SIEMENS

Engineering robots
for the future

Dawn of the industrial robots

1954 First industrial robot patent

1957 Planobot Loading and unloading of hot castings

1961 Unimate Auto industry - transported die castings, tedious, dangerous tasks, high-quality welds in somewhat inhospitable condition

1969 First spot welding robots

1979 Assembly robots - Electronics & semiconductors, miniature assembly, precision, throughput & contaminants protection
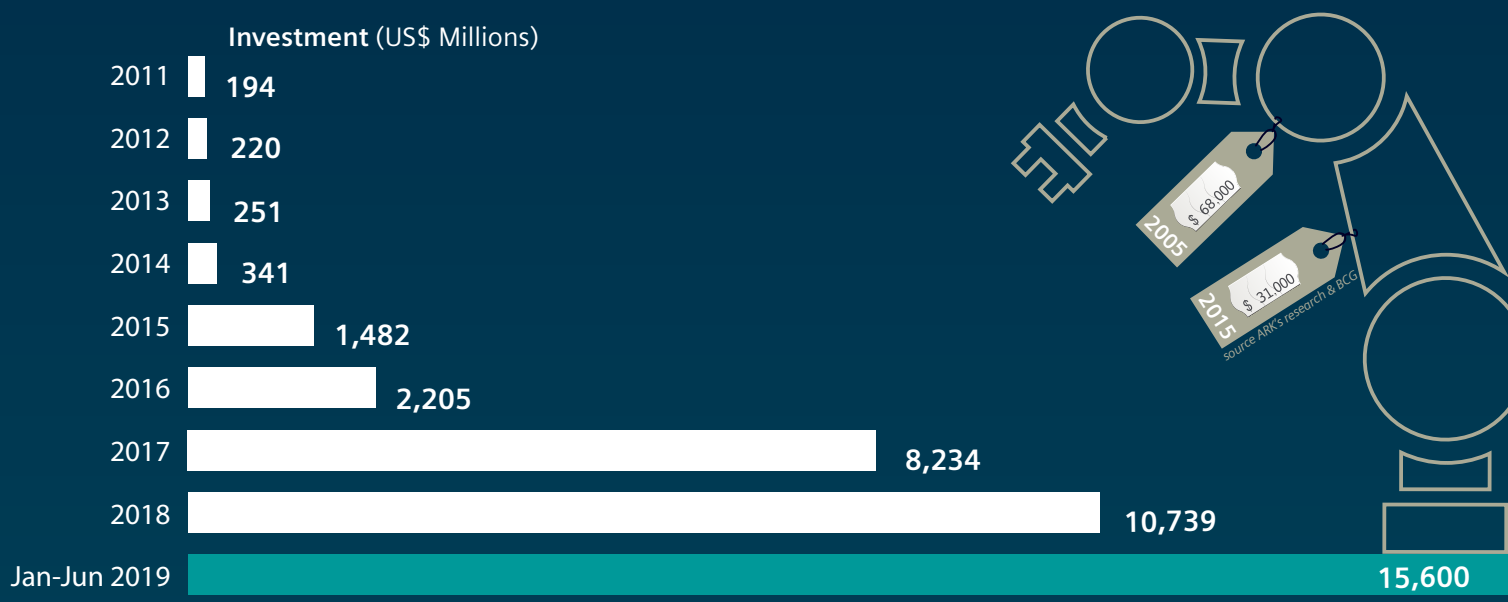
1992 Delta robots Parallel robot for the packaging industry
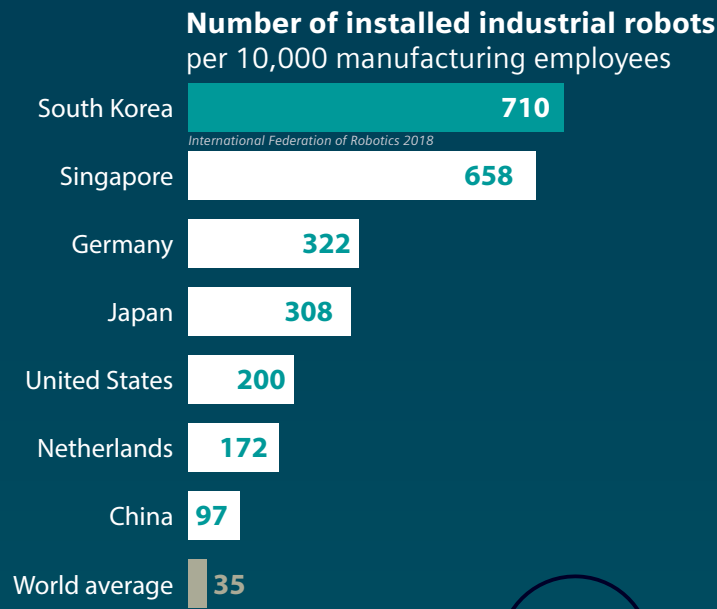
2013 COBOTS Collaborative robots

