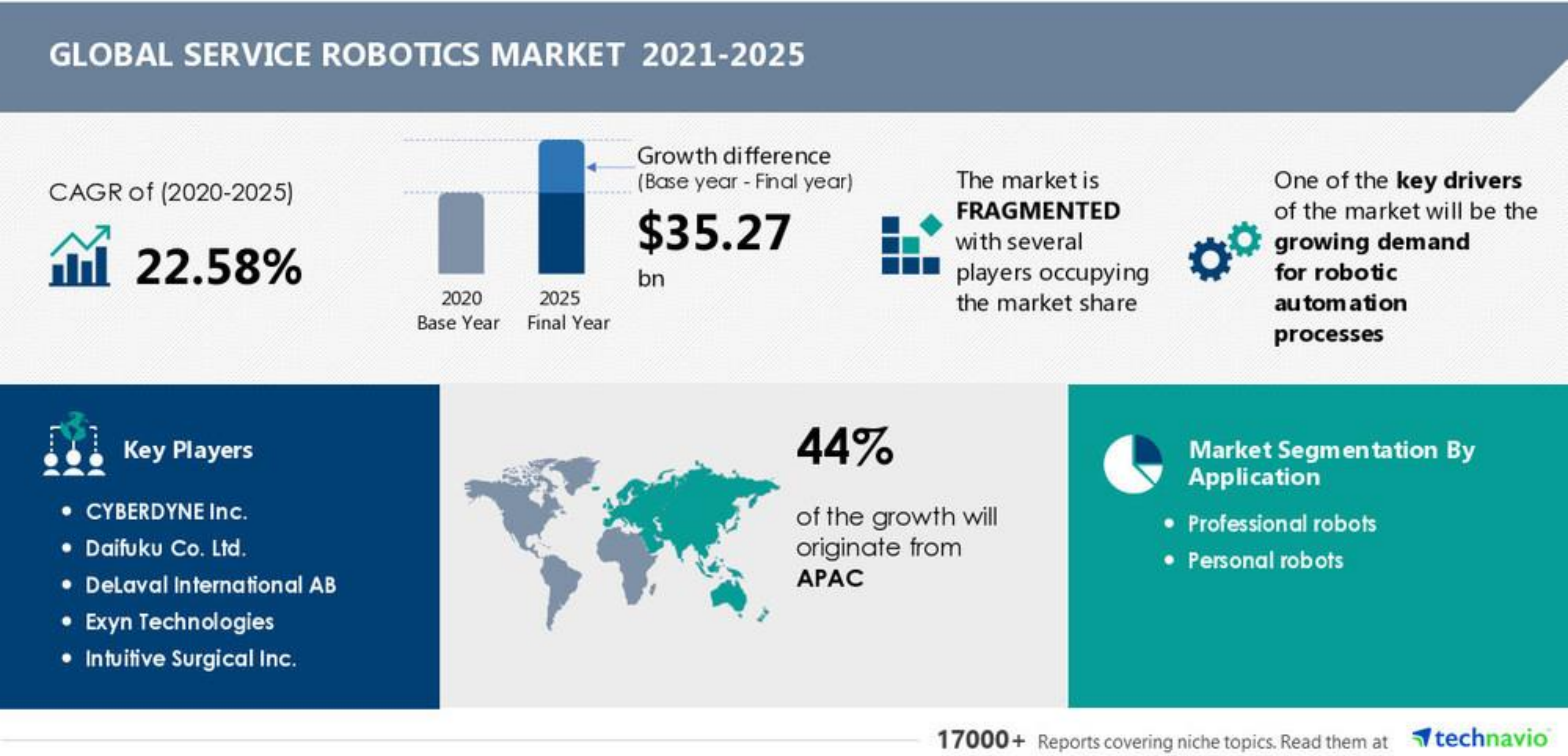
Today's Factory

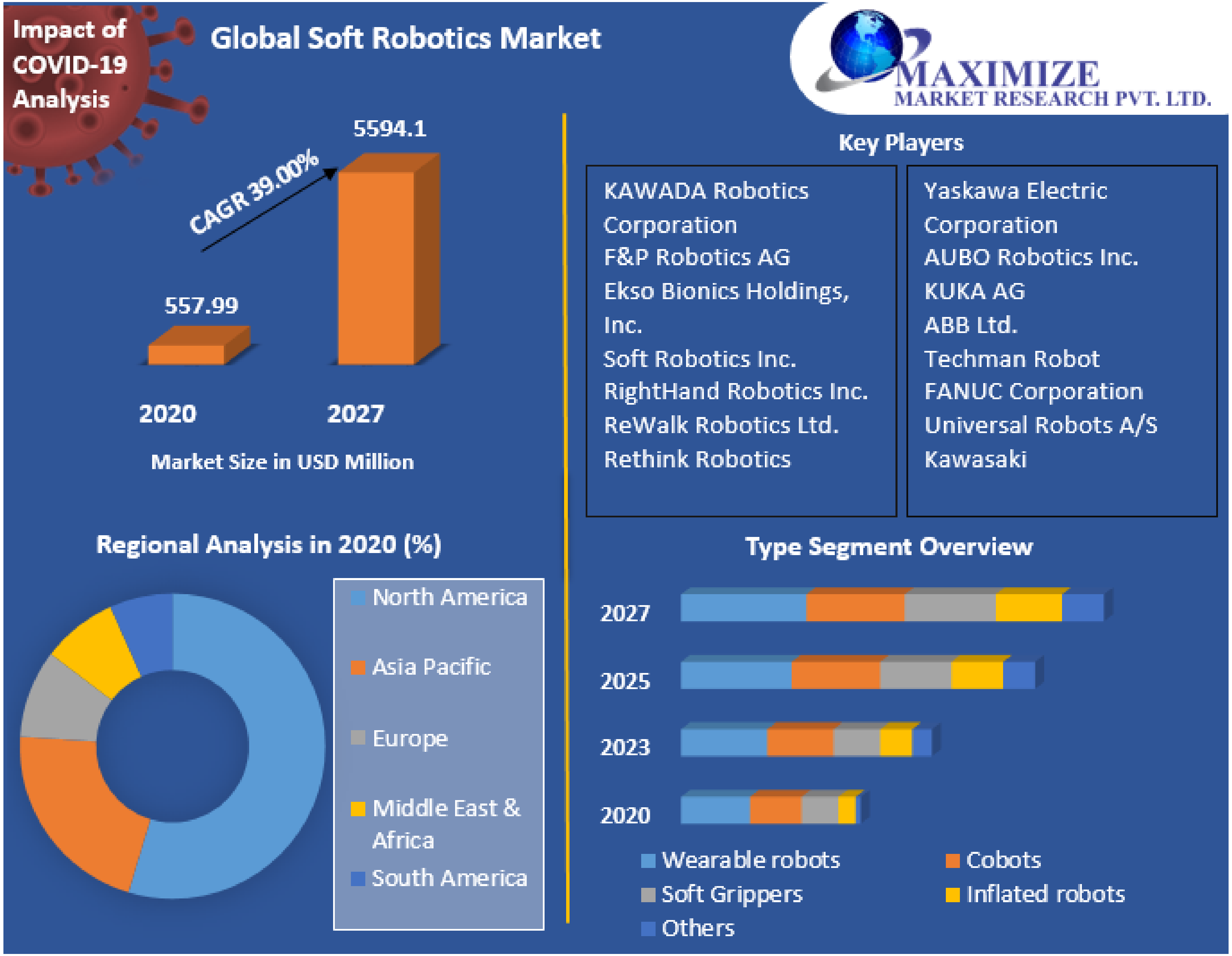


Tomorrow’s Factory



Source: Hewlett-Packard 2013


GLOBAL SERVICE ROBOTICS MARKET 2021-2025
CAGR of (2020-2025)
22.58%
2020
Base Year
2025
Final Year
Growth difference
(Base year - Final year)
$35.27
bn
The market is FRAGMENTED with several players occupying the market share
One of the key drivers of the market will be the growing demand for robotic automation processes
Key Players
• CYBERDYNE Inc.
• Daifuku Co. Ltd.
• DeLaval International AB
• Exyn Technologies
• Intuitive Surgical Inc.
44%
of the growth will originate from APAC
Market Segmentation By Application
• Professional robots
• Personal robots
17000+ Reports covering niche topics. Read them at
technavio

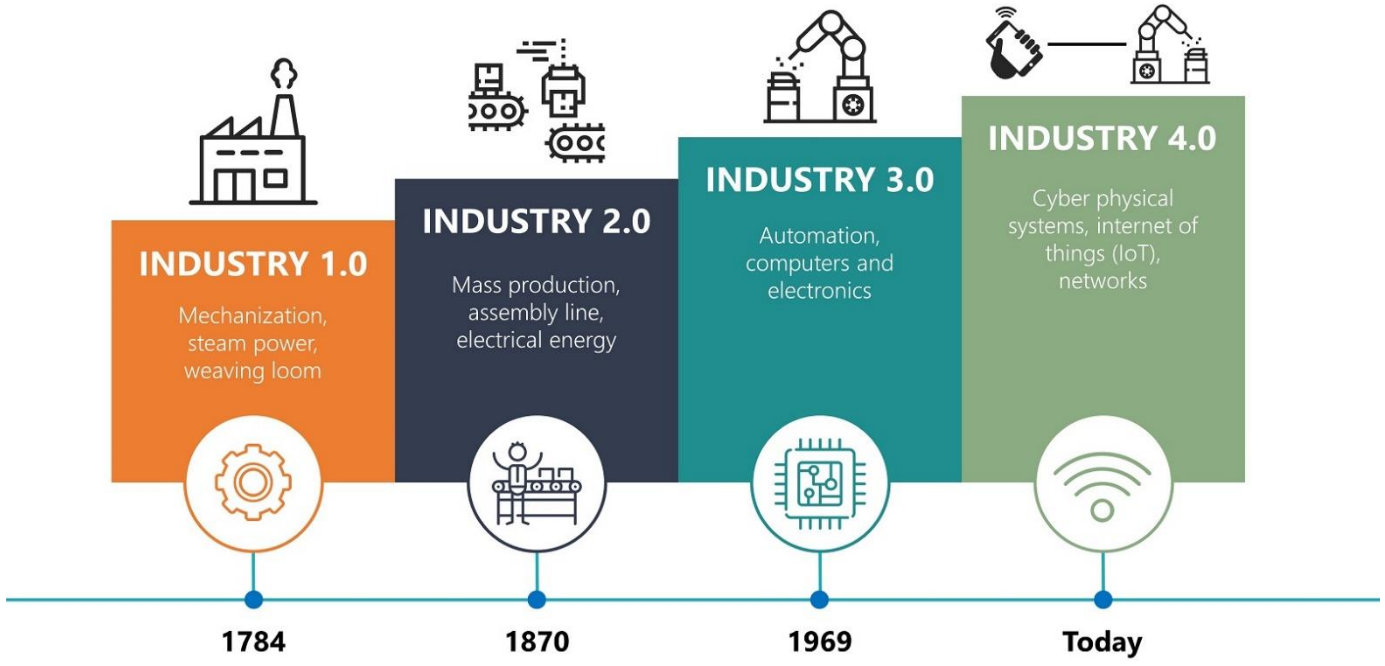


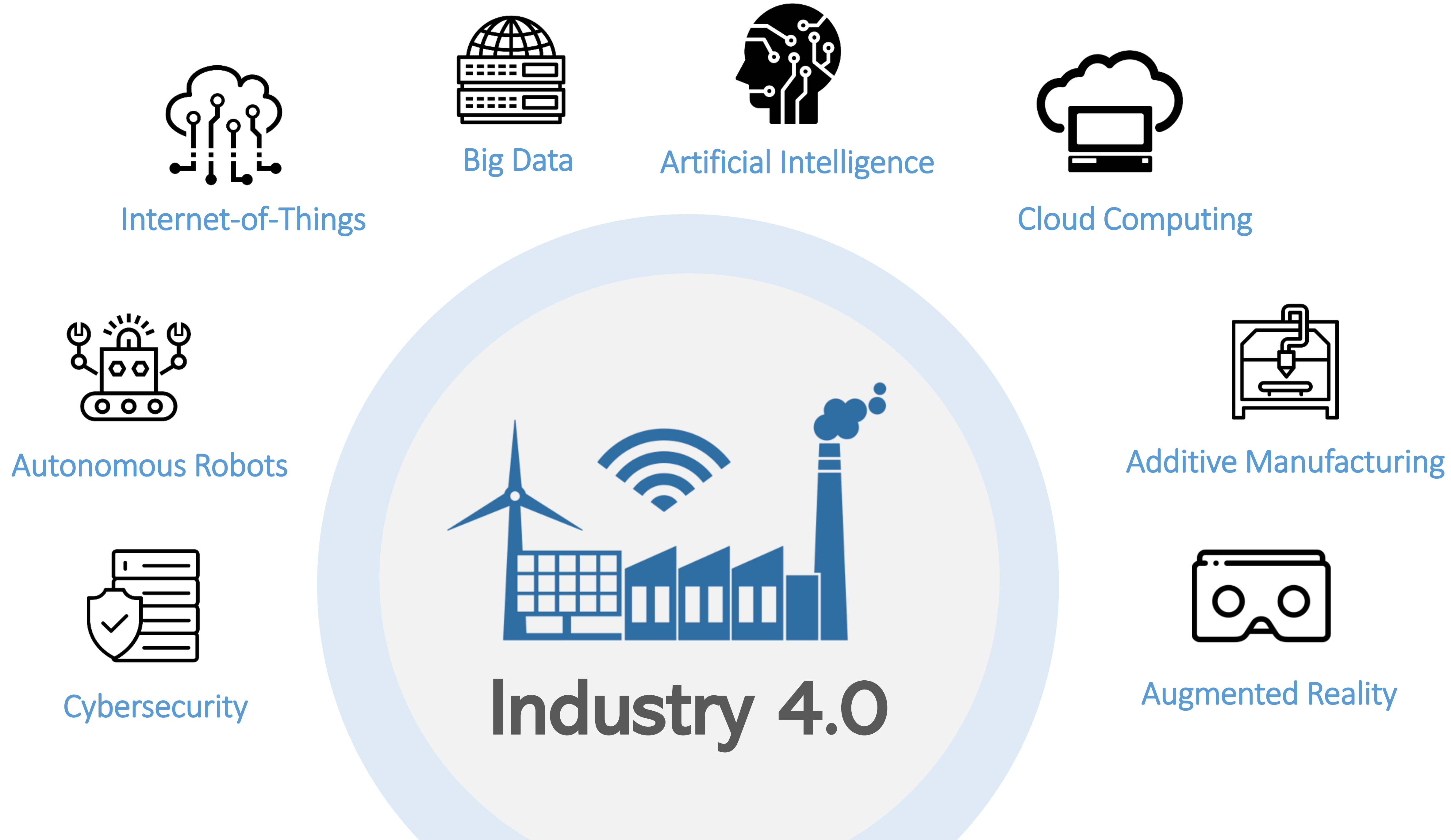
1. Soft robots are comprised of malleable materials such as fluids, gels, and synthetic rubber, and their elastic and rheological qualities allow them to adjust to the desired shape and execute a wide range of activities while overcoming barriers and severe climate changes.
2. Soft robotics is a discipline that relies on mimicking the moving processes of soft bodies found in nature to achieve smooth and complicated motion.
3. Soft robots are intended to overcome problems associated with standard robots built of hard materials.


INDUSTRY 4.0

Four (4) Phases of Industrialization

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




Big Data
Artificial Intelligence
Internet-of-Things
Cloud Computing
Autonomous Robots
Additive Manufacturing
Cybersecurity
Augmented Reality
Industry 4.0

Industry 4.0: Germany
Smart Manufacturing Leadership Coalition: USA

- **A collective term** for technologies and concepts of value chain organization. Based on the technological concepts of cyber-physical systems, the Internet of Things and the Internet of Services, it facilitates the **vision of the Smart Factory.**
- Within the modular structured Smart Factories of Industry 4.0, cyber-physical systems monitor physical processes, create a virtual copy of the physical world and make decentralized decisions.
- Over the Internet of Things, Cyber-physical systems communicate & cooperate with each other & humans in real time. Via the Internet of Services, both internal & cross-organizational services are offered & utilized by participants of the value chain.

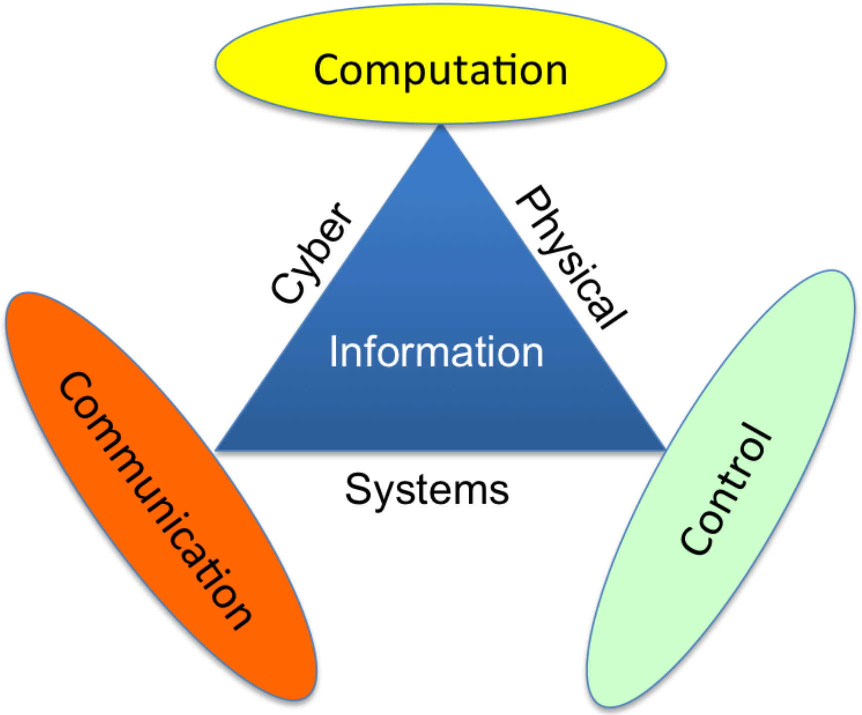
Industry 4.0: Germany

Smart Manufacturing Leadership Coalition: USA

- Builds on the Digital revolution
- Smaller & powerful sensors
- Machine Learning
- Artificial Intelligence (AI)
- Ubiquitous internet
- Labor & Energy Cost

Cyber Physical Systems

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.



Benefits
- Safer and more efficient systems
- Reduce the cost of building and operating the systems
- Build complex systems that provide new capabilities
- Reduced cost of computation, networking, and sensing
- Enables national or global scale CPS's

FACTORY OF THE FUTURE

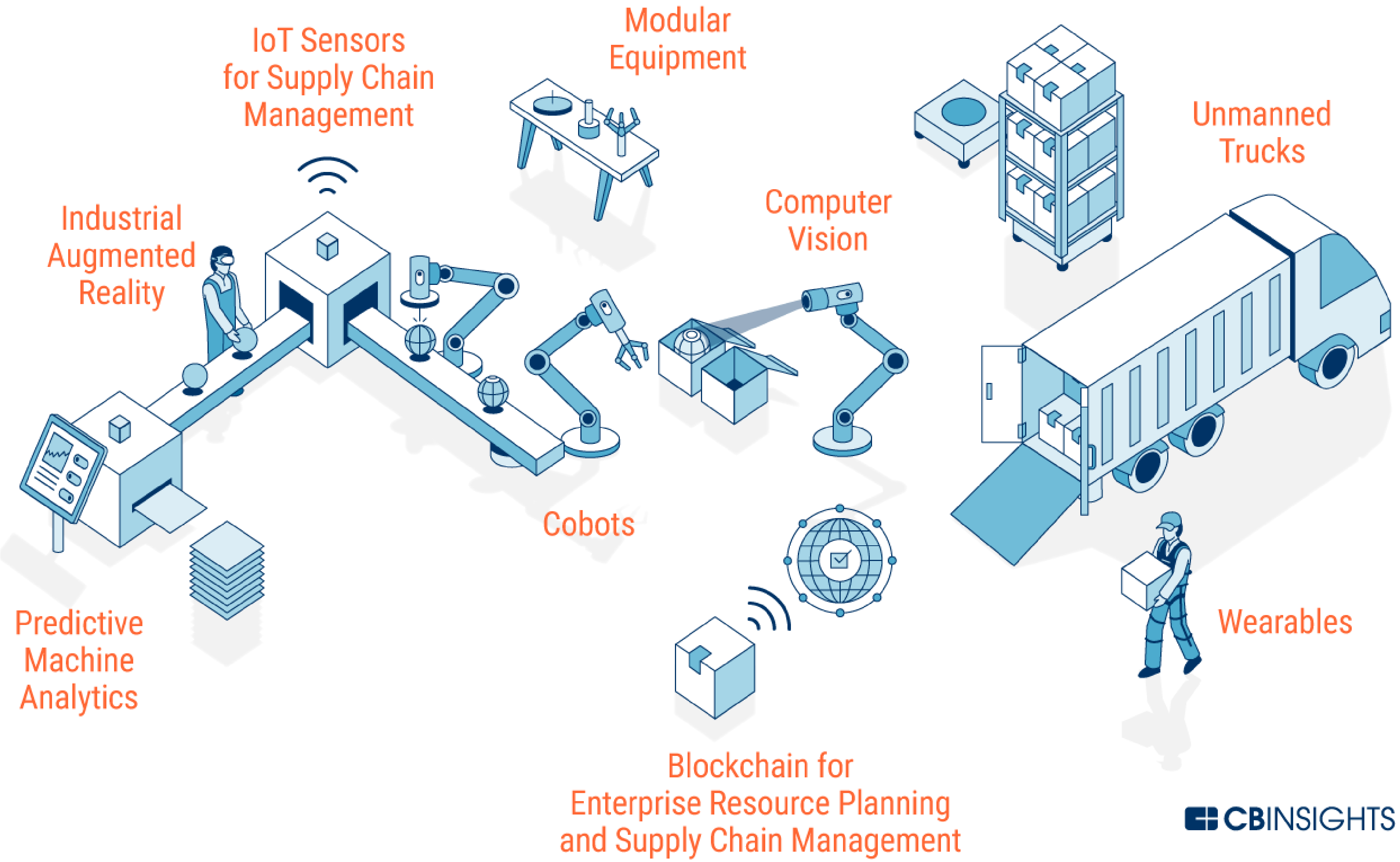
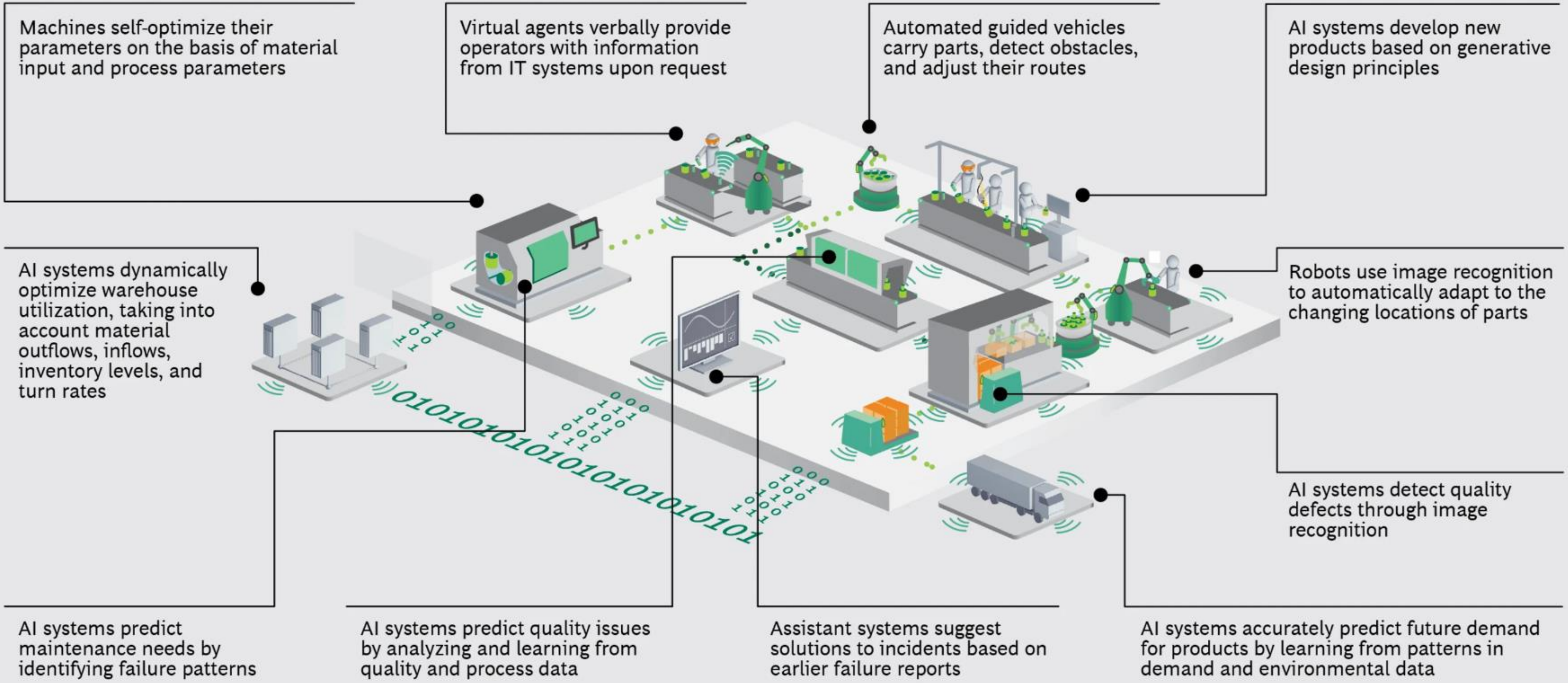


