UNIVERSAL ROBOTS

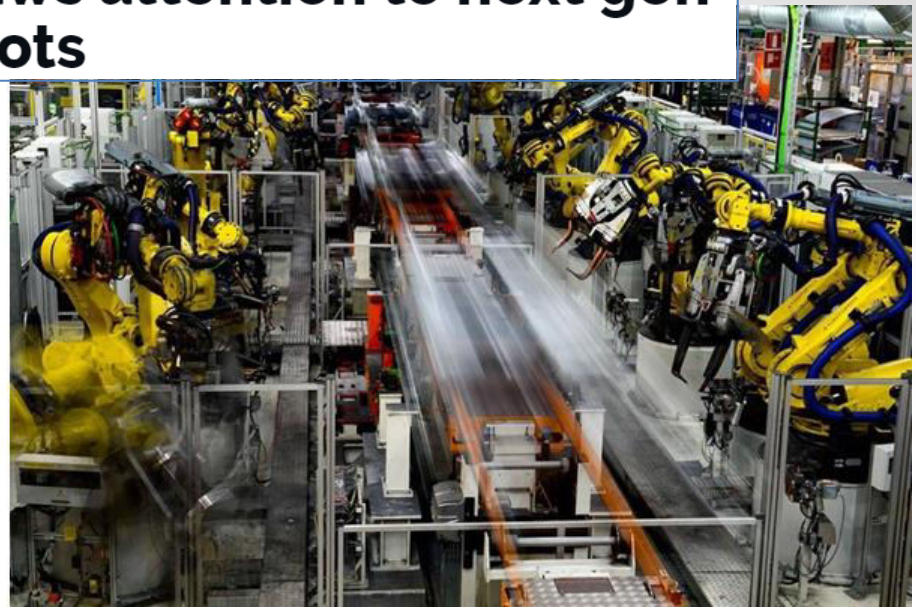
Collaborative Robots

Human/robot collaboration

UNIVERSAL ROBOTS

Prior to Cobots, Industrial Robots operated in Safety Cages at High Speed

Worker death draws attention to next gen collaborative robots



Robot Kills Man at Volkswagen Plant

Volkswagen spokesman Heiko Hillwig stressed that the robot was not one of the new generation of lightweight collaborative robots.

The machine grabbed and crushed the technician

THE TIMES OF INDIA India

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Breaking News: take in Indian Oil Corp on Monday, August 24

Terminator redux? Robot kills a man at Haryana's Manesar factory

Rao Jaswant Singh & Sanjay Yadav,TNN | Aug 13, 2015, 04.39 AM IST

Robot as a Tool

Collaborative robots are advanced tools that are used by the production staff to help them do their tasks better.

History of Industrial Revolutions

End of 18th Century

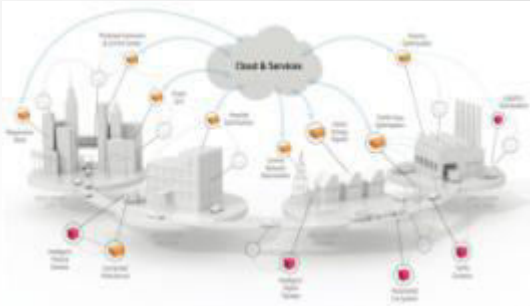
1st Industrial Revolution

End of 19th Century

2nd Industrial Revolution

1970

3rd Industrial Revolution



Today

4th Industrial Revolution

Effects of the Industrial Revolution

Created a gap in Manufacturing:

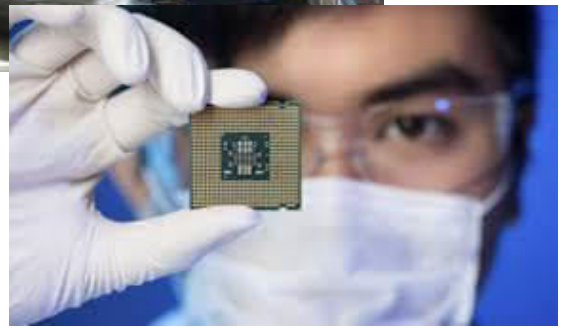
Human aspect is now missing

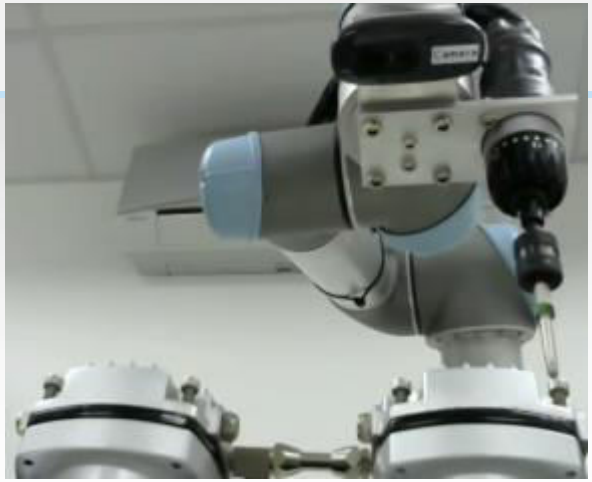
A recent study by MIT found that humans and robots working together in a team can be around 85 per cent more productive than teams made of either humans or robots alone. - Robot revolution: Humans and droids, working together | The Engineer, Nov. 2014