Fast changing robotic industry

40% growth of the number of robotics-related innovation patents **2005-2015**
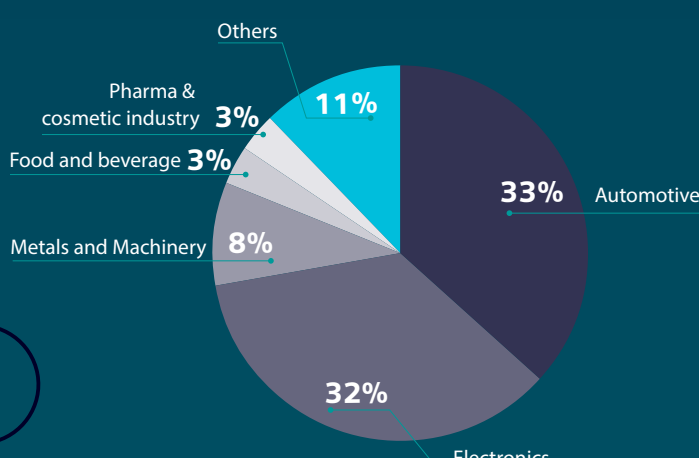
25% CAGR in **last three years**

Investment (US$ Millions)

Year	Investment
2011	194
2012	220
2013	251
2014	341
2015	1,482
2016	2,205
2017	8,234
2018	10,739
Jan-Jun 2019	15,600

Embrace future co-workers: Robots

Number of installed industrial robots
per 10,000 manufacturing employees
International Federation of Robotics 2018

Country	Robots
South Korea	710
Singapore	658
Germany	322
Japan	308
United States	200
Netherlands	172
China	97
World average	35

4 million industrial robots are expected to work in factories worldwide by 2022
World robotics 2018

Industrial composition of robot stock

- Automotive 33%
- Electronics 32%
- Metals and Machinery 8%
- Others 11%
- Pharma & cosmetic industry 3%
- Food and beverage 3%

Resource drain
+500,000 manufacturing jobs were going unfilled

27% percent of the manufacturing workforce 55 or older

+10,000 baby boomers were retiring each day

Industrial robots shipment 2017

- Articulated arms 65%
- Gantry robots 16%
- SCARA robots 13%
- Delta robots 1%

Unlock robotics adoption

Performance - Flexibility to produce small batches of customized products with high degrees of precision and at very high speeds without compromising on safety

ROI < 2 years

Technological innovation Autonomous - Low latency and ultra reliability

Machine learning

Sensors (IIoTs)