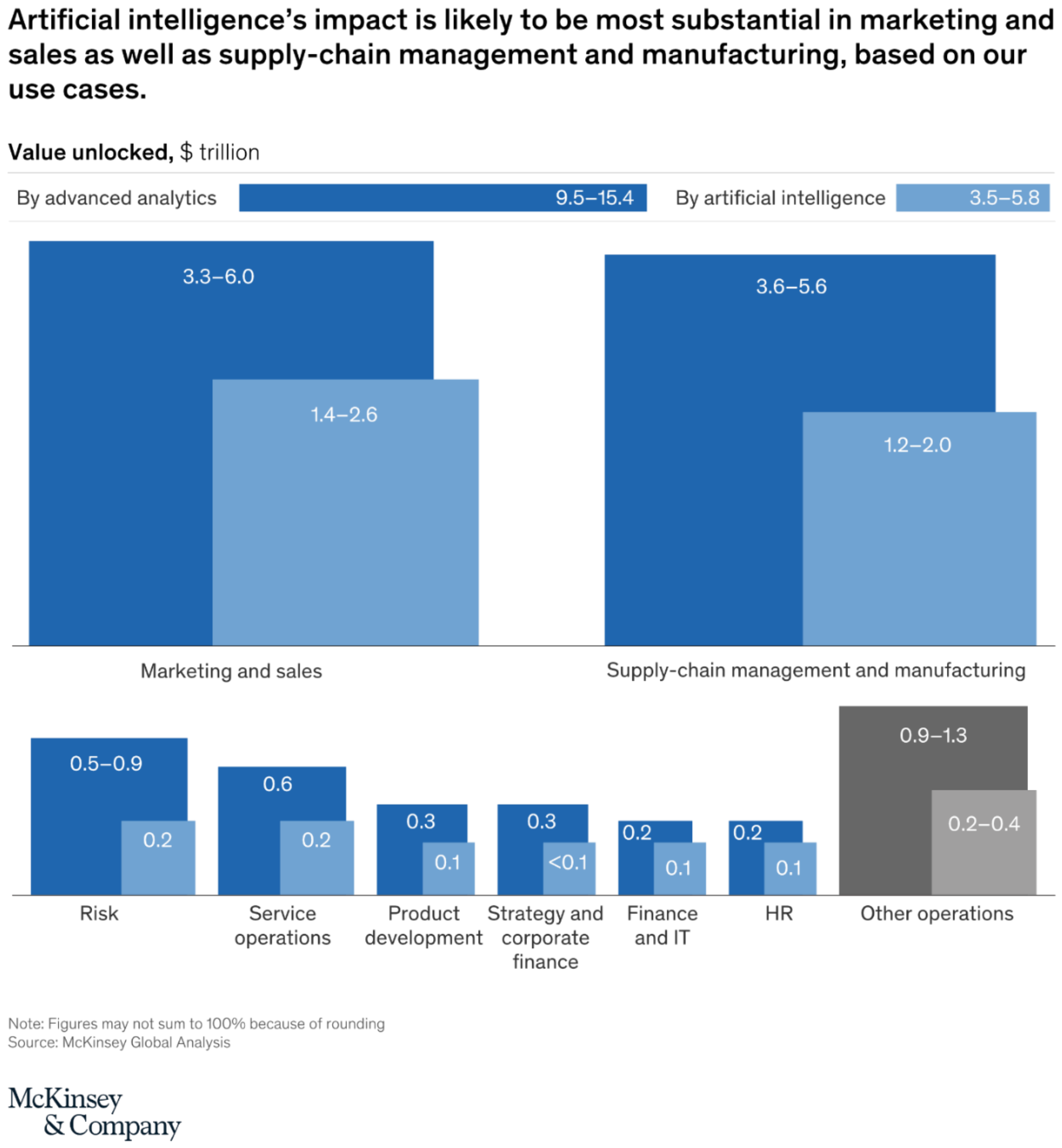
EXHIBIT 2 | AI Will Be Ubiquitous in the Factory of the Future



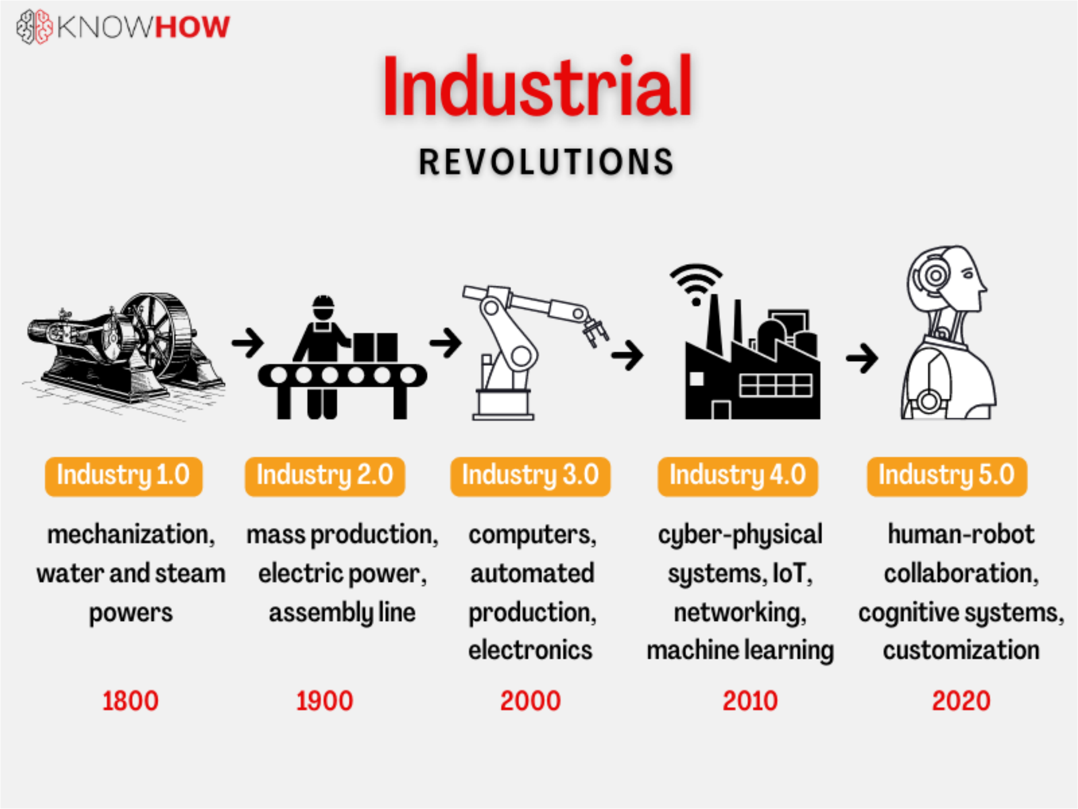
Source: BCG Global AI Survey, February–March 2018; BCG analysis.

Artificial Intelligence:

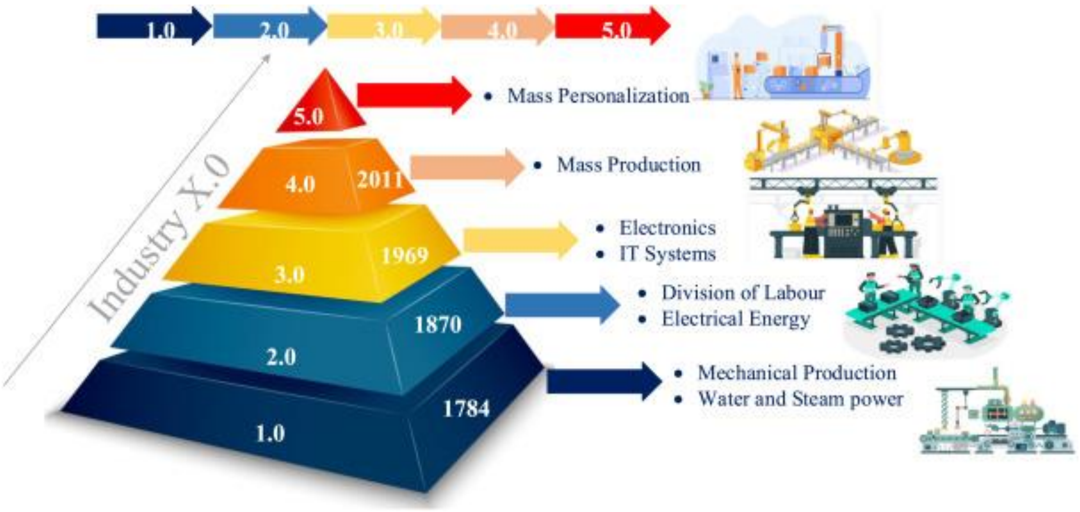
- **$1.4 trillion to $2.6 trillion** of value in marketing and sales across the world's businesses
- **$1.2 trillion to $2 trillion** in supply-chain management and manufacturing
- In manufacturing, the greatest value from AI can be created by using it for **predictive maintenance** (about $0.5 trillion to $0.7 trillion across the world's businesses)



Source: McKinsey

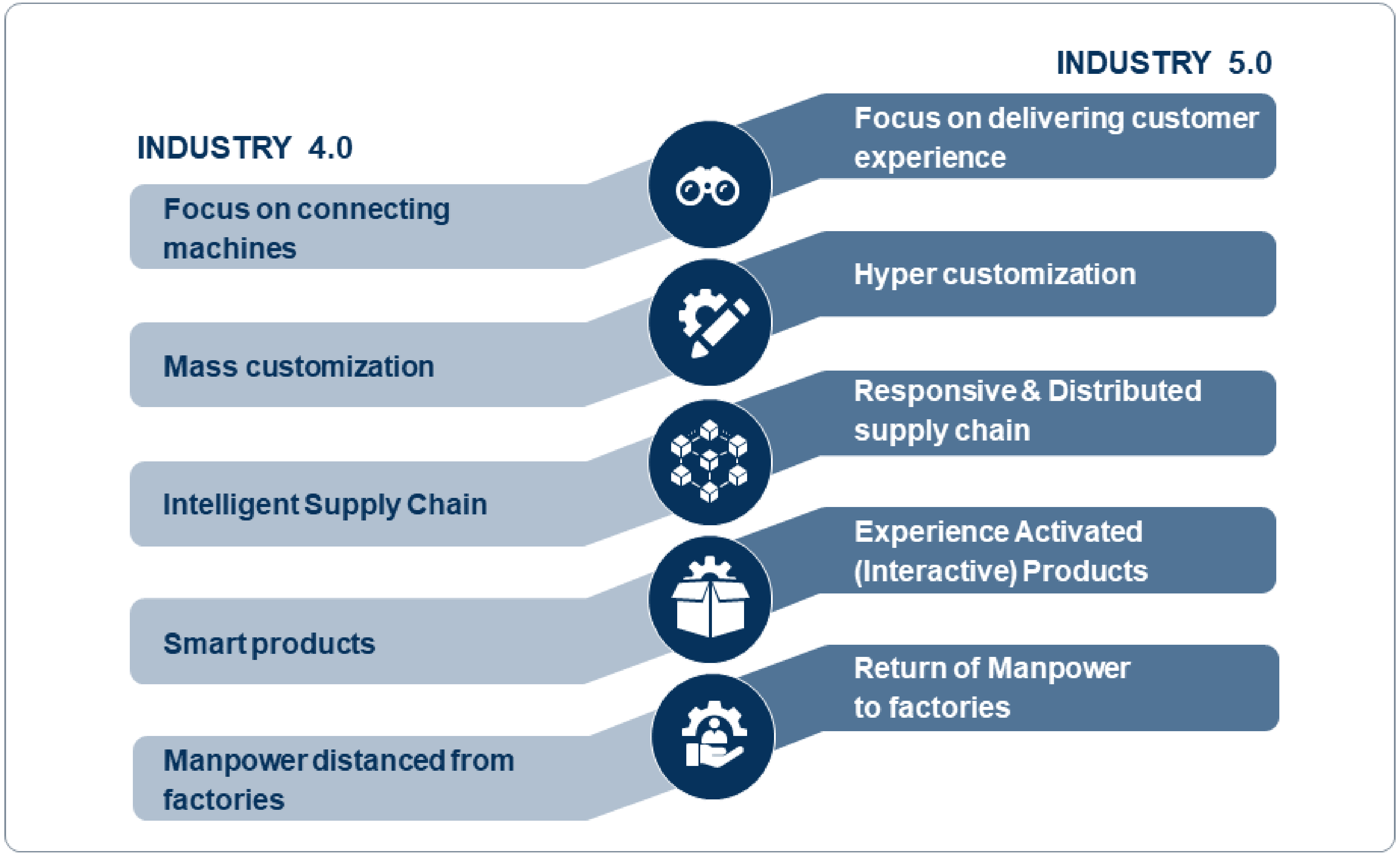


sciencedirect.com

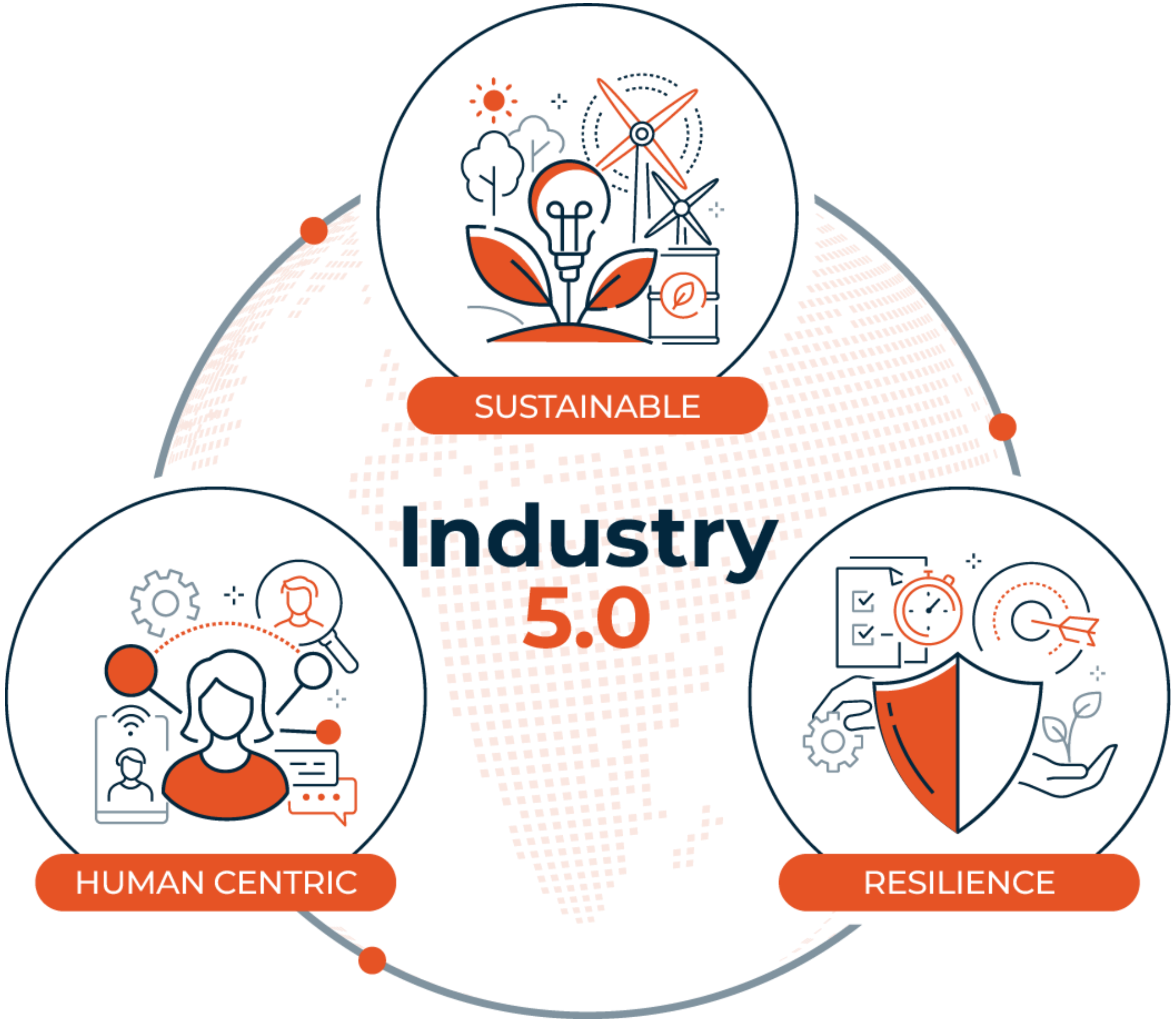


distrelec.com

Highlights of Industry 5.0 compared to Industry 4.0

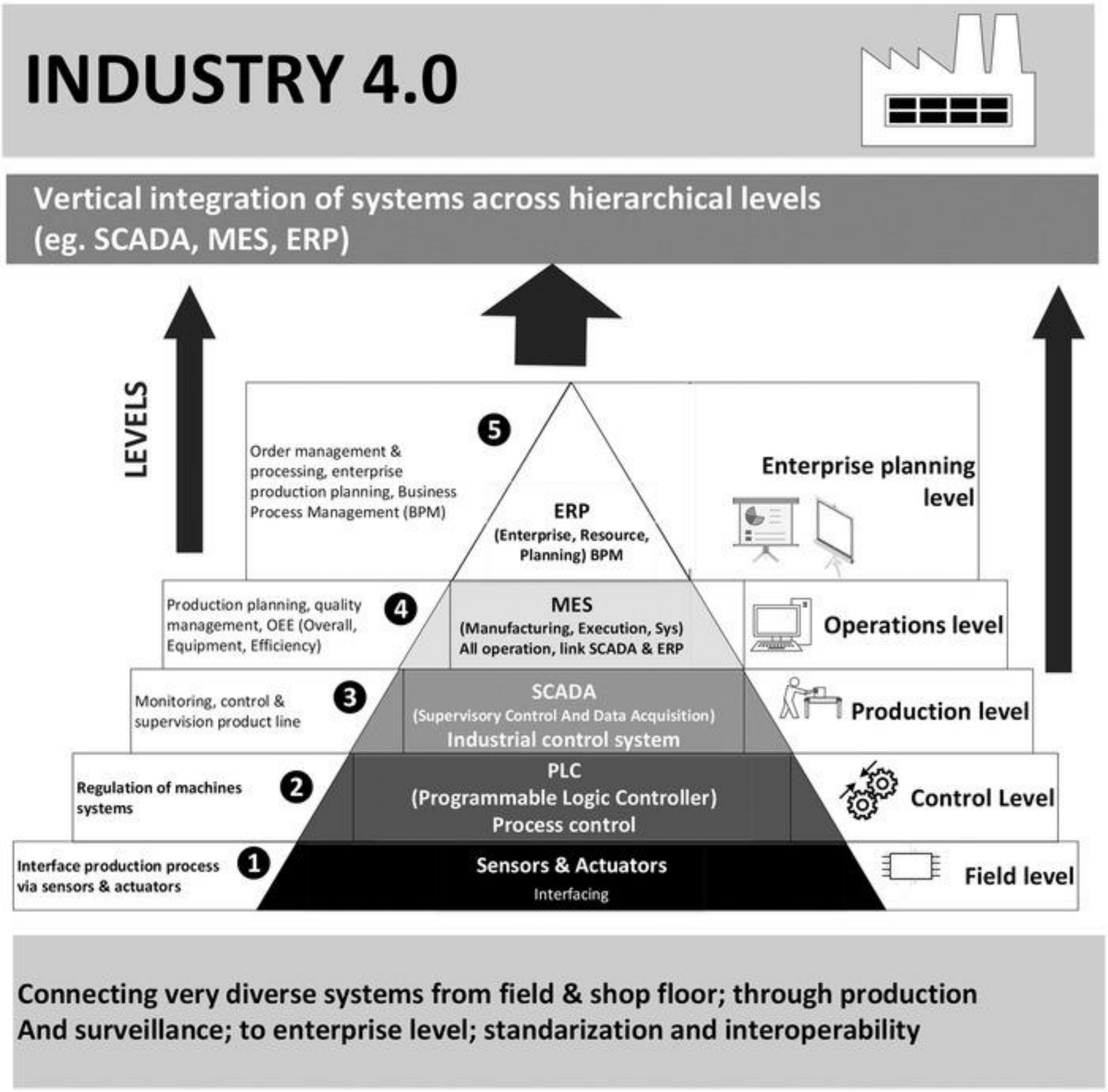


FROST & SULLIVAN



momenta.one

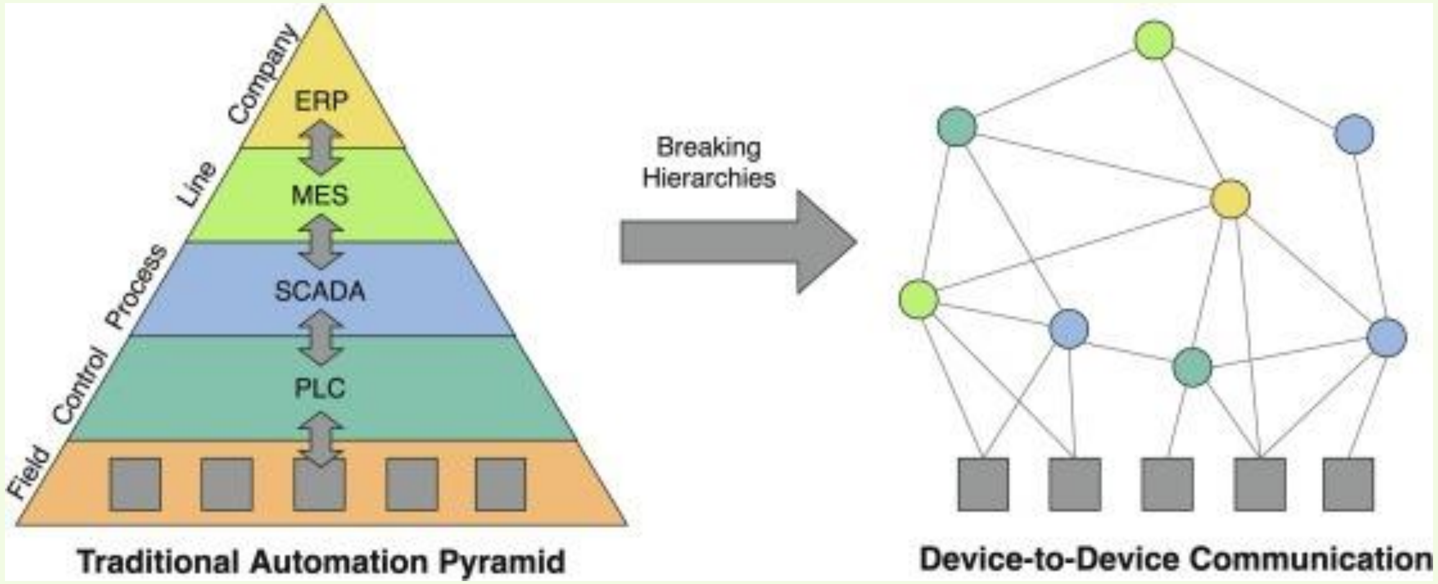
INDUSTRY 4.0 –Vertical integration



Towards a Service-Driven Model for Industry-4.0, Zakaria Benzadri, Takieddine Bouheroum, Youcef Ouassim Cheloufi, Faiza Belala, Mohamed Nadir Hassani, 10th International Conference on Software and Computer Applications, February 2021, Pages 14–21

https://dl.acm.org/doi/fullHtml/10.1145/3457784.3457787

Shift from traditional Automation Pyramid to Device-to-Device Communication

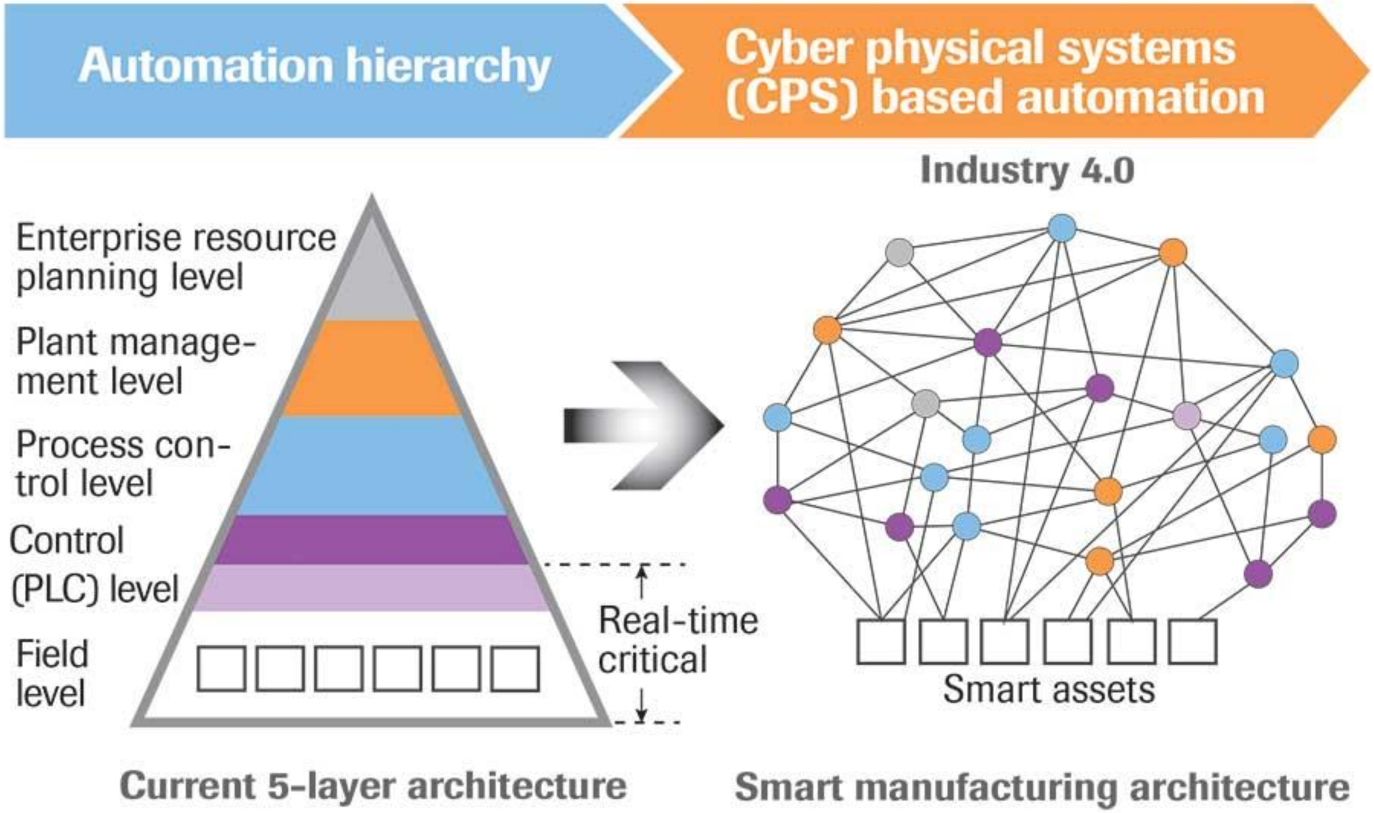


Industry 4.0 reference architectures: State of the art and future trends

www.sciencedirect.com/science/article/abs/pii/S0360835221001455

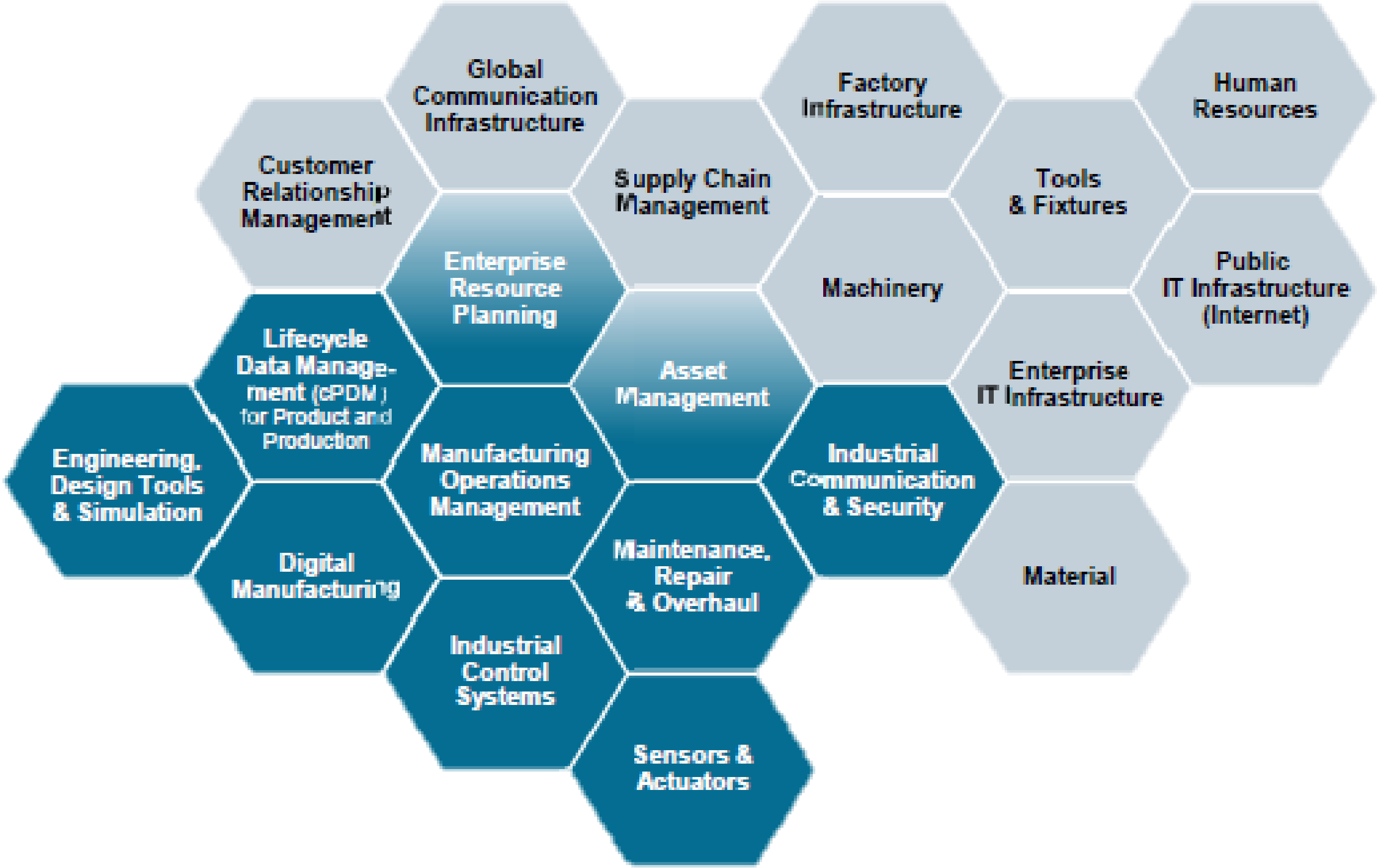
The Shift

foodengineeringmag.com



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



Impacting all aspect of value chain

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

Smart Warehouse

- Jabbar et al. (2018) stated that a smart warehouse is a warehouse that is designed to operate with maximum efficiency and integrates best practices and advanced technologies.
- Cyber-Physical Systems (CPS) that help to build virtual copies of industrial processes can transform traditional warehouses into smart warehouses. There are four components of CPS-based smart warehouses, namely robots, humans, CPS devices, and inventories.
- Several features such as optimal order picking, optimal product placement, and zone capacity picking, are implemented using different algorithms in smart warehouse management systems.

Design of a reference architecture for developing smart warehouses in industry 4.0

https://doi.org/10.1016/j.compind.2020.103343

Robots working in Amazon WH

- Amazon now has more than 100,000 robots inside its warehouses worldwide.
- But despite the sheer volume of robotic employees working in its fulfilment centres, Amazon insists robots will not replace human labour entirely - at least, not yet. Jun 5, 2018.

https://www.dailymail.co.uk/sciencetech/article-5808319/Amazon-100-000-warehouse-robots-company-insists-replace-humans.html

Examples SIEMENS

German manufacturing giant Siemens, an industrial user, is implementing an Industry 4.0 solution in medical engineering.

For years, artificial knee and hip joints were standardized products, with engineers needing several days to customize them for patients.

Now, new software and steering solutions enable Siemens to produce an implant within 3 to 4 hours.

Source: Think Act: INDUSTRY 4.0 The new industrial revolution How Europe will succeed

Examples TRUMPF

German toolmaker Trumpf, an Industry 4.0 supplier and worldwide market leader of laser systems, has put the first "social machines" to work.

Each component is "smart" and knows what work has already been carried out on it.

Because the production facility already knows its capacity utilization and communicates with other facilities, production options are automatically optimized.

Source: Think Act: INDUSTRY 4.0 The new industrial revolution How Europe will succeed

Examples GE

Predix, the operating system for the Industrial Internet, is powering digital industrial businesses that drive the global economy.

By connecting industrial equipment, analyzing data, and delivering real-time insights, Predix-based apps are unleashing new levels of performance of both GE and non-GE assets.

Source:https://www.ge.com/digital/predix

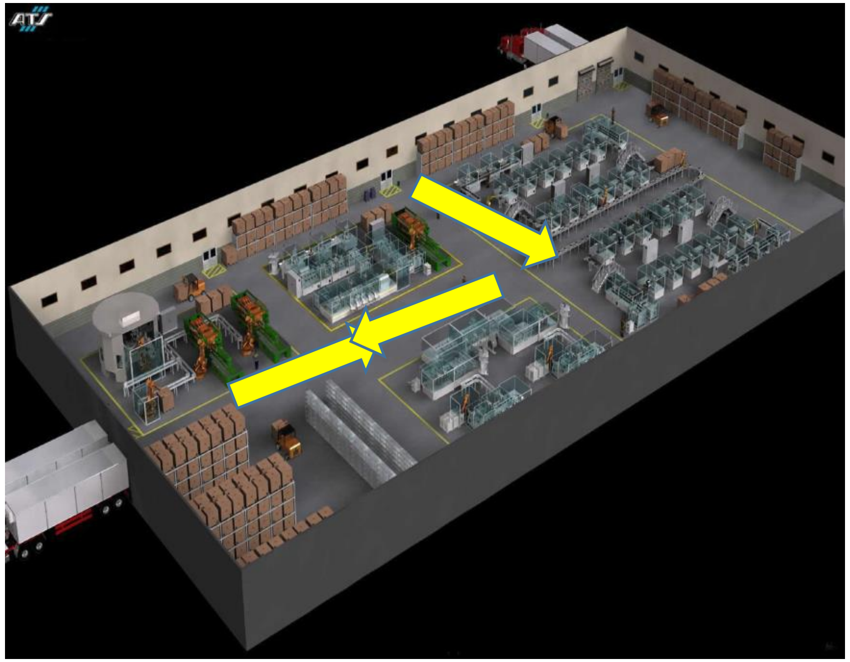
Streamlined Factories

Sensors are attached to components, forklifts, employees and other assets.

Many manufacturing companies are streamlining their factories by deploying IoT Solutions.

Streamlined Factories

By geolocating the sensors, one can visualize how people and products are moving.



Processes can be streamlined and production time reduced.

SMART Inventory management

- Sensors on containers can determine when a product is running low
- Employees will be alerted to proactively re-order the parts when a certain level is reached, or orders can be automatically placed with suppliers
- Components will not run out or run low Reduced costs of production. More uptime for factories which leads to higher productive levels.

SMART Inventory management

- Sensors can also be used to determine if a container is reaching its capacity.
- This could trigger an alert for a forklift to remove the container and replace it with an empty one.
- Can also be used for waste management.

Challenges

- If not proactively monitored, components can run out or run low.
- Increased costs can be from not producing or have to pay more to get parts quickly).

SMART Quality control

- RFIDs attached to products can be used to tag defective products
- If over a certain number, an employee can be alerted to see if there is a bad batch of components or if an adjustment needs to be made to the machinery
- Employees can be alerted if the problem is the result of a defective part
- If an adjustment is needed, it can be automatically made in real-time
- Product quality is controlled, and course corrections are made while product is still moving through the production line

Manufacturing Revolution is shaping SMART Factories…

- Smart factories are connected in a network through the use of cyber-physical production systems which lets factories and manufacturing plants react quickly to variables, such as demand levels, stock levels, machine defects, and unforeseen delays
- This networking also involves the smart logistics and smart services
- The whole value chain in such integrated network is subjected to through-engineering, where the complete lifecycle of the product is traced from production to retirement through the use of IoT technologies

The Benefits of Industry 4.0

AUTOMOTIVE

10%–20%

Productivity increase as measured by conversion costs

6%–9% productivity increase as measured by total manufacturing costs

COMPONENTS

20%–30%

Productivity increase as measured by conversion costs

4%–7% productivity increase as measured by total manufacturing costs

FOOD AND BEVERAGE

20%–30%

Productivity increase as measured by conversion costs

5%–10% productivity increase as measured by manufacturing costs

MACHINERY

20%–30%

Productivity increase as measured by conversion costs

10%–15% productivity increase as measured by manufacturing costs

OTHER

10%–15%

Productivity increase as measured by conversion costs

4%–7% productivity increase as measured by manufacturing costs

Source: BCG analysis.

www.bcg.com/capabilities/manufacturing/industry-4.0

Stronger Customer Centricity

- Agility
- Connect & Collaborate Externally
- Expandable Infrastructure
- Flexible Manufacturing
- …

More Efficient Production Processes

- Deep Learning
- Data Driven Insights
- Digital Twins
- Remaining Useful Life
- Predictive Maintenance
- Optimize Assets
- …

INDUSTRY 4.0

New Marketing & Business Models

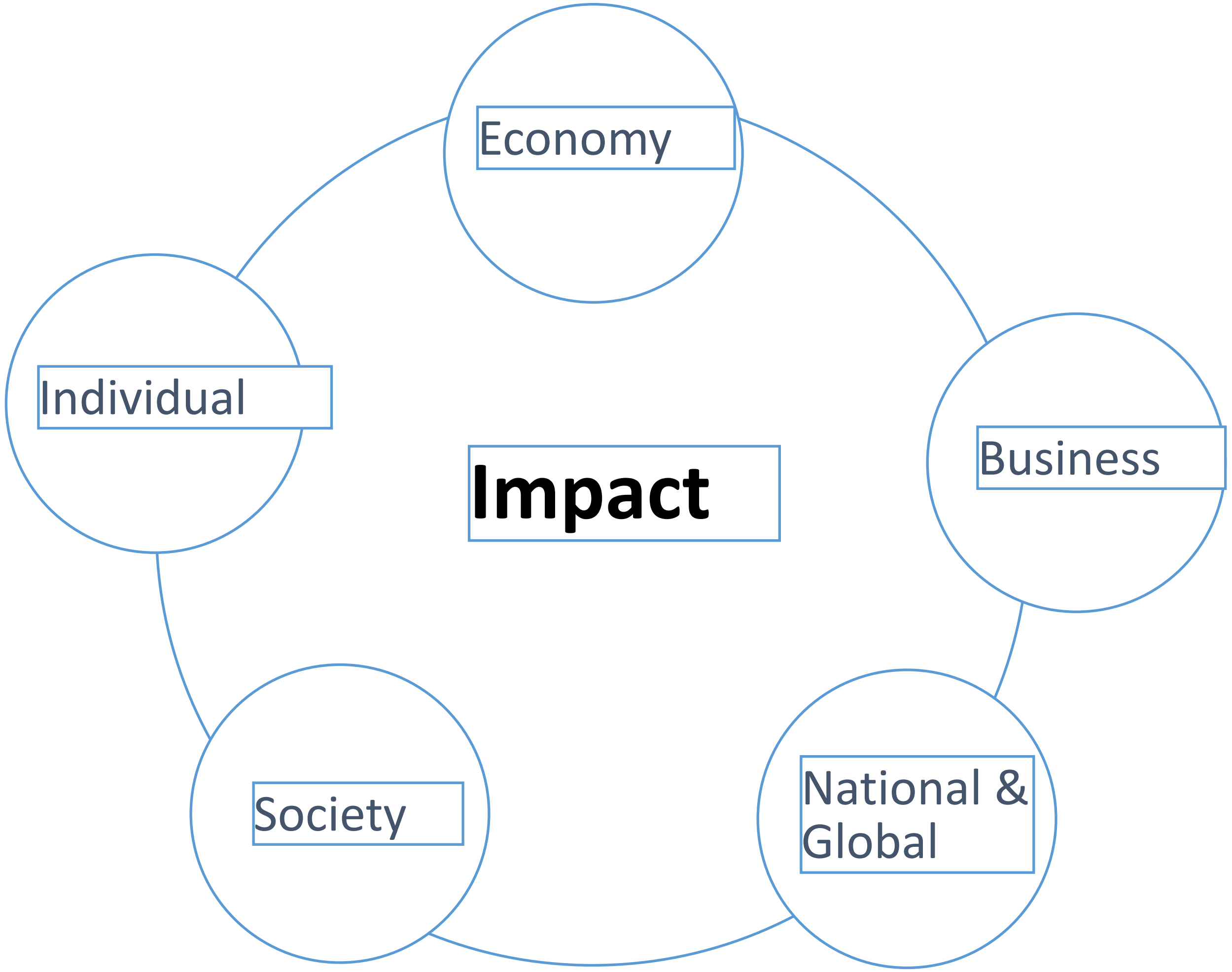
- Open Innovation
- Co-Development
- Inclusive Leadership
- Frugal & Sustainable

Risks

- Secure Physical & Cyber Assets
- Maximize Uptime

Value Chain Transformation through Networked Processing & Objects

Impact


Economy
Individual
Impact
Business
Society
National &
Global

Impact

Economy

- Growth
- Ageing
- Productivity
- Employment
- Labour substitution
- The nature of Work

Impact

- **Business**
  - Customer expectations
  - Data enhanced products
  - Collaborative innovation
  - New operating models

Combining digital, physical and biological worlds

Impact

- **National & Global**
  - Governments
  - Countries, regions & cities
  - International security
- **Society**
  - Inequality
  - Community
- **The Individual**
  - Identity, morality & ethics
  - Human connection

Autonomous
Cars
Electric Vehicles

Electric Vehicles (EV)

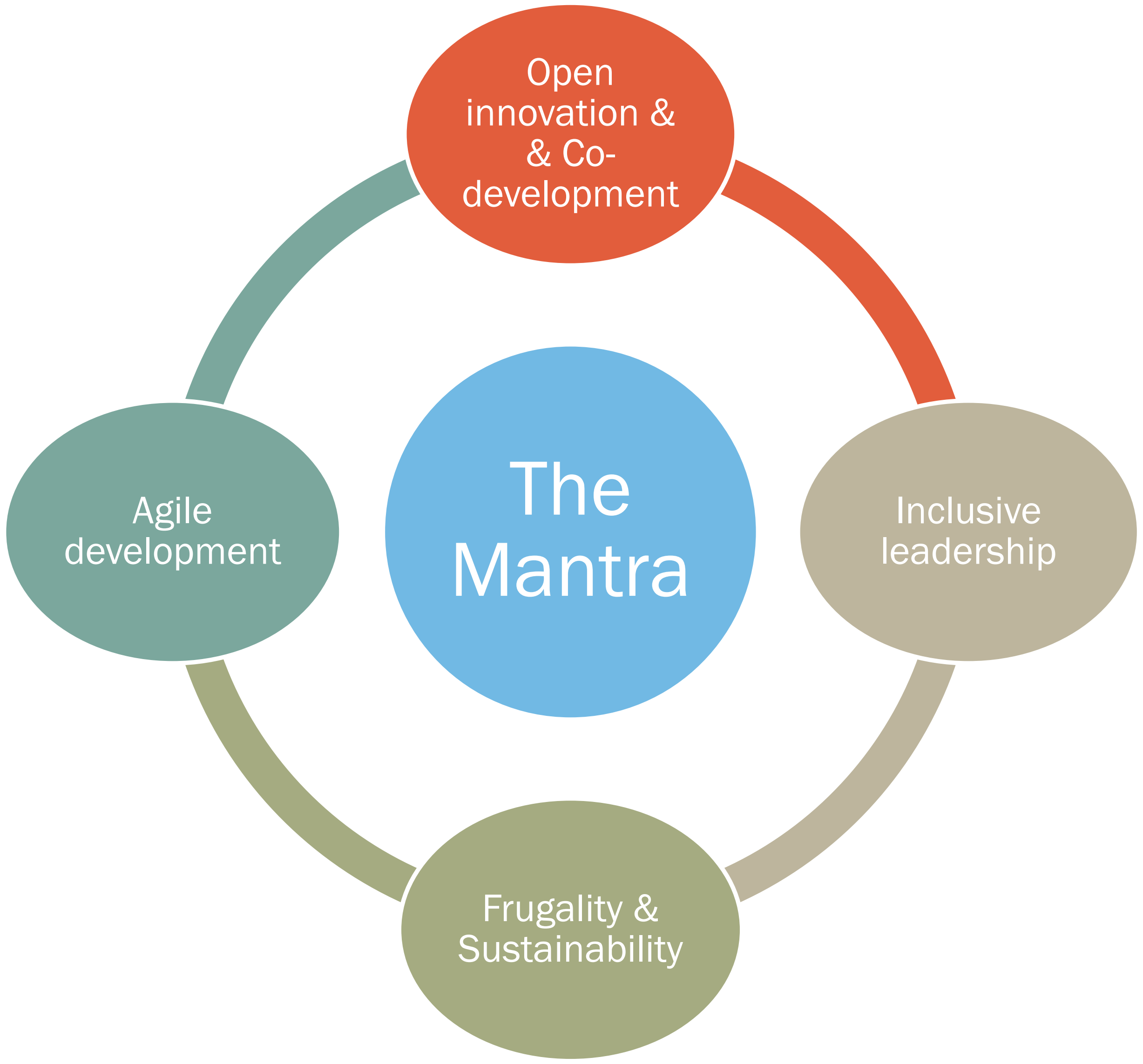
- 70% of an electric vehicle‘s component parts may be different from a gasoline-powered vehicle.
- Moving parts
- EV – 1 (the motor)
- Gasoline-powered vehicle – 100s
- The EV requires less periodic maintenance and is more reliable.
- CALSTART, the advanced transportation consortium in California

Robotics –legal challenges

- Needs to explore the best legal infrastructure to prioritize safety and compensate victims while preserving the conditions for innovation and investment.
- If we have a more intelligent vehicle, who takes the responsibility when it has an accident – Mark Tilden
- Cars are relatively well understood, with standardized components and interiors. Thus, it may make sense to hold today's manufacturers accountable for "aggressive" airbags that cause needless injury.
- But cars were developed as consumer products a hundred years ago, prior to robust product liability laws and industry standards. Personal robots may not survive similar treatment. (M. Ryan Calo, Stanford law School)

NEW MANTRA

- Open Innovation & Co-development
- Agile development
- Frugality & Sustainability – Do More with Less
- Inclusive Leadership