Robot manipulators payload range 1/2 KG — 2000 KG

Efficient energy management

5G

Regulations reduce residual risk and increase operational safety

Further adoption of AI
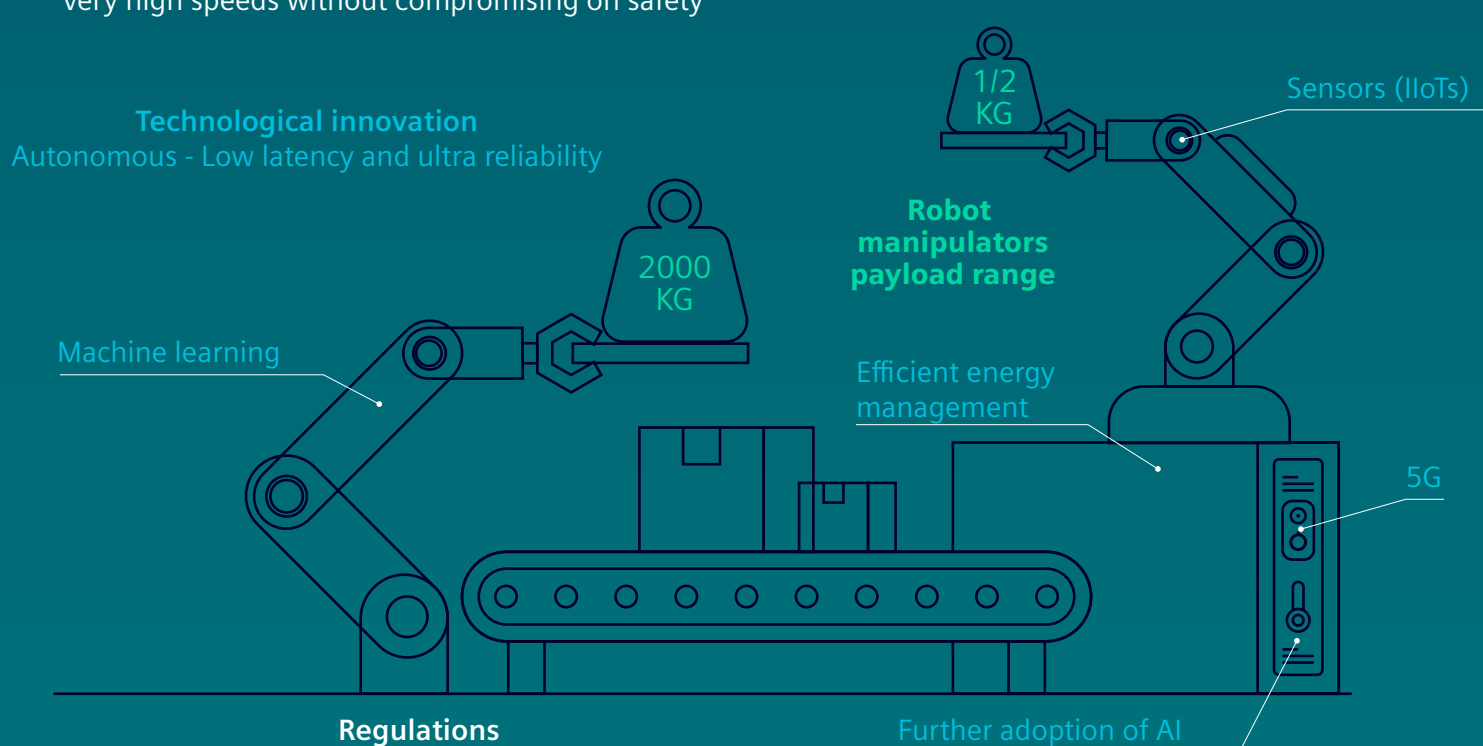
Taking control of the complexity and cost

Kinematics
"With every new project, we start with our skeleton or envelope design and perform feasibility studies."
E2M Technologies

Structural
"With breakthroughs in both structural design and autonomous control systems, we submitted two applications for national patents."
Siemens and Aucma

Dynamics
"Virtually modeled Curiosity's components, assemblies and systems, and simulated their performance under a variety of conditions."
Jet Propulsion Laboratory

Precision
"Identifying different resonance frequencies that occur when the production line accelerates to minimize/prevent vibrations"
Agfa Graphics

Thermal analysis
"Verified accuracy of design values for thermal parameters by directly measuring the resulting thermal resistances and capacitances."
Yaskawa Electric

Durability
"Virtually simulate the behavior of a component or complete structure when subjected to specific loads and constraints."
Mecalac

Security
"Developing and validating the control and software strategies for any situation and environment is key for safety-critical functions and necessitates the use of closed-loop simulation."
Twinswheel

Regulation
"Our machines are subject to very strict security rules as they work in interaction with the public, spectators and operators."
La Machine

Integration
"Comprehensive and detailed system knowledge is essential to faster and better product innovation."
Parker Hannifin

Energy efficiency
"Provide a detailed representation of energy behavior for each component while integrating with the global machine's multiphysics environment."
Picanol

Optimization
"Analyze hundreds of designs to choose the best compromise."
CAE Value

Virtual Commissioning
"The software and hardware need to be developed in sync to achieve required hardware costs and system performance."
Twinswheel