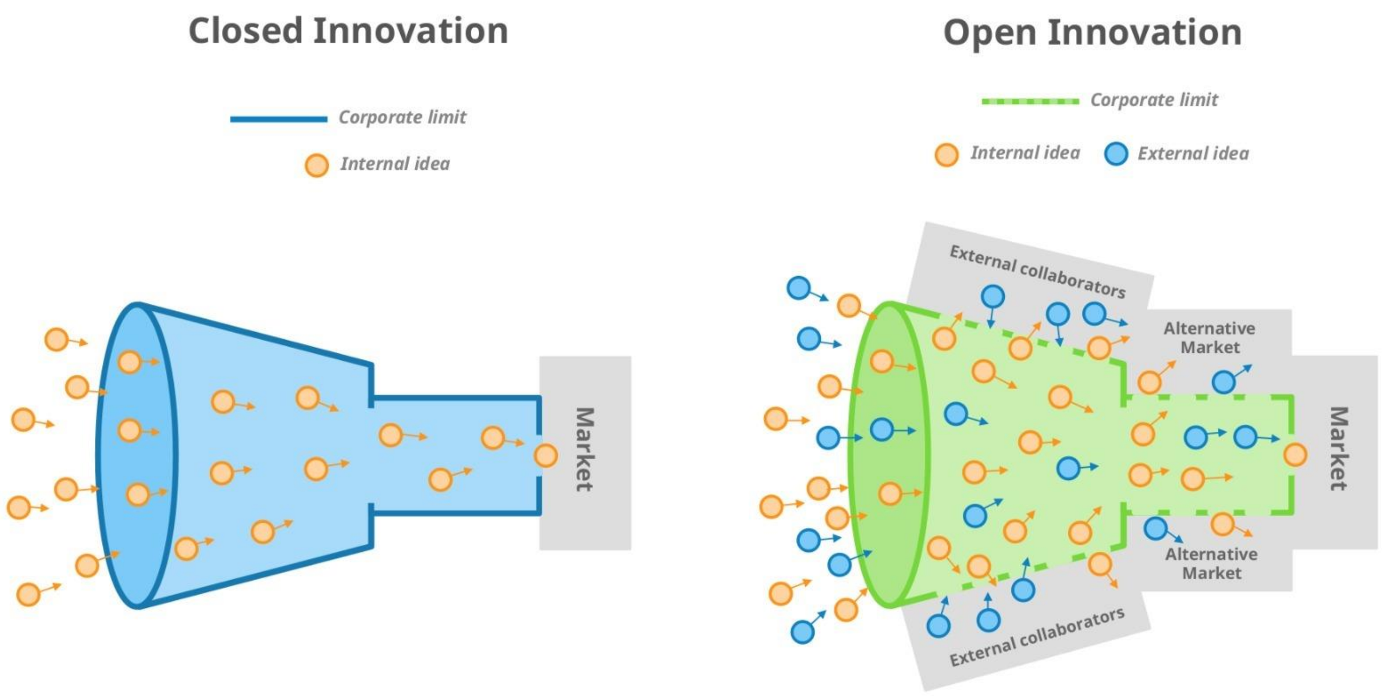


OPEN INNOVATION

OPEN INNOVATION WITHOUT PRESET MINDSET & HIERARCHY

BORDERLESS, MULTI & CROSS-DISCIPLINARY APPROACH FOR ADDRESSING COMPLEX PROBLEMS

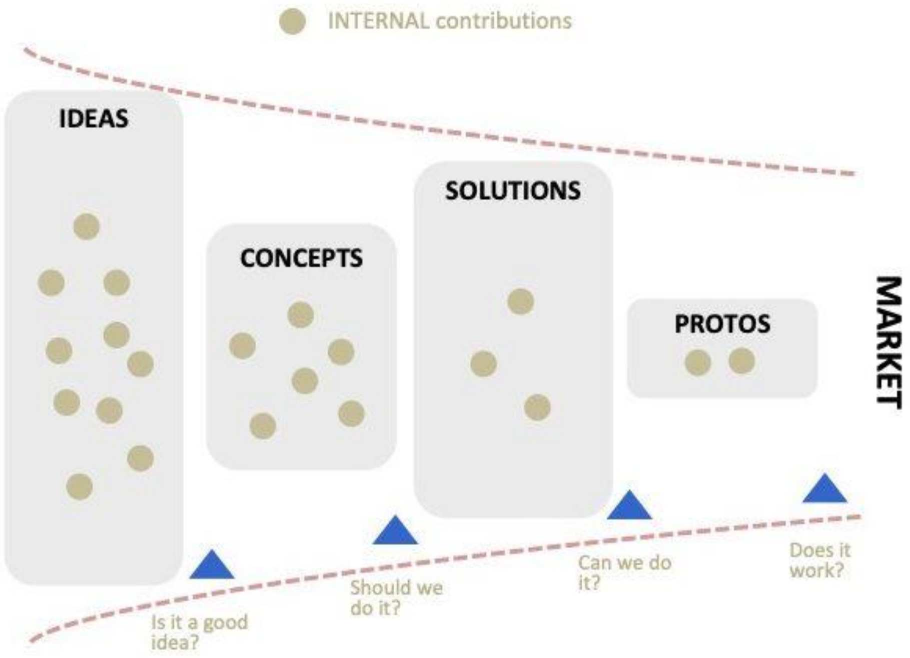
MID AND LONG-TERM STRATEGY FOR ENHANCING LIVES



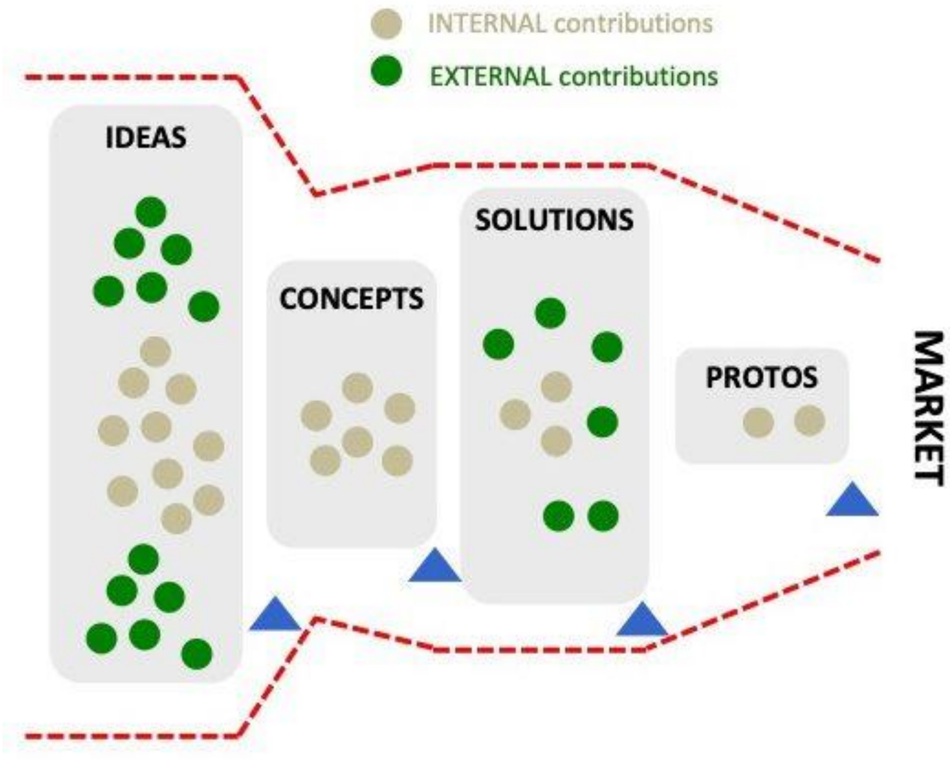
www.viima.com

OPEN INNOVATION
ACCELERATING YOUR INNOVATION RESULTS

Traditional Innovation Funnel



Open Innovation Rocket Model



www.ennomotive.com/open-innovation

OPEN AND CLOSED INNOVATION MODELS

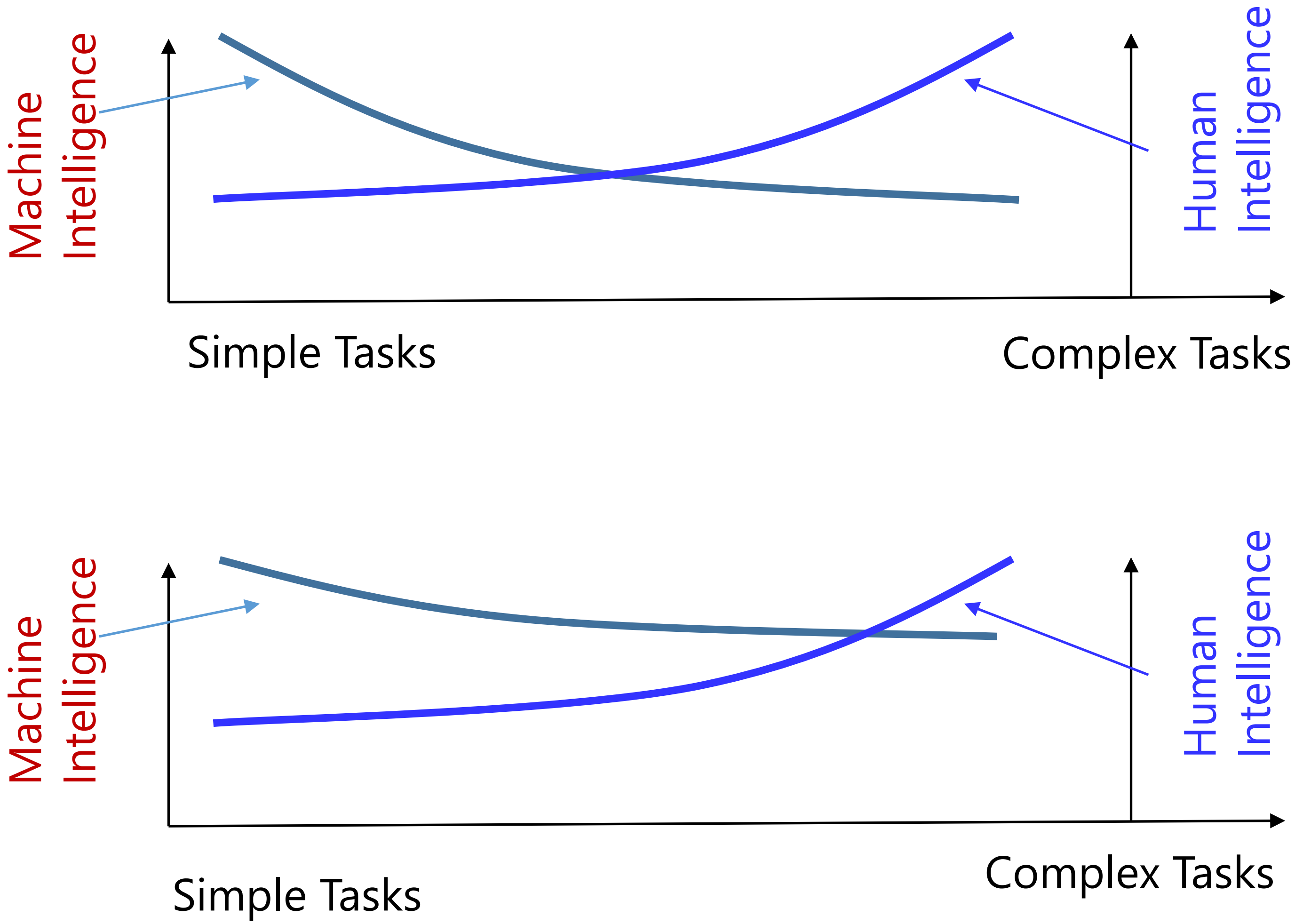
Closed Model	Open Model
Use knowledge from internal sources	Internal + External knowledge sources
Low (typically 20-30%) success rate	Double innovation success rate, up to 80%
A lot of rework, low productivity	40-60 % productivity increase
Low speed of innovation	High speed of innovation (x 3)

www.ennomotive.com/open-innovation

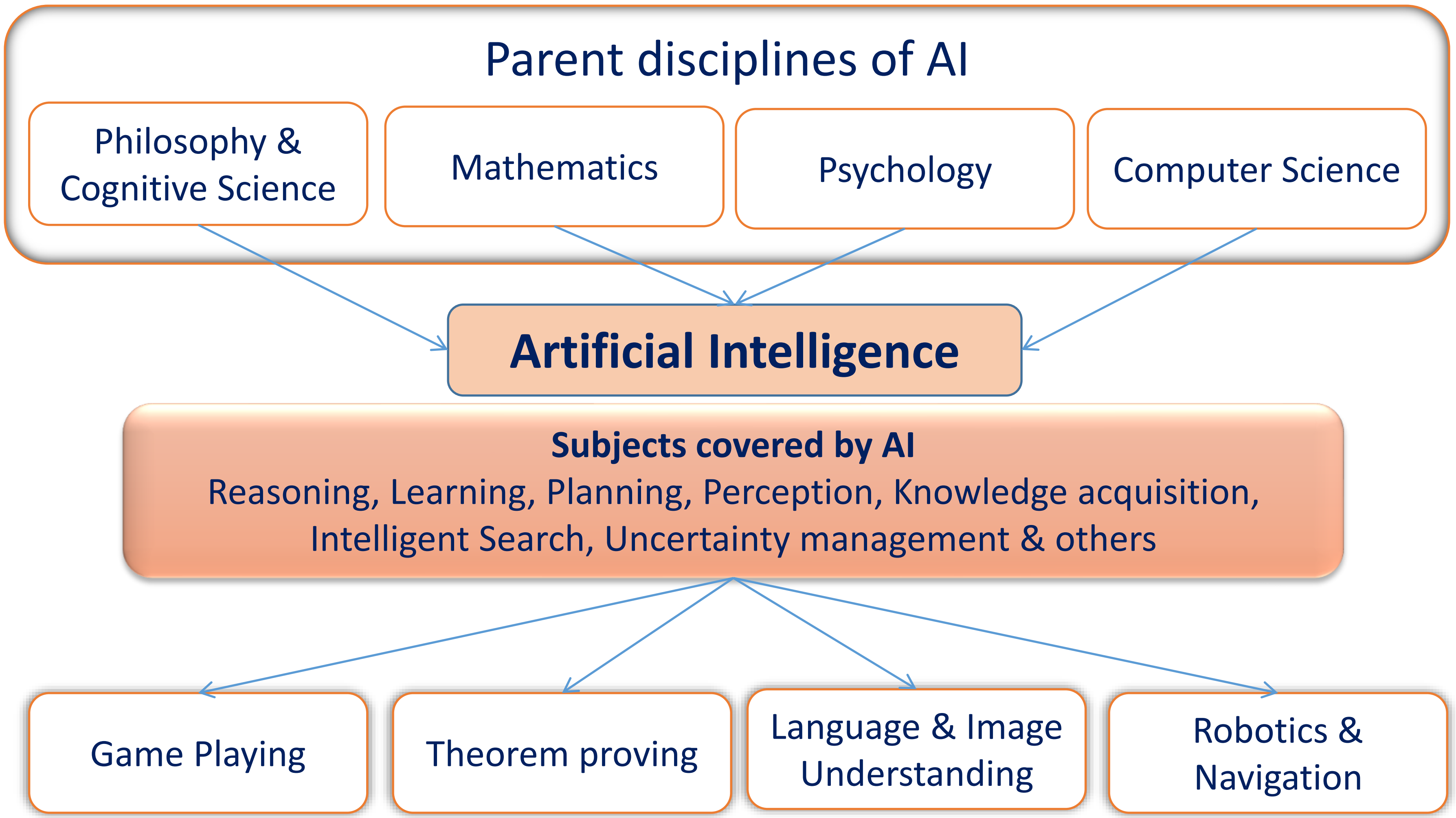
OPEN INNOVATION PLATFORM
OPEN TECHNOLOGY PLATFORM (SIMTECH)

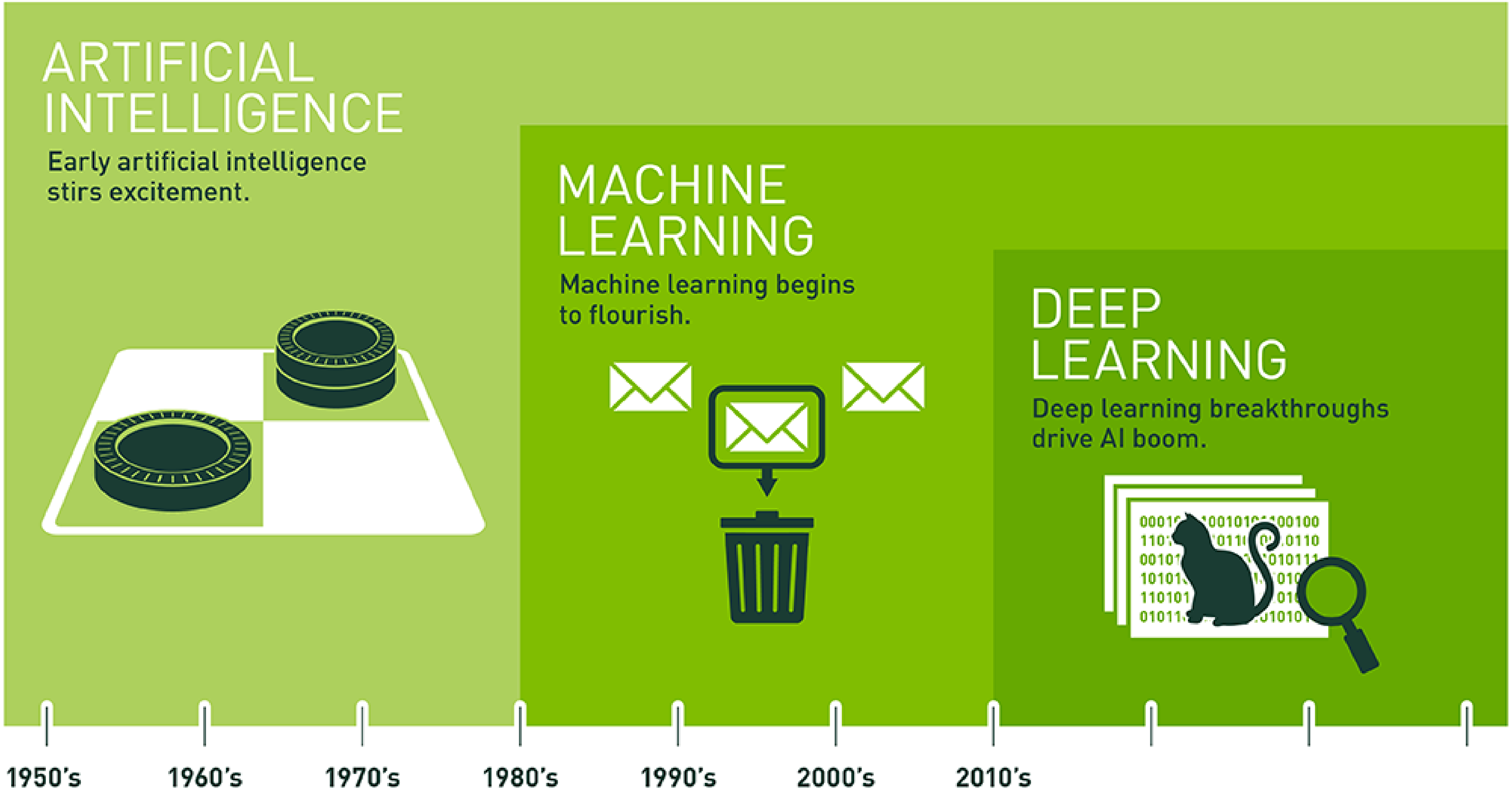
- https://www.openinnovation.sg/imda
- project arrow – open innovation platform
- Follow standards

Sliding Autonomy

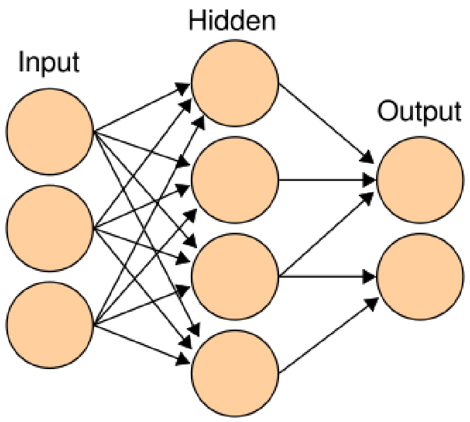


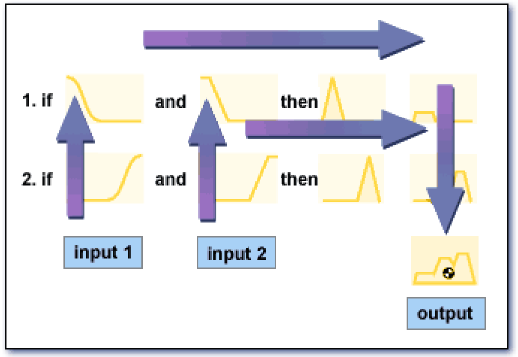
Artificial Intelligence



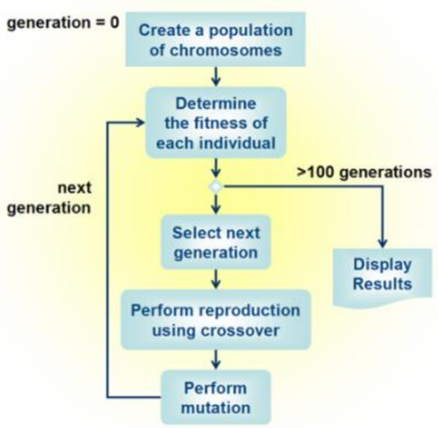


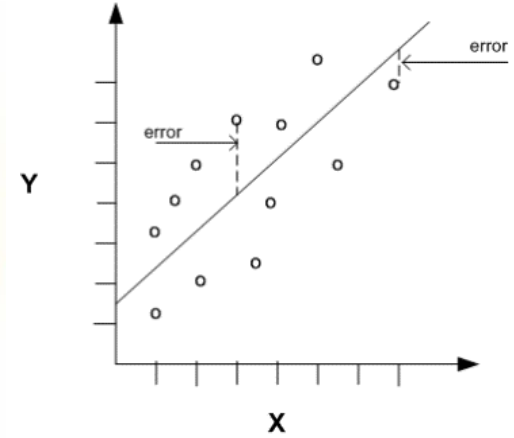
Since an early flush of optimism in the 1950s, smaller subsets of artificial intelligence – first machine learning, then deep learning, a subset of machine learning – have created ever larger disruptions.

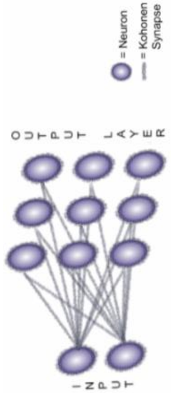


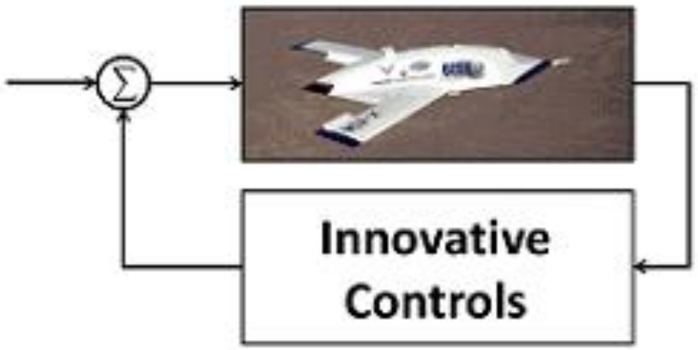


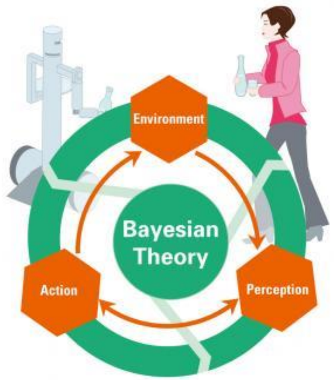
Interpreting the Fuzzy Inference Diagram

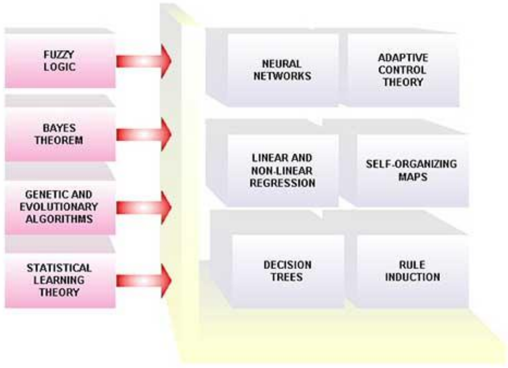


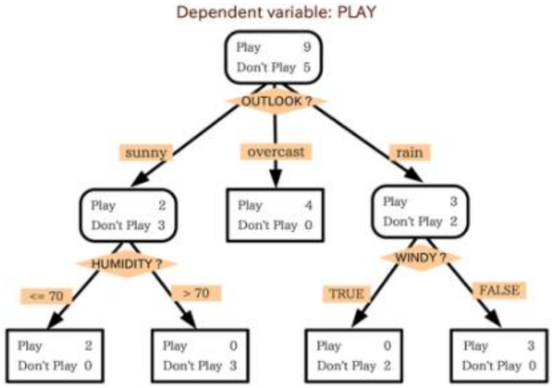










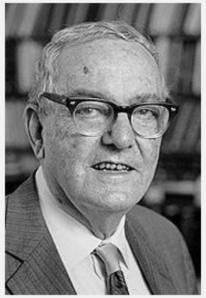


Machine Learning

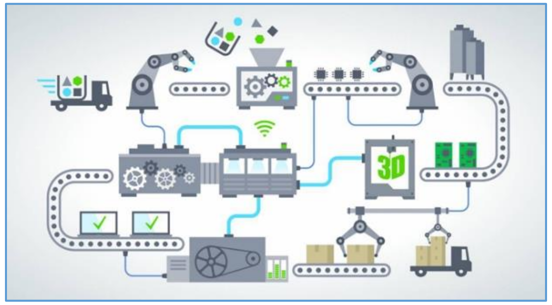
Why Machine Learning?

"Learning is any process by which a system improves performance from experience"

"Machine Learning is concerned with computer programs that automatically improve their performance through experience"



Herbert Simon
Nobel Prize in Economics 1978



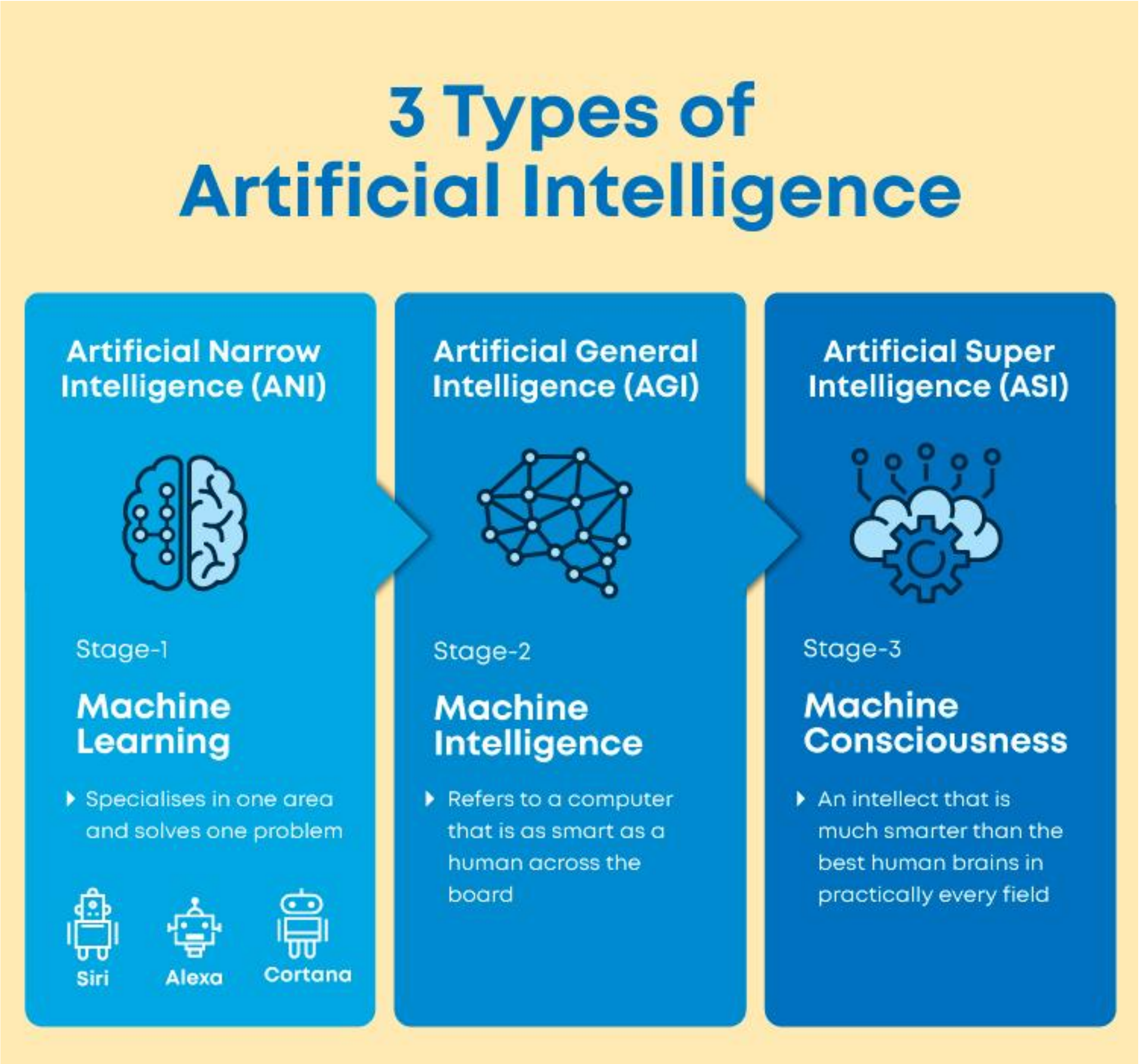
Growing and Complex Industry Challenges

Ease of Availability and storage of data

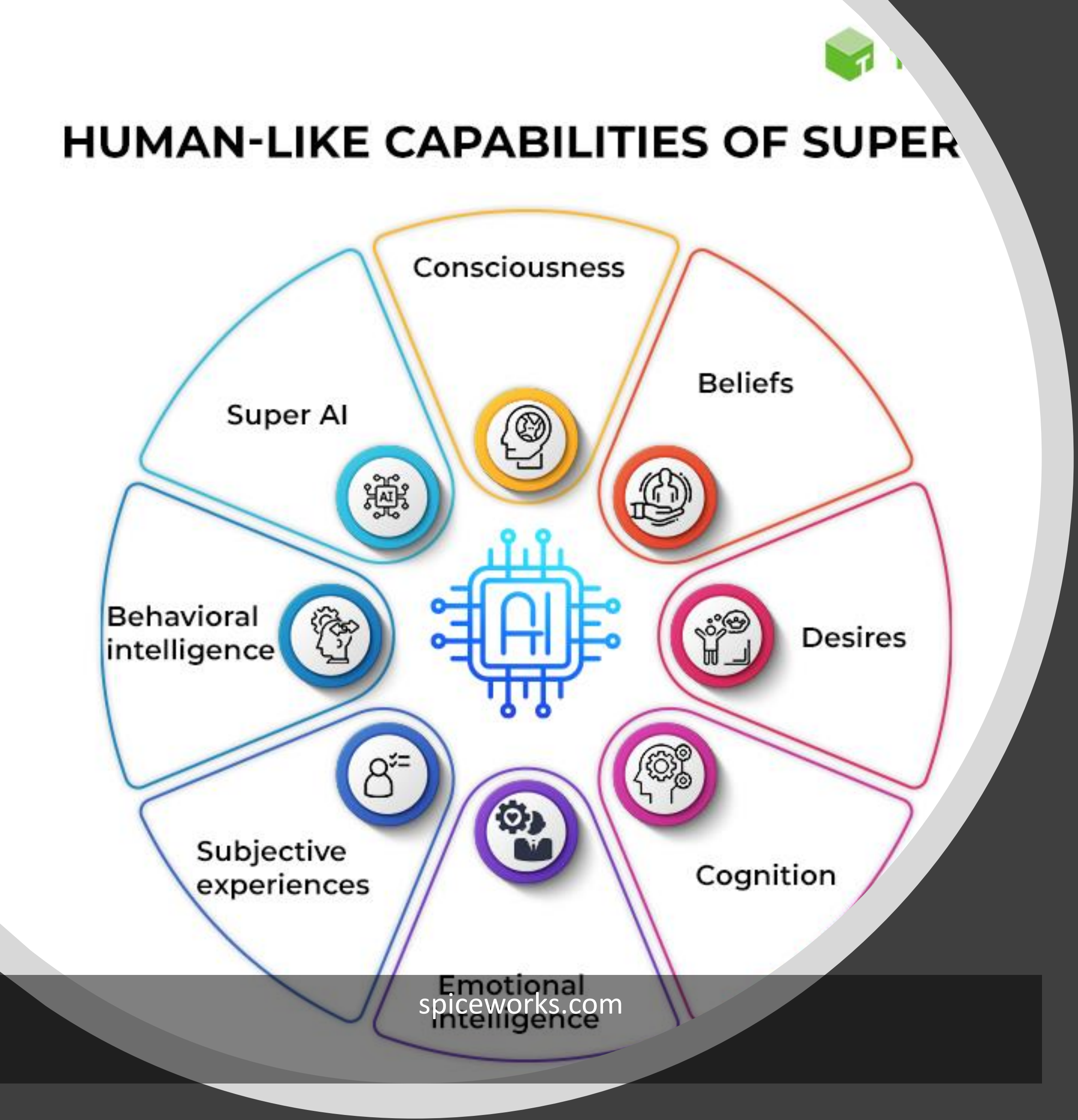
Advances in Computational Technology

Development in Learning Algorithms

Three Types of AI



mygreatlearning.com



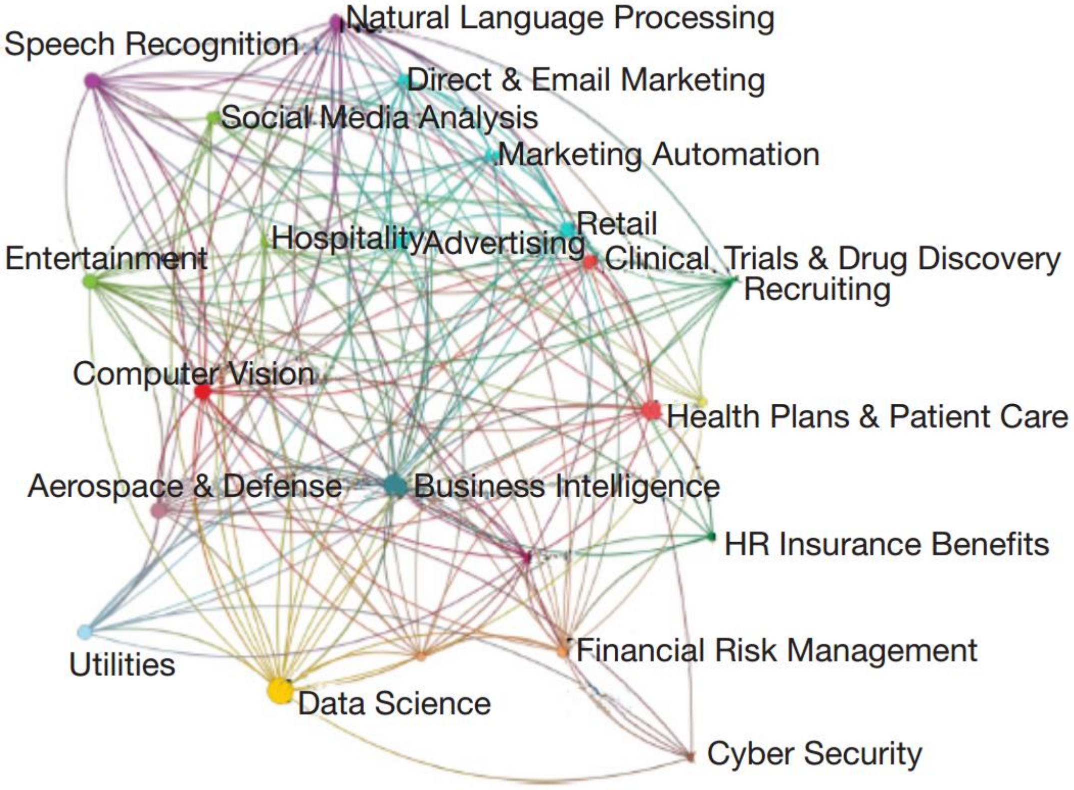
spiceworks.com

Human Like Capabilities of Super AI

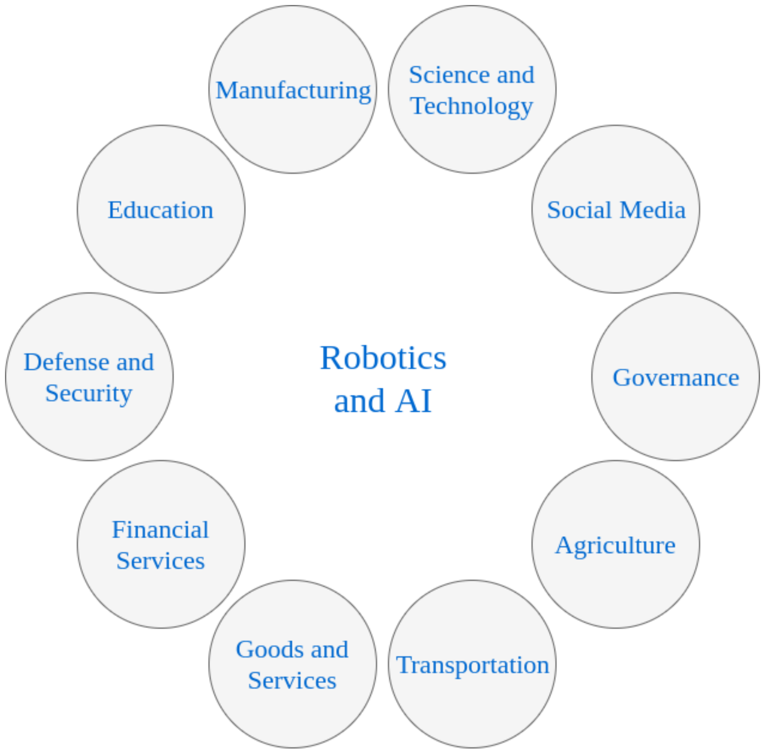
- A superintelligence is a hypothetical agent that possesses intelligence far surpassing that of the brightest and most gifted human minds. "Superintelligence" may also refer to a property of problem-solving systems (e.g., superintelligent language translators or engineering assistants) whether or not these high-level intellectual competencies are embodied in agents that act in the world. A superintelligence may or may not be created by an intelligence explosion and associated with a technological singularity.
- https://en.wikipedia.org/wiki/Superintelligence

Robotics

Omnipresence of Robotics and AI



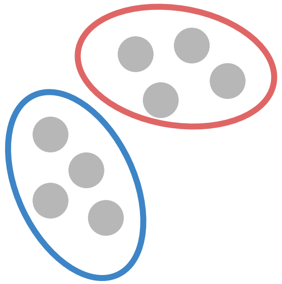
Focus areas of organizations in AI

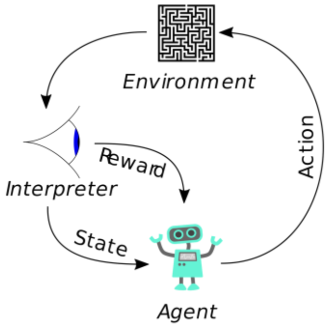


Fields that are directly impacted by Robotics and AI

Source: Artificial Intelligence and Robotics, Leveraging artificial intelligence and robotics for sustainable growth, PWC, March 2017

Types of Learning





Supervised

- Classification
- Regression

Unsupervised

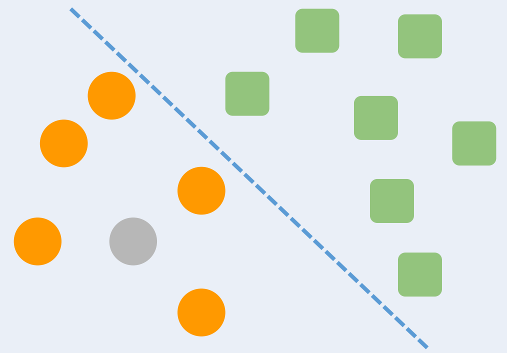
- Clustering
- Anomaly detection

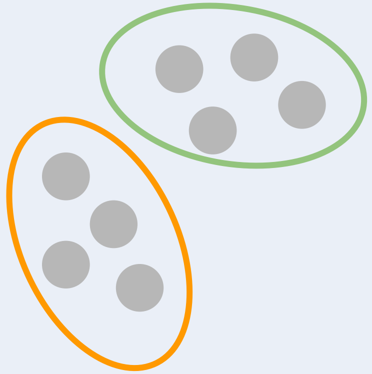
Reinforcement

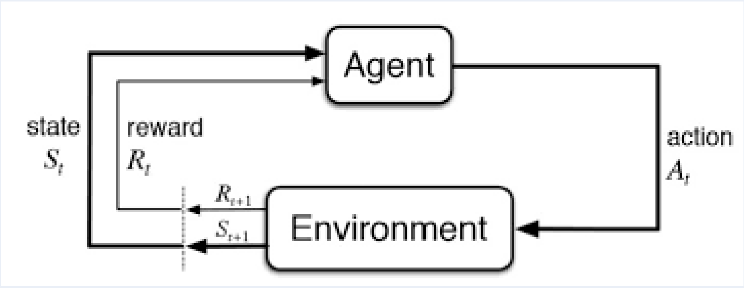
- Utility learning
- Q-learning

Types of Learning

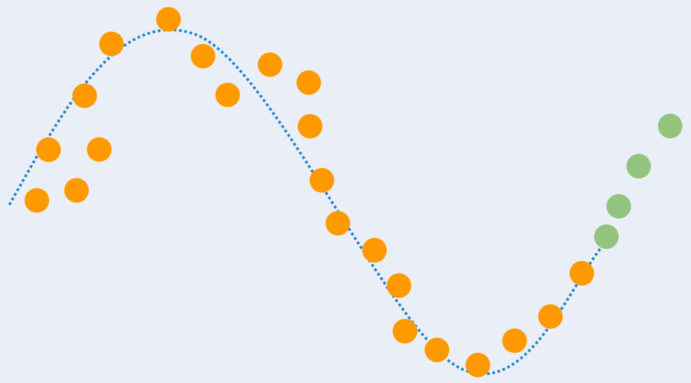
Supervised Learning	Unsupervised Learning	Reinforcement Learning

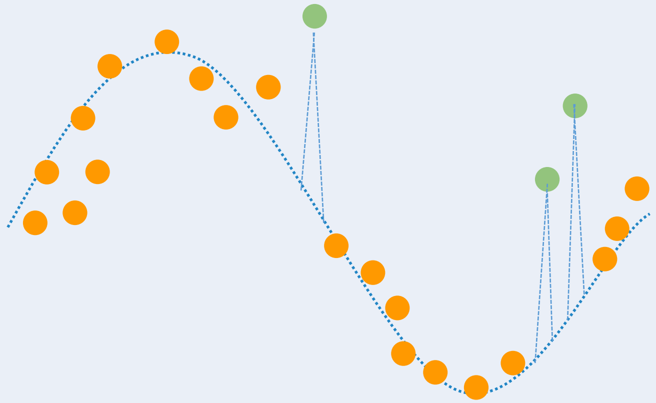


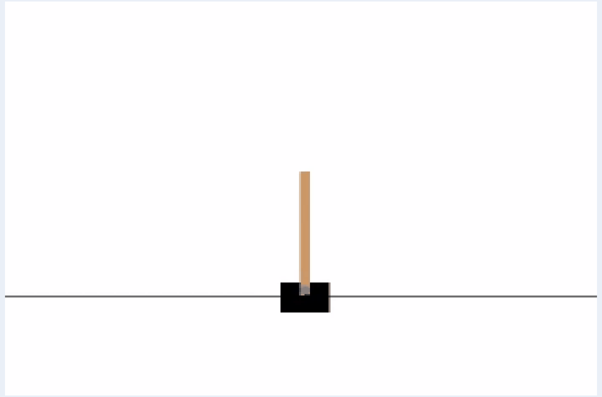




Classification | **Clustering** | **Agent-Environment Interaction**







Regression | **Anomaly Detection** | **An example**

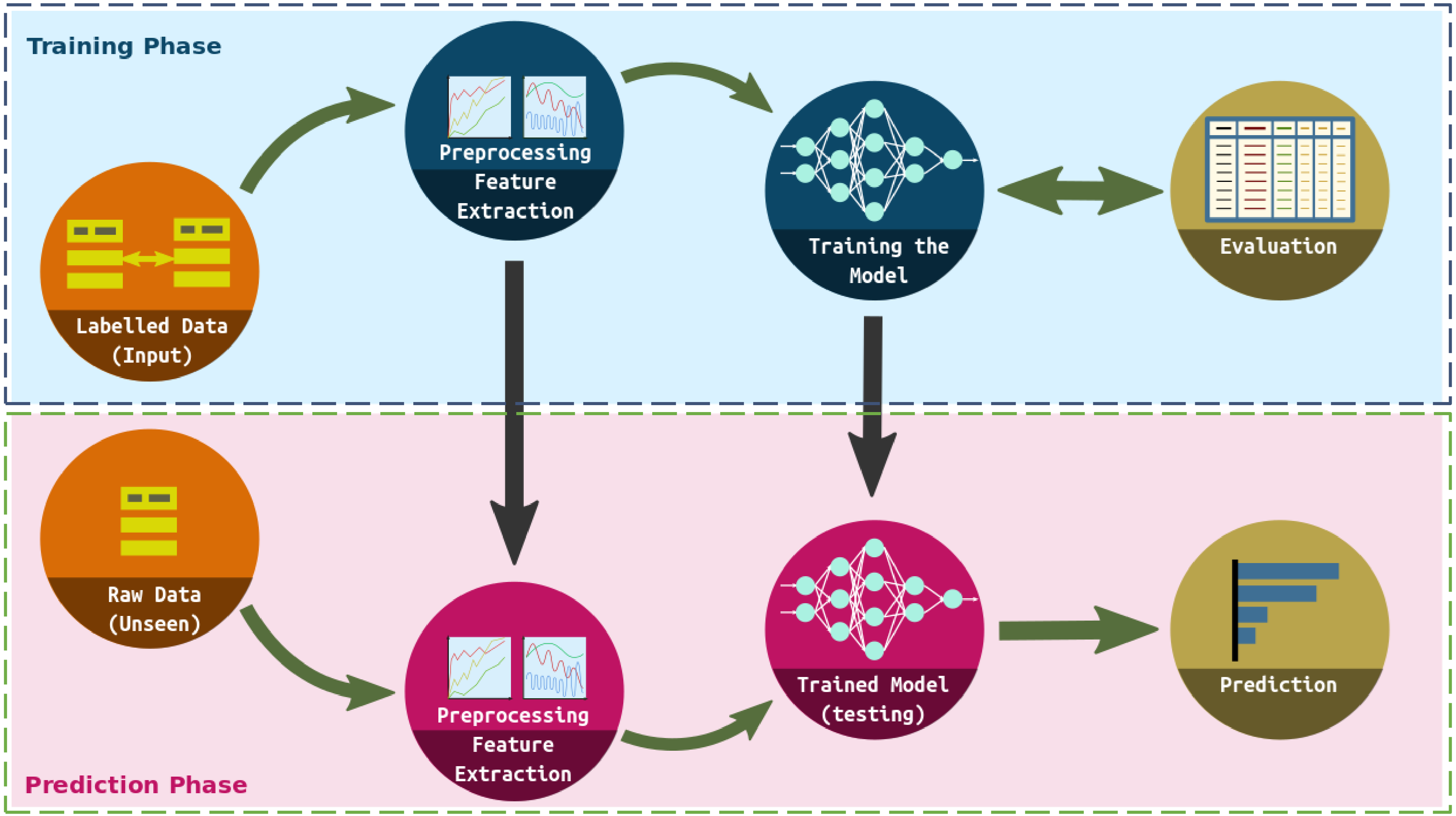
Machine learning algorithms

Supervised learning: Using labelled datasets to classify or predict insightful information, where training data that is correctly classified is fed into the model’s calculations, and refinement of weights used in calculation is repeatedly performed to improve the model’s prediction.

Unsupervised learning: Input data used in machine learning is unlabeled, and the model is used to identify patterns or clusters inherent in the dataset without requiring human intervention.

Reinforcement learning: The algorithm is provided with a set of parameters, actions and end states, undergoing iterations which explore possible courses of actions while navigating through a predetermined set of rules and constraints. A reward system is in place to incentivize the model when it is successful while “punishing” the model when it is not. The model will aim to maximize the reward obtained.

The Supervised Learning Concept



Deep Learning

- Neural Network based model development
- Design and Architecture
- Hardware Setup
- Open-Source Libraries
- Large Datasets
- Understanding Data

- Deep Learning is a technology that strives to make machines, AI capable.
- It uses multiple levels of abstraction and representation layers to learn and extract features”

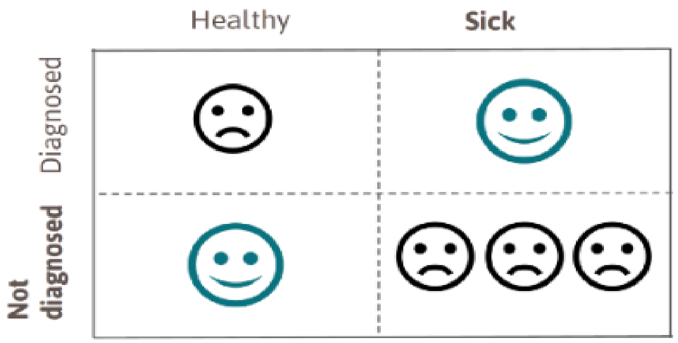
Deep Learning

- Computer Vision
  - Image segmentation and classification, self-driving cars
  - Pattern Recognition
- Natural Language Processing, Translation, Captioning, Object identification
- Regression and Forecasting
  - Stock markets forecasting, Trends analysis
- Predictive Analytics
  - Prognostics and Diagnostics

Deep Learning Challenges – Real World Problems

Availability of useful training data

failure cases for quality estimation, larger datasets



Imbalanced classes

more instances of one case over the other

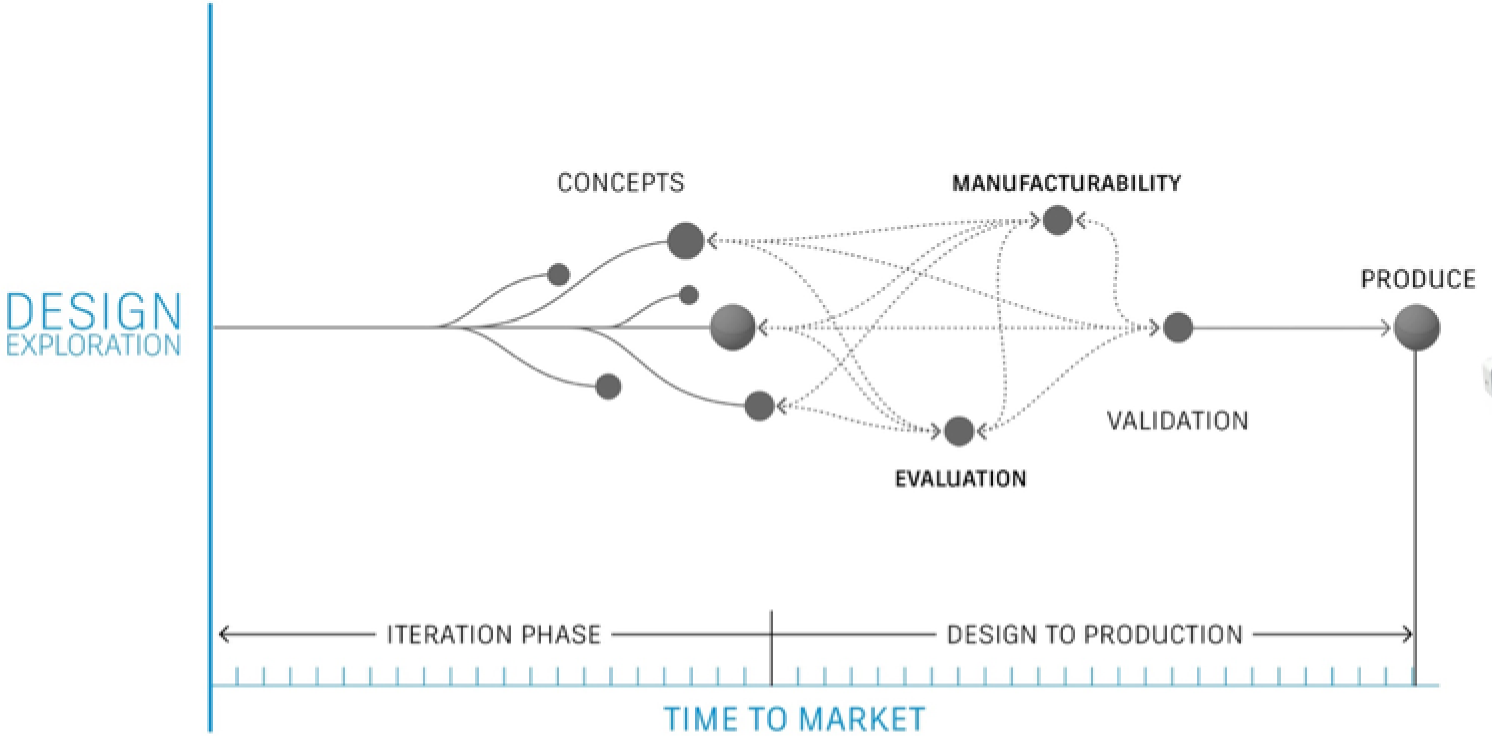
Misclassification costs

penalties, real world effects

Variations between data

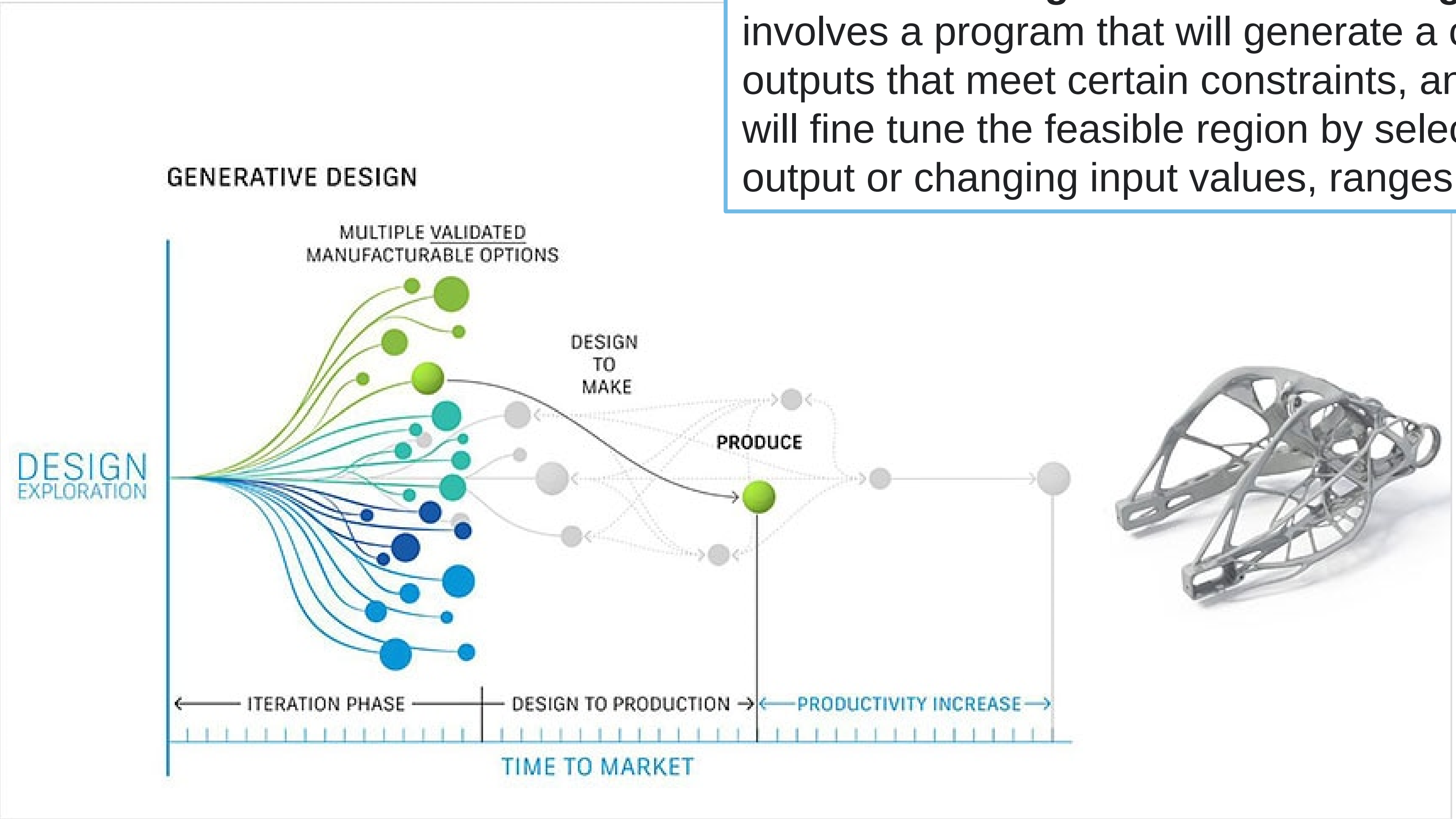
HOW DOES GENERATIVE DESIGN HELP THE PRODUCT DEVELOPMENT PROCESS

TRADITIONAL



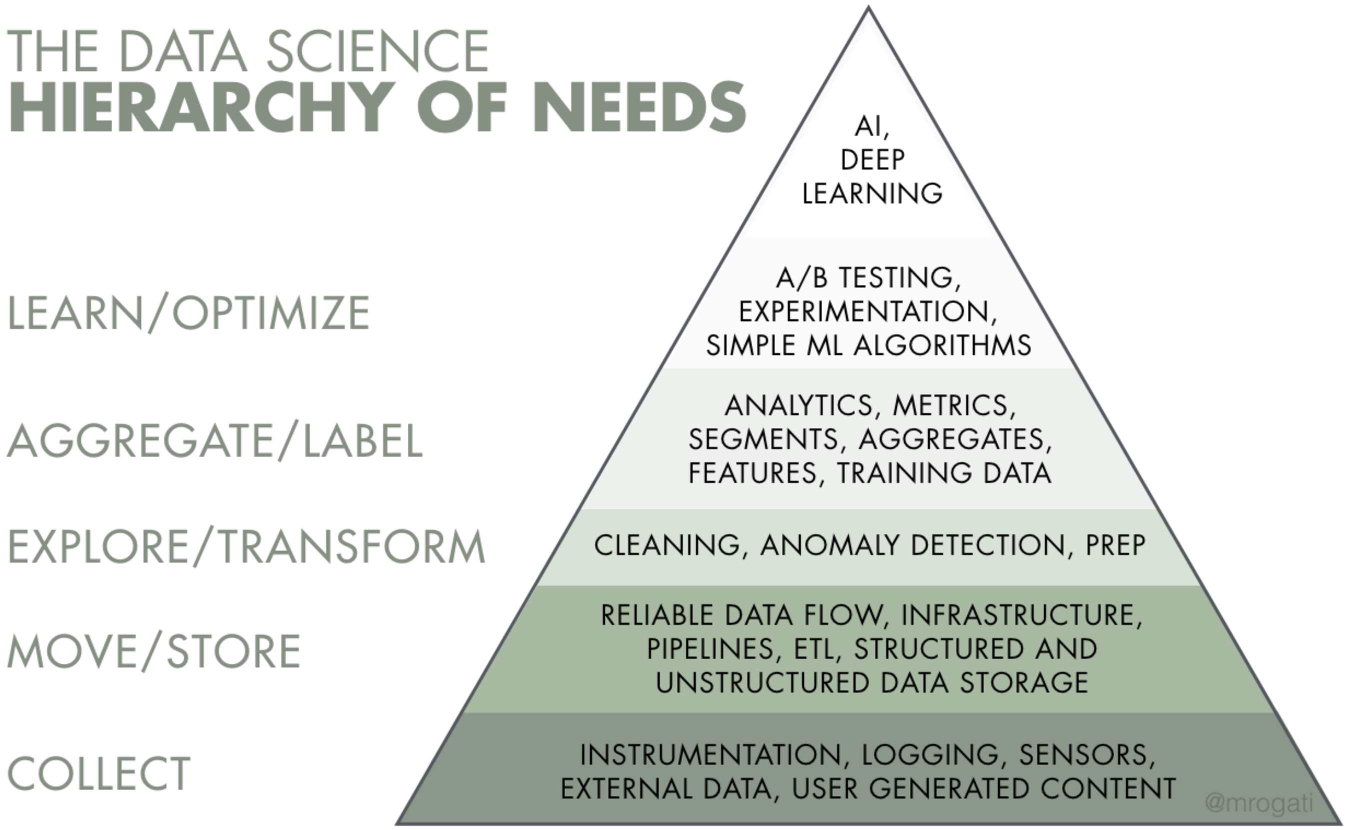
HOW DOES GENERATIVE DESIGN HELP THE PRODUCT DEVELOPMENT PROCESS

Generative design is an iterative **design** process that involves a program that will generate a certain number of outputs that meet certain constraints, and a designer that will fine tune the feasible region by selecting specific output or changing input values, ranges and distribution.



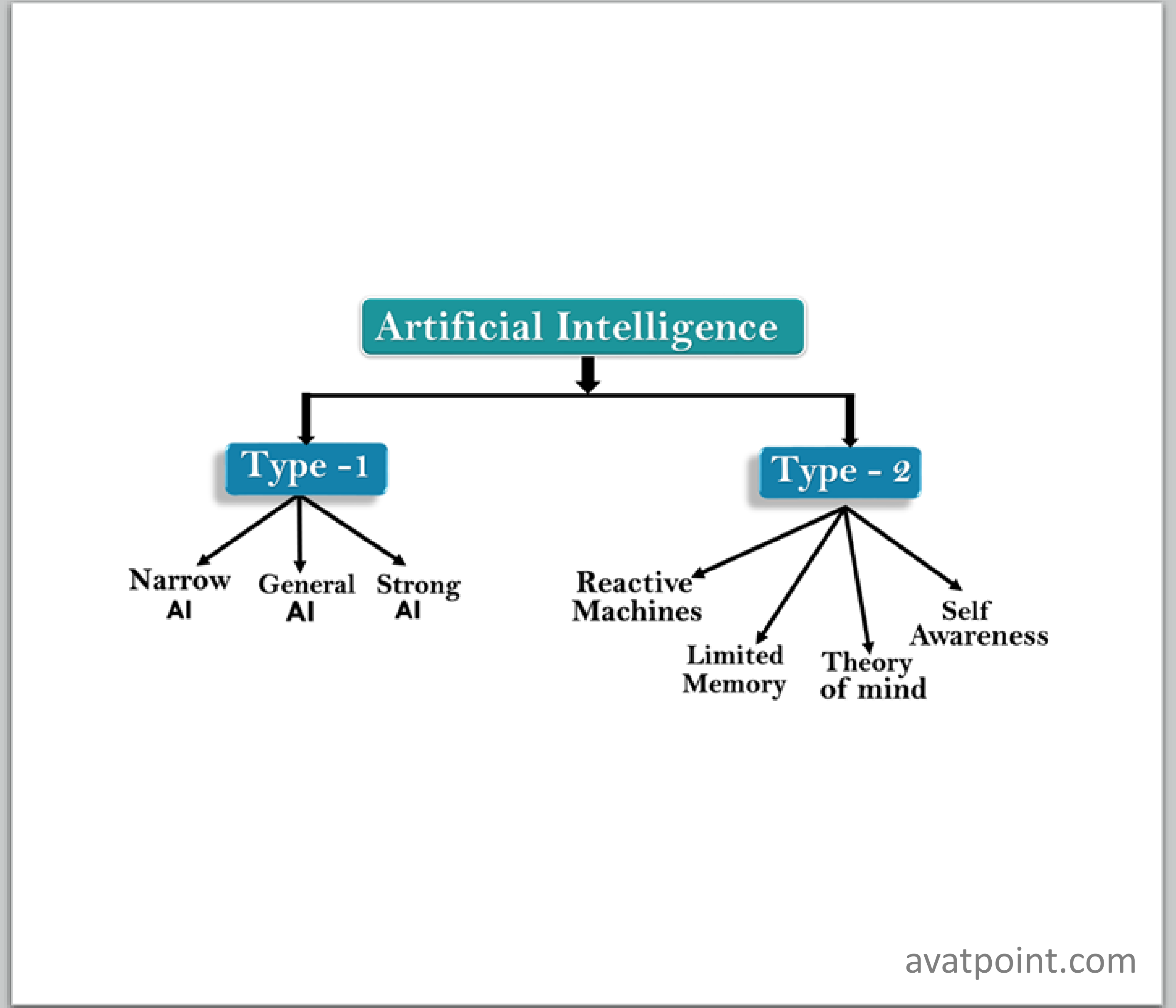
autodesk.com

The AI Hierarchy of Needs

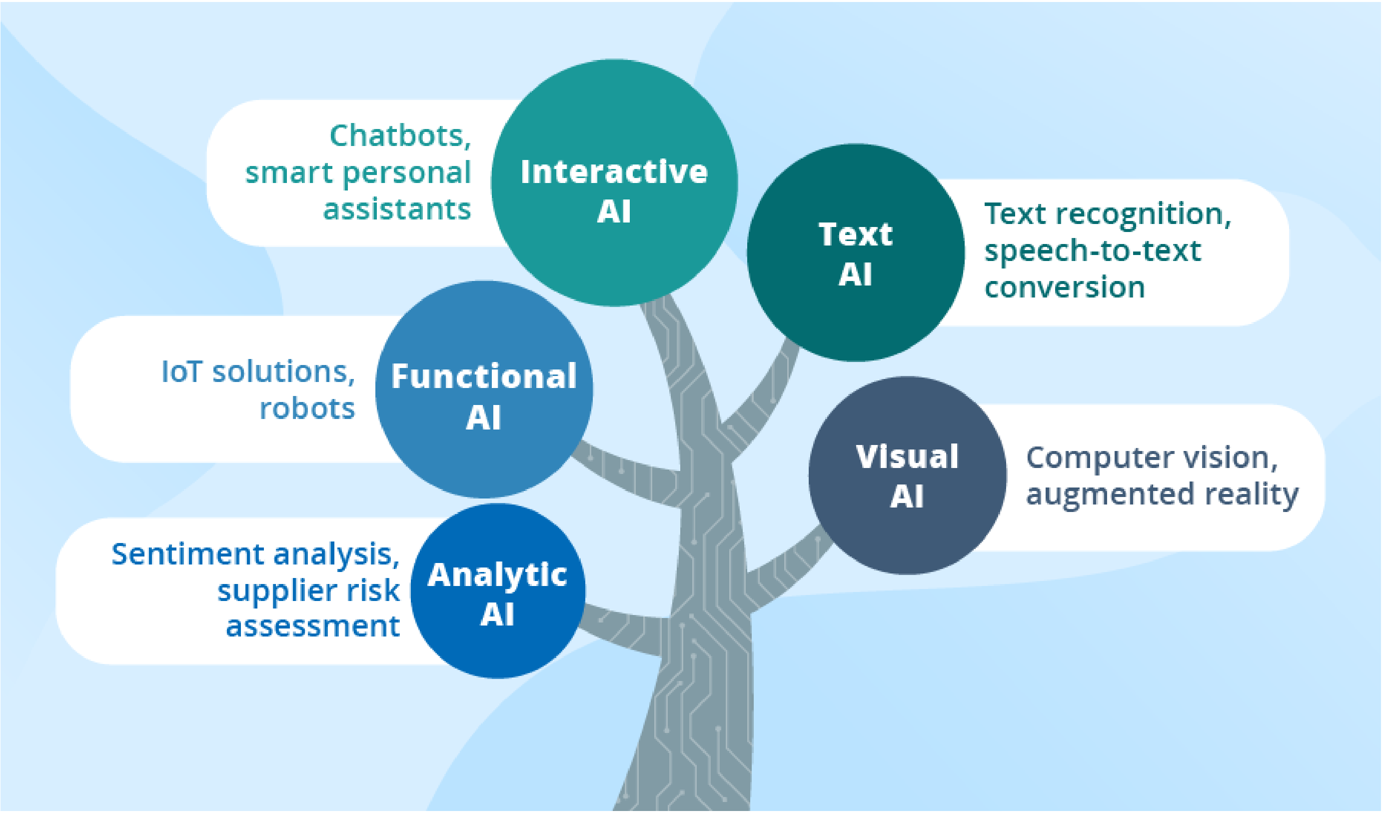


Types of Artificial Intelligence

- **Artificial narrow intelligence (ANI) Artificial general intelligence (AGI) Artificial super intelligence (ASI)**
- Performs specific tasks at a proficiency surpassing human capabilities Able to execute general tasks and solve broad problems at a level akin to human cognitive function Excels in general tasks and surpassing human abilities in most areas. Able to expand functions independently.
- *Today ~ 20-30 years into the future Uncertain*



5 Types of Artificial Intelligence That Bring Value to Business



scnsoft.com

Digital Labour

What is out there?

Can we prepare for the future?

Digital Labour and Dignity of Work

Eliminating

Dull

Dangerous

Dirty

Jobs

Innovation

Frees up human talent to innovate and create

Risk Reduction

Expected reduction in mistakes, accidents, casualties, regulatory violations and fraud

Job Creation

Increased quality of work and innovation resulting in alternative jobs creation

Source: Digital Labor: What the future of work looks like, KPMG, IBM InterConnect 2017

Robotic and Cognitive Automation (RCA)

- Automating processes by mimicking repetitive human actions using *software robots (bots)* or *digital labors* replacing human effort in mundane tasks.

- According to an October 2016 World Bank Report, automation would be threat to 69% of the current jobs (in India).

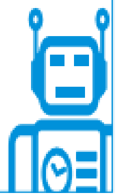
- India insights: The Indian economy newsletter, KPMG, August 2016
- Robotics and cognitive automation, KPMG, SPICON 2016
- http://www.worldbank.org/en/news/speech/2016/10/03/speech-by-world-bank-president-jim-yong-kim-the-world-bank-groups-mission-to-end-extreme-poverty

Robotic and Cognitive Automation (RCA)

The global market for robots and artificial intelligence is expected to reach **$152.7 billion by 2020**. The adoption of these technologies could improve productivity by 30 percent
- Bank of America Merrill Lynch

$152.7 BILLION

A recent study by HfS Research and KPMG LLP reports that **55 percent of North American enterprises** are looking at new opportunities available with ***RPA systems***



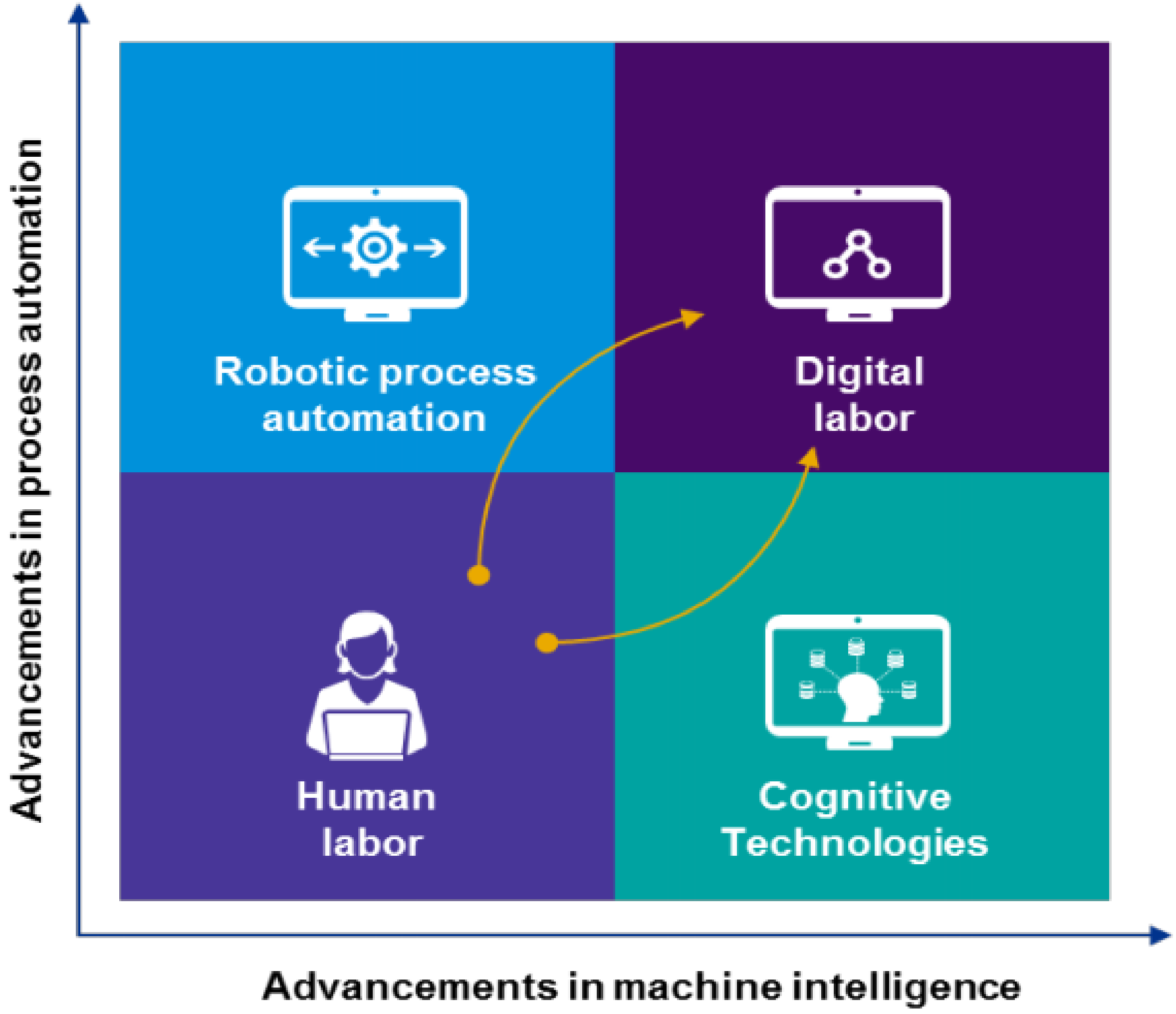
Recent research from London School of Economics suggests a ***return on investment*** in robotic technologies of **between 600% and 800%** for specific tasks

The KPMG 2016 CEO Outlook finds **85% of CEOs** are concerned about the integration of basic automated business processes with artificial intelligence and cognitive processes

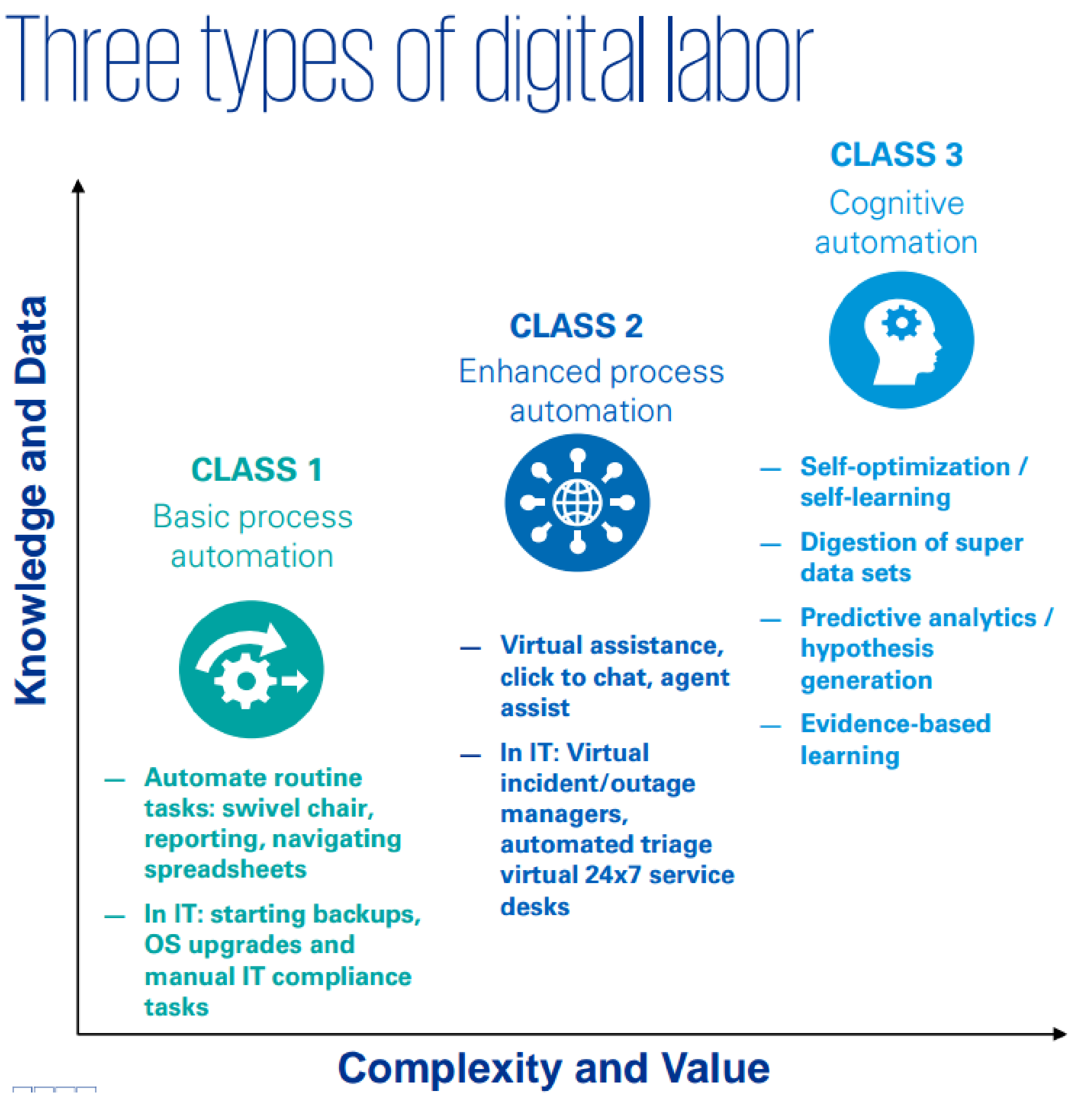
Gartner predicts that by 2020, ***smart machines*** will be a ***top five investment priority*** for more than 30% of CIOs

McKinsey research suggests that smart robots will replace more than **100 million knowledge workers** – or one-third of the world's jobs – by 2025

1. India insights: The Indian economy news letter, KPMG, August 2016
2. Robotics and cognitive automation, KPMG, SPICON 2016
3. http://www.worldbank.org/en/news/speech/2016/10/03/speech-by-world-bank-president-jim-yong-kim-the-world-bank-groups-mission-to-end-extreme-poverty



Robotic and Cognitive Automation (RCA)



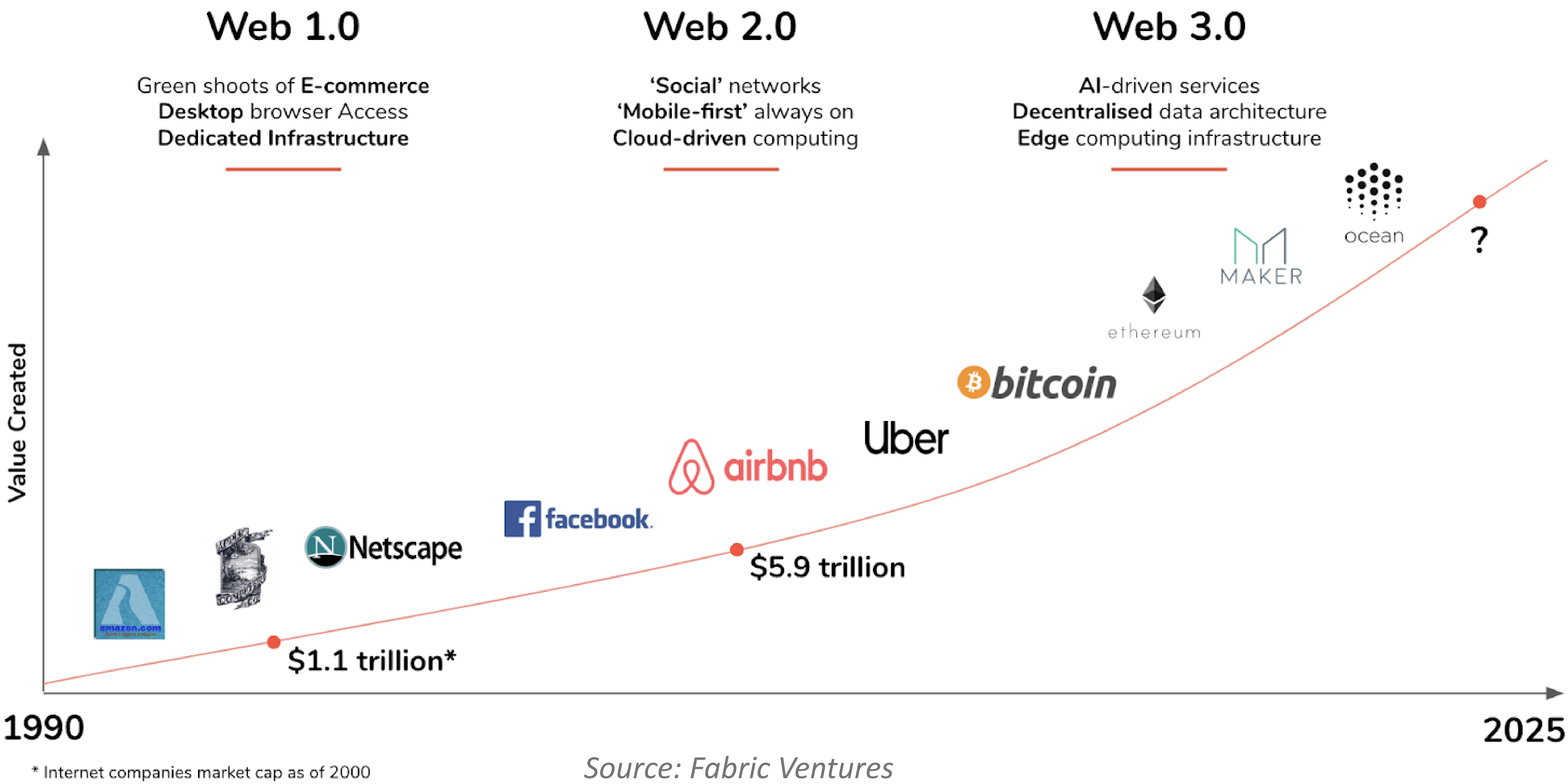
Robotic and Cognitive Automation (RCA)

Sources: Robotics and cognitive automation, KPMG, SPICON 2016

WEB 3.0

- Web 3.0 is built largely on three new layers of technological innovations:
- artificial intelligence driven services
- edge computing infrastructure, and,
- decentralized data networks / architectures.
- *a composable human-centric & privacy preserving computing fabric for the next wave of the web*

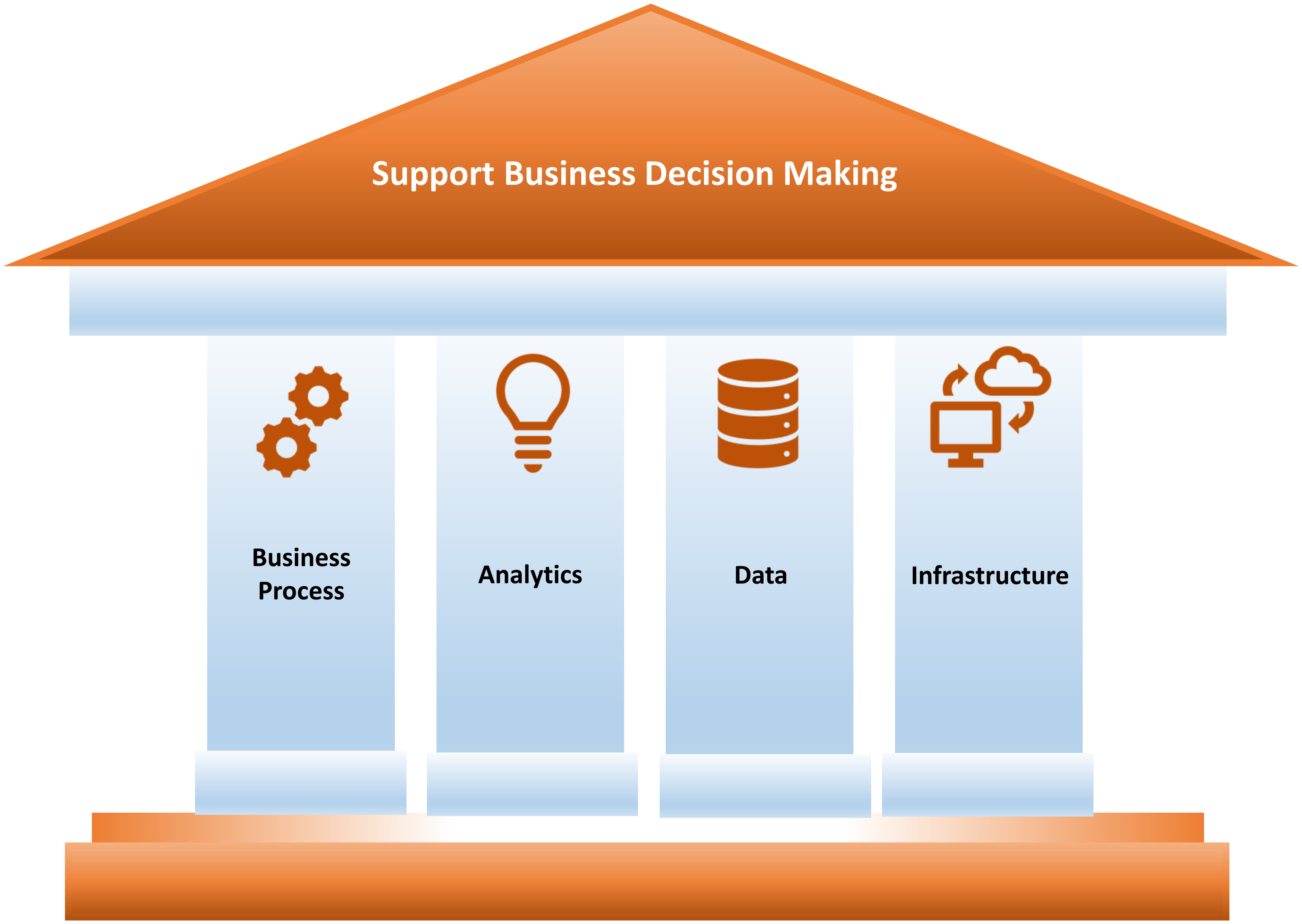
The Evolution of the Web



Source: Fabric Ventures

Data Analytics for Industry 4.0

Supporting Business – from Data to Decisions



Overview

Advisory and consulting

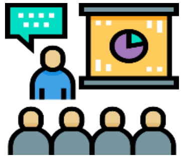
- Strategy Planning
- Data Governance and Security
- Data Management
- Define Analytics System

Problem Scoping

- Define the business problem
- Identify Key Business Metrics and its significance
- Monitor business performance indicators through dashboards
- Provide analytics solutions based on business problem

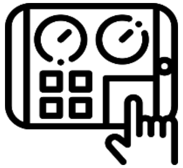
Analytics Solutions

- Consumer Analytics
- Real-time Visualization
- Advanced Analytics techniques
- Text & Sentiment Mining



Training and Development

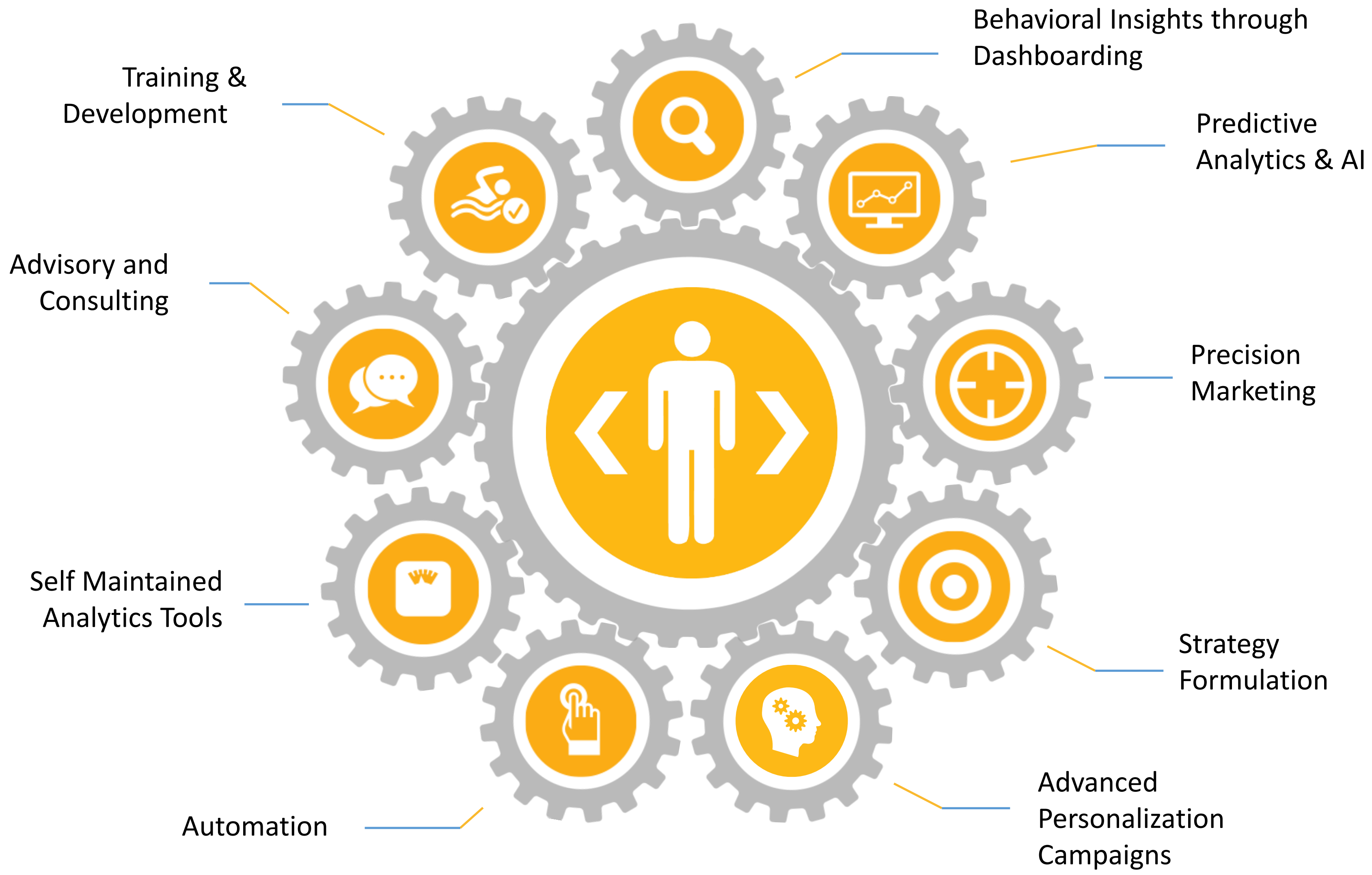
- Foundation training on Tableau (Visualization) software’s
- Support to improve basic query languages and database expertise



Automation

- Convert redundant jobs using automation tools
- Setup automated process pipelines to reduce manual interventions and error.

Analytics Offering



Analytics Solutions for Different Industries

Data Visualization and Dashboarding

HR Management	Retail	Logistics	Operational Industry
Support decision making on HR activities	Outlet Financial Analytics	Vendor Management	Lean Manufacturing Analytics
Streamline Hiring Process	Warranty Analysis & Fraud Detection	Inventory Management	Yield Analysis & Optimization
Address Staff Attrition	Analyze Customer movement in stores/malls	Sourcing	Asset Performance Analytics
Address Staff Attrition	Queue & Product Management	Network Planning and Return Management	Sales Margin Analytics

Analytics Solutions for Different Industries

Data Visualization and Dashboarding

Banking	Insurance	Healthcare	Hospitality
Next Best Offer	Propensity Score Modelling	Clinical Trials for new drugs	Optimizations
Fraud Prediction	Risk Modelling	A/B Testing	Customer feedback analysis
Customer Segmentation	Graph Network Models	Genetics Analysis	NPS Score for Customer Experience
Credit Risk Analysis	Claim Analytics	Epidemic Forecasting & Control	Customer waiting time analysis

Analytics Solutions for Different Industries

Data Visualization and Dashboarding

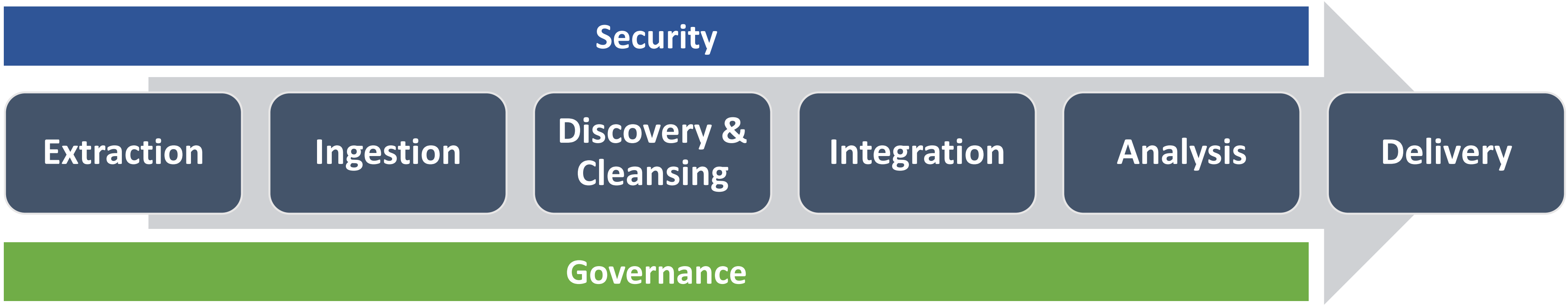
Media
- Risk Modelling
- Fraud Prediction
- Customer Segmentation
- Credit Risk Analysis

Education
- Staff Attrition Models
- Student Withdrawal model
- Child behavioral analysis
- Resource Planning

Sports
- Ticket Pricing and Sales Inventory
- CRM and fan engagement
- Social Media and Digital Analytics for fan engagement
- Game output prediction

Telecom
- Customer Profiling
- Pricing Analysis
- Call Volume Forecasting
- Customer Life Time Value Estimation

Data Analytics Value Chain



Extraction – Structured, unstructured and semi-structured data from multiple sources

Ingestion – Loading vast amounts of data onto a data store

Discovery & Cleansing – Understanding format and content; clean up and formatting

Integration – Linking, entity extraction, entity resolution, indexing and data fusion

Analysis – Intelligence, statistics, predictive and text analytics, machine learning

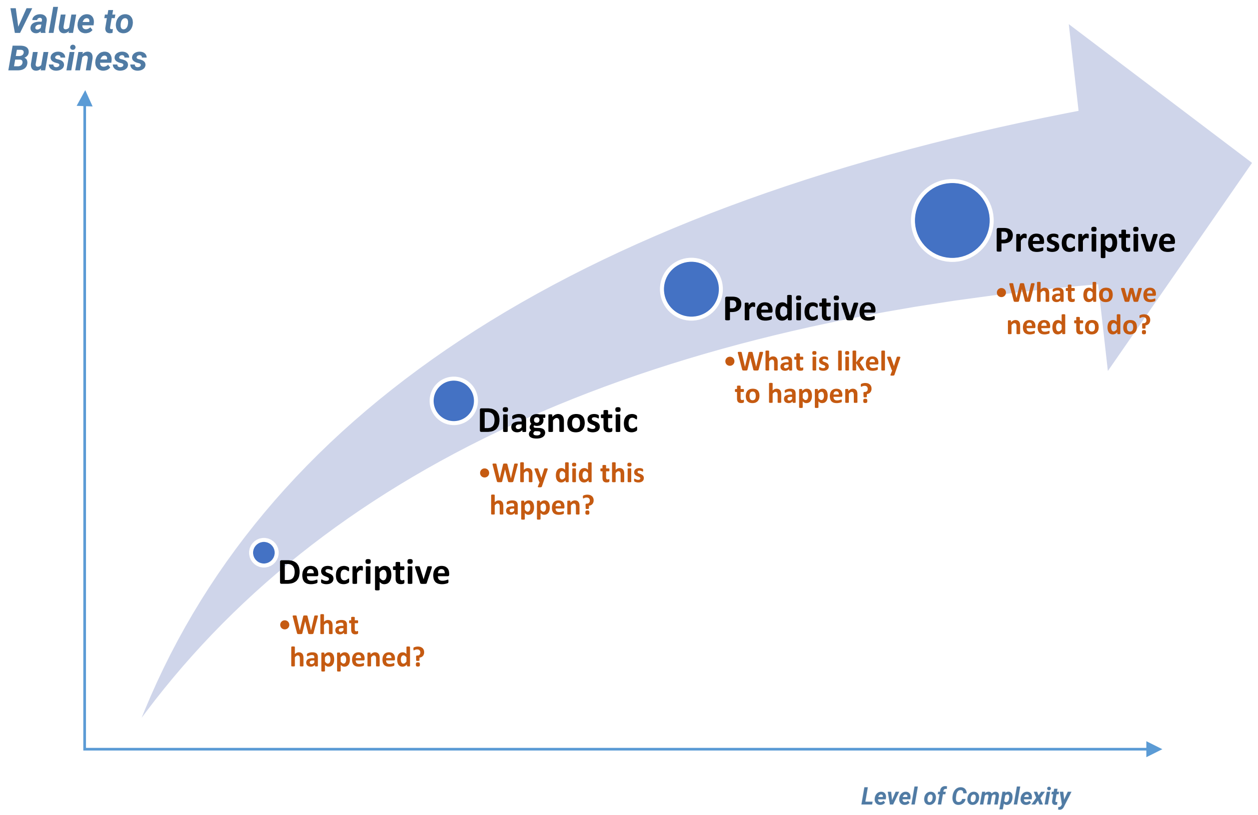
Delivery – Querying, visualization, real time delivery on enterprise-class availability

Source O'Reilly Strata 2012

Data Analytics Trend

- Data Analytics methods have grown from providing hindsight on what happened to providing **actionable insights** on what we can do!

- While this adds significant value to business it also leads to increased complexity with larger amount of data requirements and use of advanced AI algorithms



Opportunities for Data Analytics in Industries

Machine Health Prediction	Fault Detection	Product Quality Estimation
Resource Optimization	Energy Cost Reduction	Risk Management

Known Industry Challenges

Availability of useful training data

Failure cases for quality estimation, large datasets etc.

Imbalanced classes

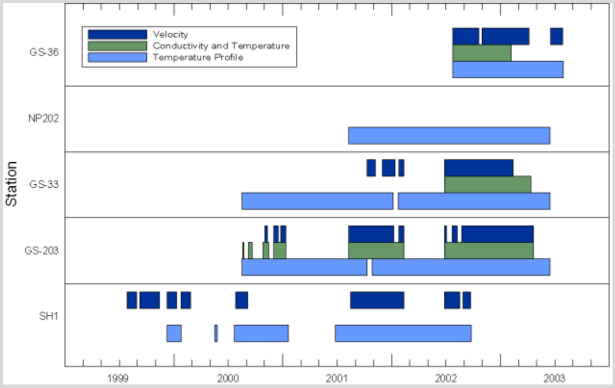
More instances of one case over the other

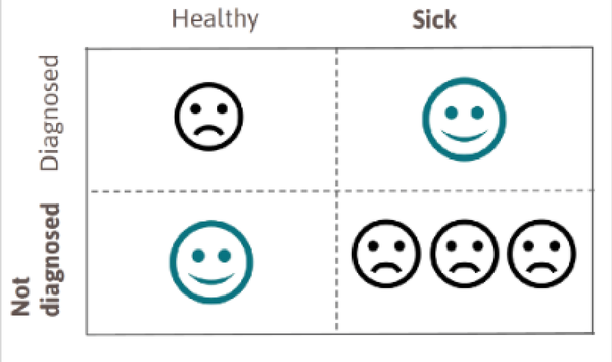
Misclassification costs

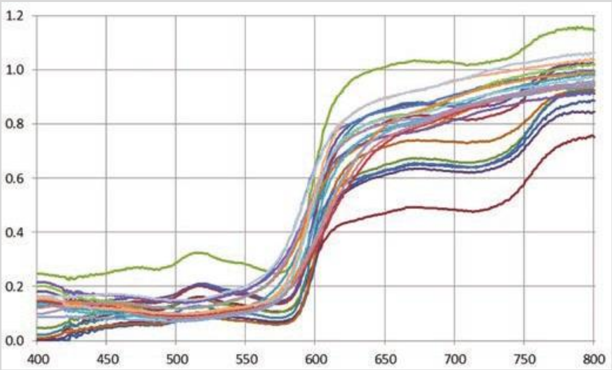
Penalties, real world effects

Standardization

Data from different sources need to be standardized







Tools and Libraries

Not exhaustive …

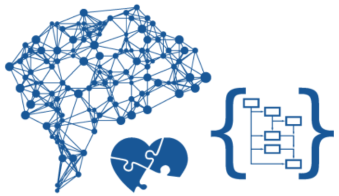
Top 10 Skills to be relevant in Industry 4.0

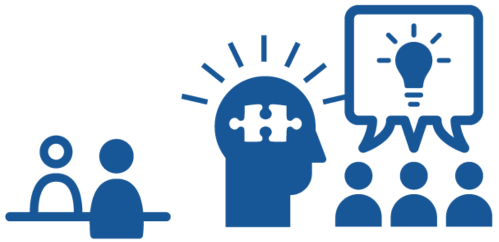
in 2020

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

Top 10 Skills to be relevant in Industry 4.0

The Essential Eight Technologies

Based on current technology trends and the future drive PwC has identified the essential technology areas for 2020

Artificial Intelligence (AI)	Augmented Reality (AR)	Blockchain	Drones
Internet of things (IoT)	Robotics	Virtual Reality (VR)	3D printing

Source: Artificial Intelligence and Robotics, Leveraging artificial intelligence and robotics for sustainable growth, PWC, March 2017

World "Growth" Initiatives

By 2025, 97 million new roles may emerge that are more adapted to the new division of labour among humans, machines and algorithms.

World economic forum

according to data gathered by LinkedIn, Coursera and the World Economic Forum in the Future of Jobs Report 2020.

https://www.weforum.org/agenda/2020/10/x-charts-showing-the-jobs-of-a-post-pandemic-future-and-the-skills-you-need-to-get-them/

2025 – humans and machines

By 2025, 85 million jobs may be displaced by a shift in the division of labour between humans and machines

Some 97 million new roles may emerge that are more adapted to the new division of labour among humans, machines and algorithms

https://www.weforum.org/agenda/2020/10/x-charts-showing-the-jobs-of-a-post-pandemic-future-and-the-skills-you-need-to-get-them/

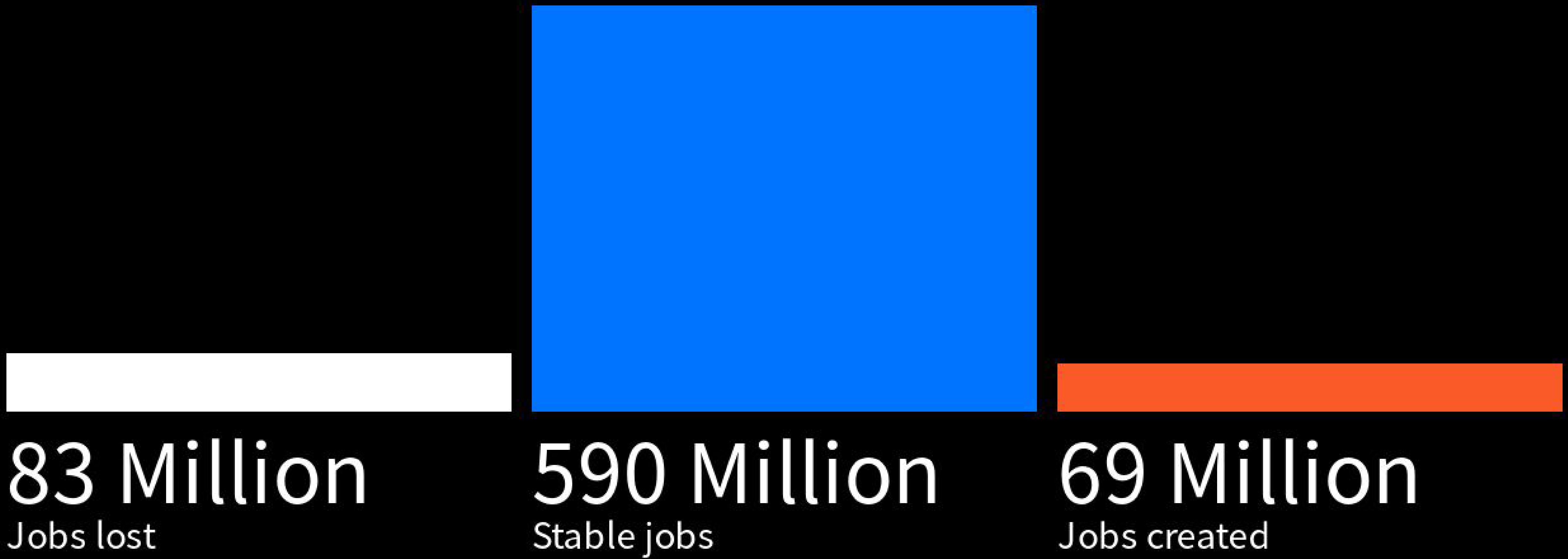
2027 – humans and machines

Some 23% of jobs are expected to change by 2027, with 69 million new jobs created and 83 million eliminated

Fastest-growing jobs are AI and machine learning specialists, sustainability specialists, business intelligence analysts and information security specialists; largest absolute growth is expected in education, agriculture and digital commerce

https://www.weforum.org/press/2023/04/future-of-jobs-report-2023-up-to-a-quarter-of-jobs-expected-to-change-in-next-five-years/

Jobs Created and Destroyed Between 2023 and 2027



Source: World Economic Forum, Future of Jobs Survey 2023; International Labour Organization, ILOSTAT

Bloomberg

Fastest growing vs. fastest declining jobs

WORLD ECONOMIC FORUM

Top 10 fastest growing jobs		Top 10 fastest declining jobs	
1.	AI and Machine Learning Specialists	1.	Bank Tellers and Related Clerks
2.	Sustainability Specialists	2.	Postal Service Clerks
3.	Business Intelligence Analysts	3.	Cashiers and ticket Clerks
4.	Information Security Analysts	4.	Data Entry Clerks
5.	Fintech Engineers	5.	Administrative and Executive Secretaries
6.	Data Analysts and Scientists	6.	Material-Recording and Stock-Keeping Clerks
7.	Robotics Engineers	7.	Accounting, Bookkeeping and Payroll Clerks
8.	Electrotechnology Engineers	8.	Legislators and Officials
9.	Agricultural Equipment Operators	9.	Statistical, Finance and Insurance Clerks
10.	Digital Transformation Specialists	10.	Door-To-Door Sales Workers, News and Street Vendors, and Related Workers

Source
World Economic Forum, Future of Jobs Report 2023.

Note
The jobs which survey respondents expect to grow most quickly from 2023 to 2027 as a fraction of present employment figures

Top 10 skills on the rise

WORLD ECONOMIC FORUM

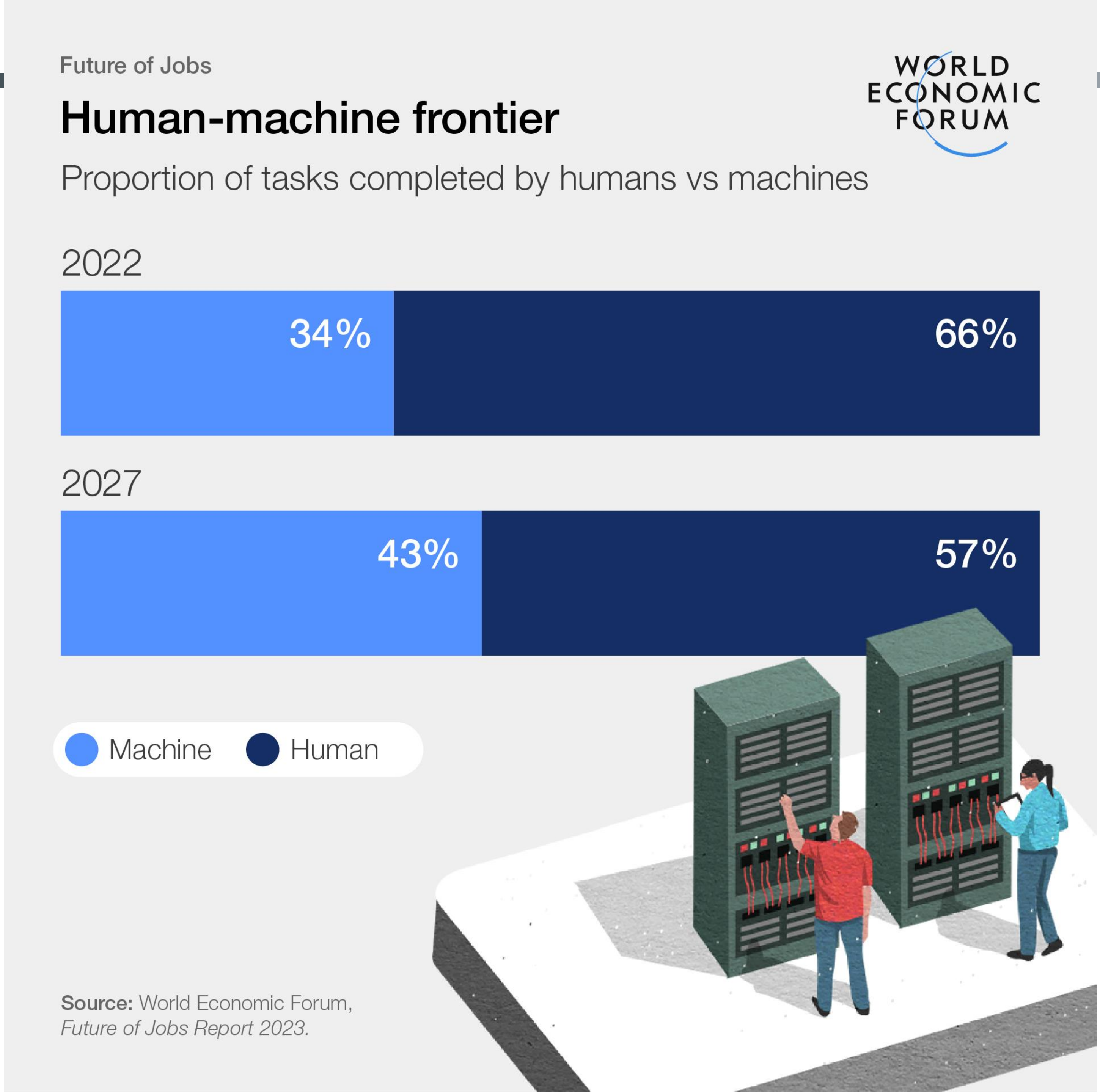
1. Creative thinking
2. Analytical thinking
3. Technological literacy
4. Curiosity and lifelong learning
5. Resilience, flexibility and agility
6. Systems thinking
7. AI and big data
8. Motivation and self-awareness
9. Talent management
10. Service orientation and customer service

Type of skill

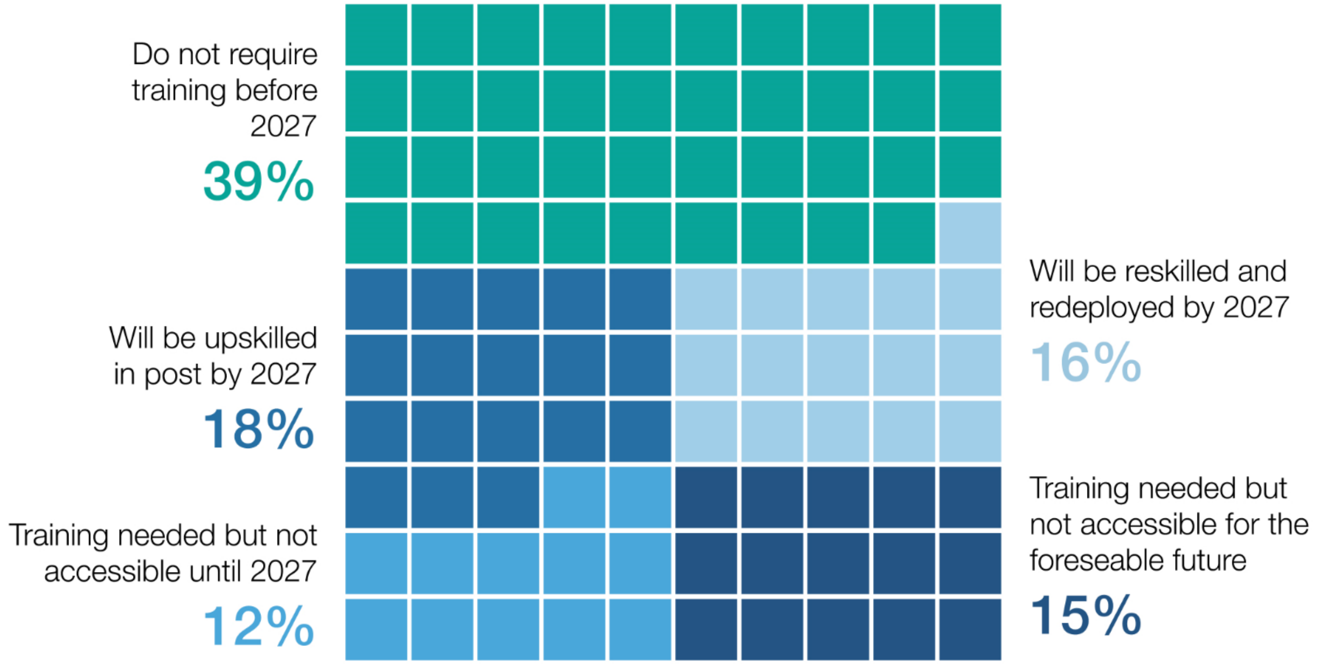
Cognitive skills · Self-efficacy · Management skills · Technology skills · Working with others · Engagement skills

Source
World Economic Forum, Future of Jobs Report 2023.

Note
The skills judged to be increasing in importance most rapidly between 2023 and 2027

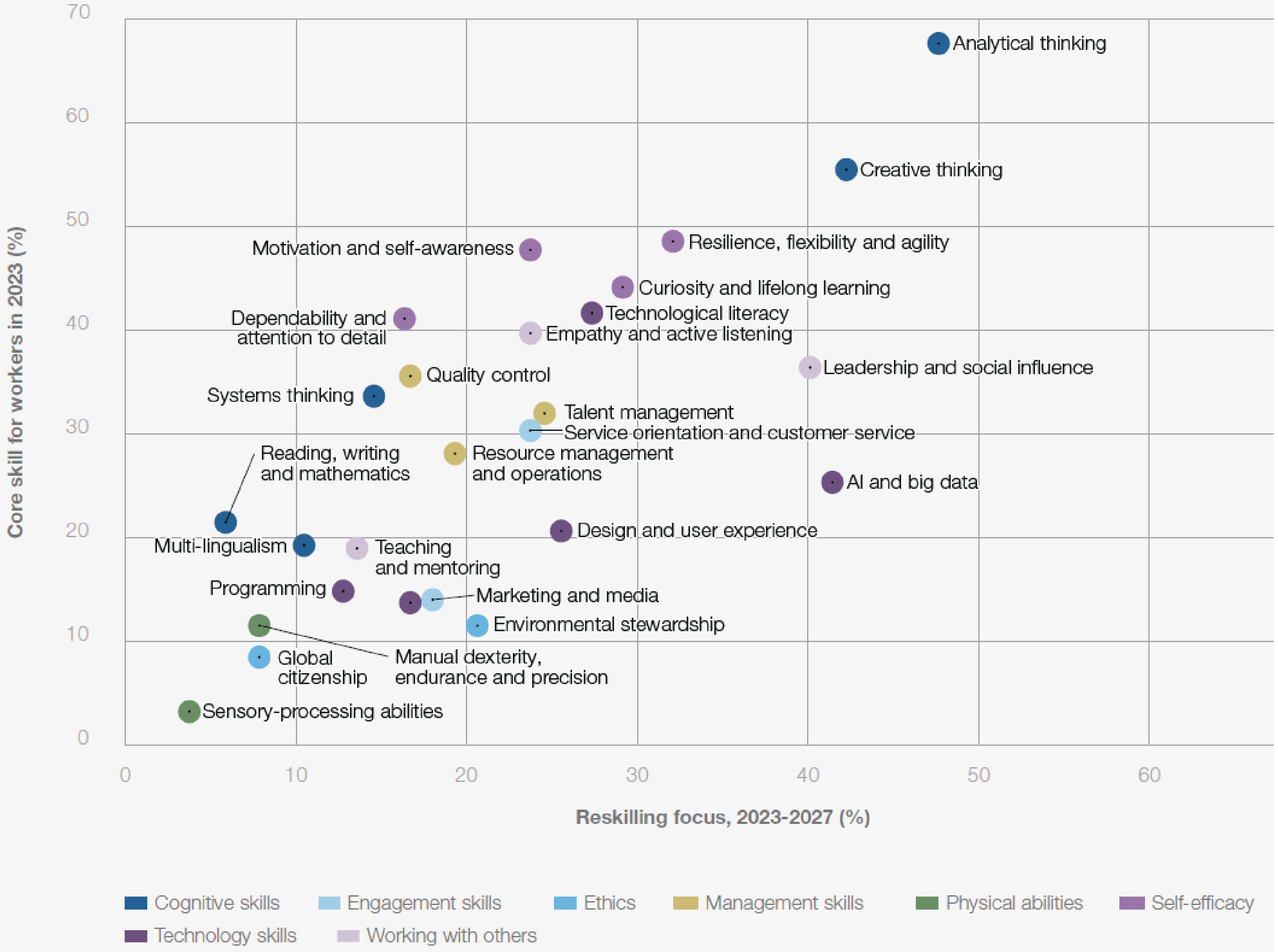

Future of Jobs
Human-machine frontier
Proportion of tasks completed by humans vs machines
2022
34%
66%
2027
43%
57%
Machine
Human
WORLD ECONOMIC FORUM
Source: World Economic Forum, Future of Jobs Report 2023.

Training strategies needed, 2023-2027

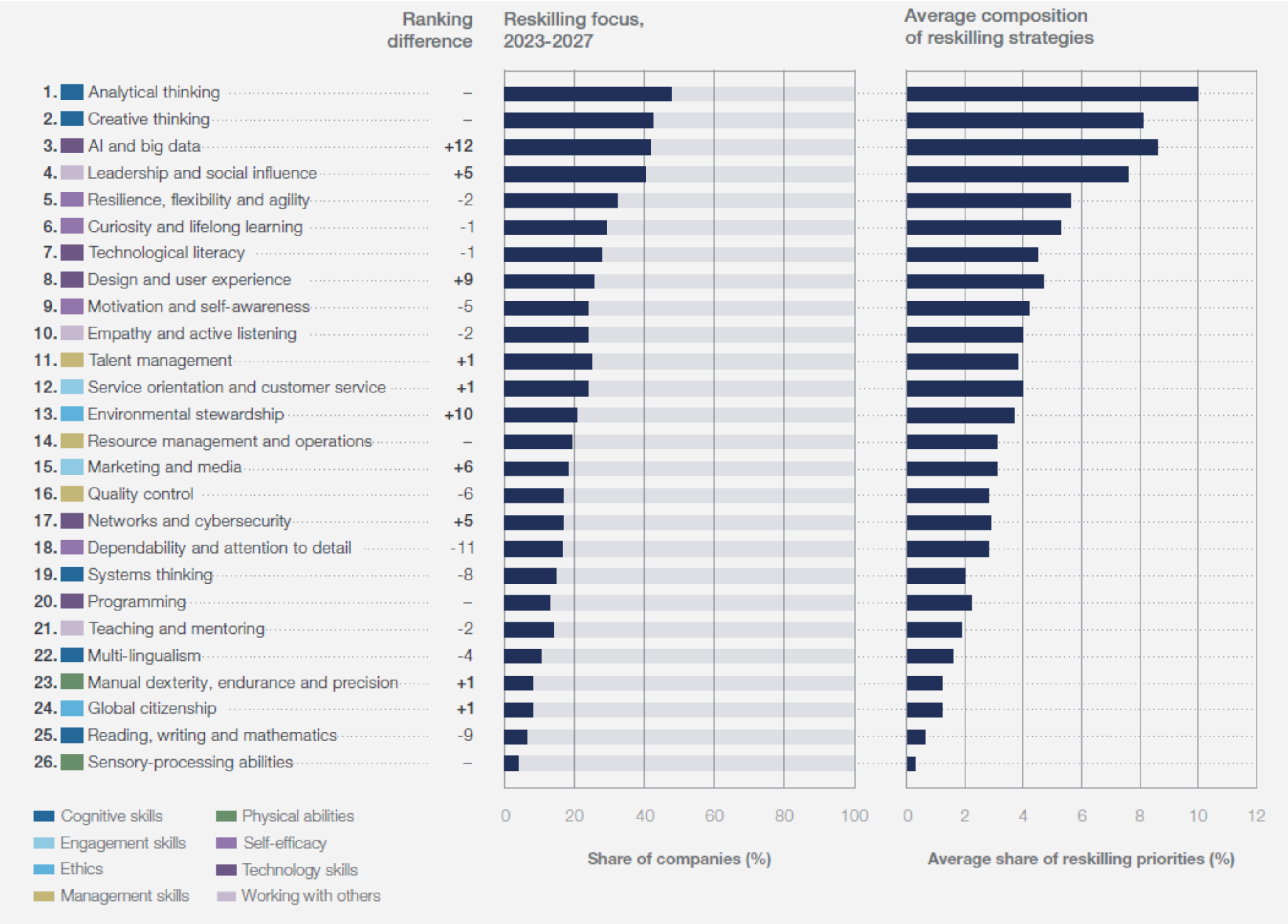


Source
World Economic Forum, Future of Jobs Report 2023.

World Economic Forum, Future of Jobs Survey 2023



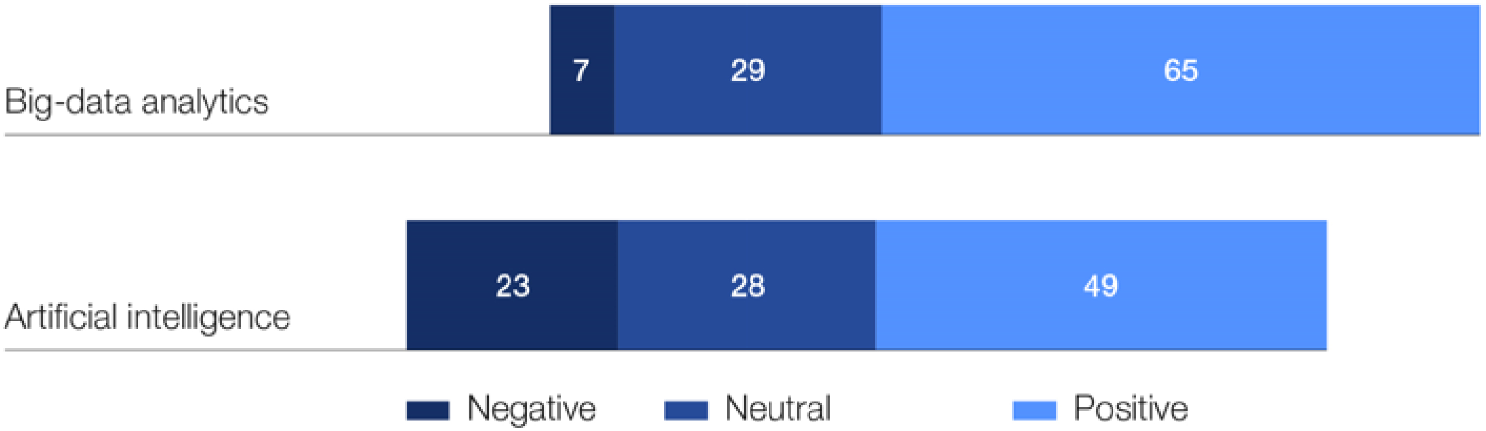
- World Economic Forum, Future of Jobs Survey 2023



Future of Jobs

Businesses expect Big Data and AI to drive job growth

Expected impact of trends on jobs:



Including jobs such as

AI and machine learning specialists,

Data analysts and scientists, and

Big data specialists.

Source: Future of Jobs, World Economic Forum, April 2023.

BE PREPARED FOR A LIFETIME OF CAREERS

VANISHING BOUNDARIES OF SPECIALIZATIONS

REQUIREMENT OF MULTIPLE SKILLS

BE AGILE AND READY TO LEARN NEW SKILLS