People & Production

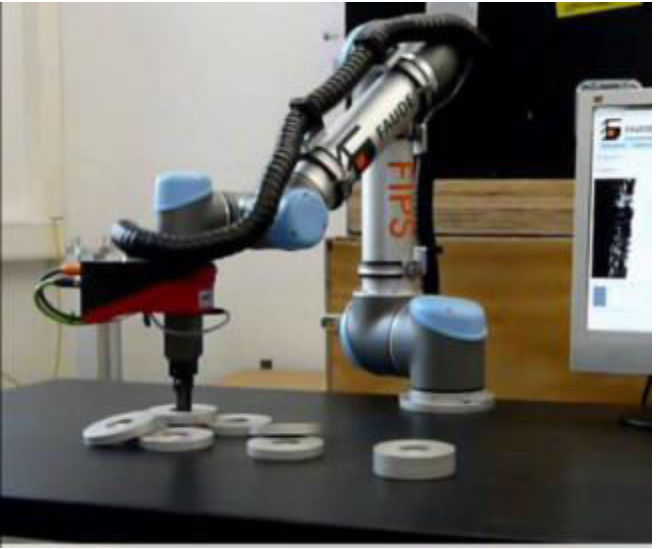
Change in Manufacturing Assembly Lines

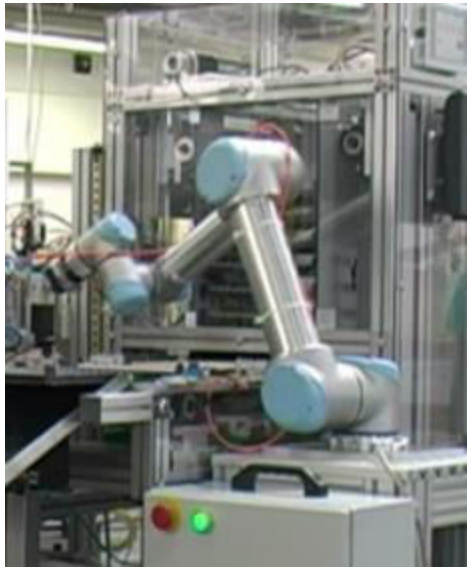
- Power back to the worker
- Transition from clear Blue-collar to a mix of Blue/White-collar production
- Humans back into production in collaboration with robots
- Humans do what humans do best, machines do what machines do best
- Build Love/Passion into the products on the factory floor






OKUMA
Machine tending application





UR5 used in neurosurgery

British celeb Chef Tim Anderson's actions being replicated by a cobot

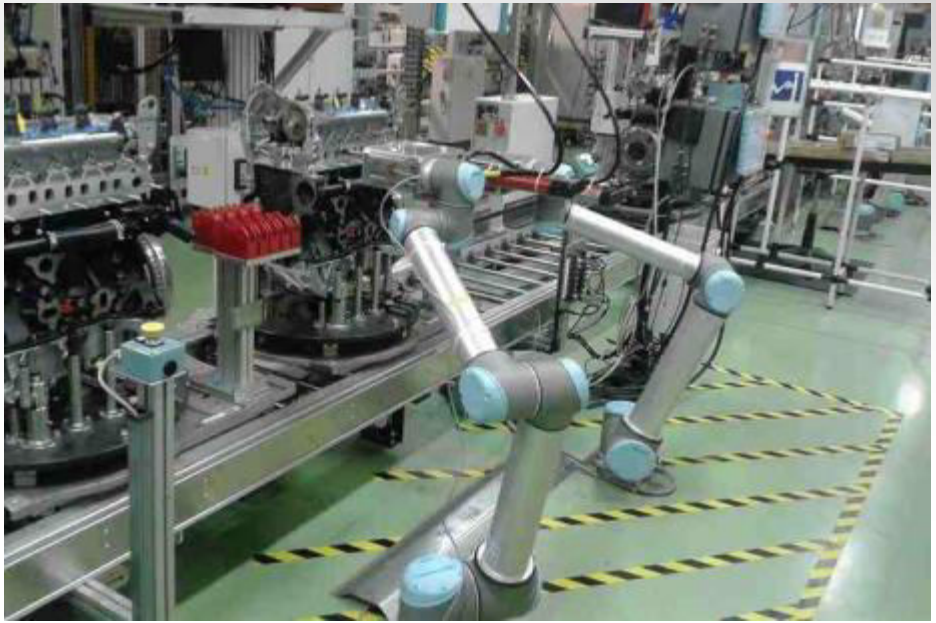
Electronic Assembly like cellphones & laptops

Bar Tending – Mr. Mofongo in Holland

Rehabilitation Robotics

Bee tending

Microscan Machine Vision Cameras for Inline Robotic Inspection Systems



At a Renault car plant, cobots drive screws into engines—a sign of their progress in handling small parts

Safety Standards for Applications of Industrial Robots
Related Standards & Directives

IEC 61508 is the international standard for electrical, electronic and programmable electronic safety related systems. It sets out the requirements for ensuring that systems are designed, implemented, operated and maintained to provide the required safety integrity level (SIL). Four SILs are defined according to the risks involved in the system application, with SIL4 being used to protect against the highest risks. The

Performance Level (PL)	Average Probability of Dangerous Failures per Hour
a	$\geq 10^{-5}$ to $<10^{-4}$
b	≥3 · 10-6 to <10-5
c	$\geq 10^{-6}$ to $<3 \cdot 10^{-6}$
d	$\geq 10^{-7}$ to $<10^{-6}$
e	$\geq 10^{-8}$ to $<10^{-7}$

Table 1 - ISO 13849 performance levels

Table 1: Standard Levels

LEVEL A
- IEC 61508 – Functional Safety
- ISO 12100 – Risk Assessment

LEVEL B
- EN ISO 13849 – 1 :2008 or IEC 62061 :2005

LEVEL C
- ISO 11161 – Integrated Manufacturing Systems
- ISO 10218-2 – Robot System/Cell
- ISO 10218-1 – Industrial Robots
- * ISO/TS 15066 – Collaborative Operation

ISO 10218-1: Written for large ”cast iron” robots. Can be used for collaborative robots, but in many cases seems like overkill

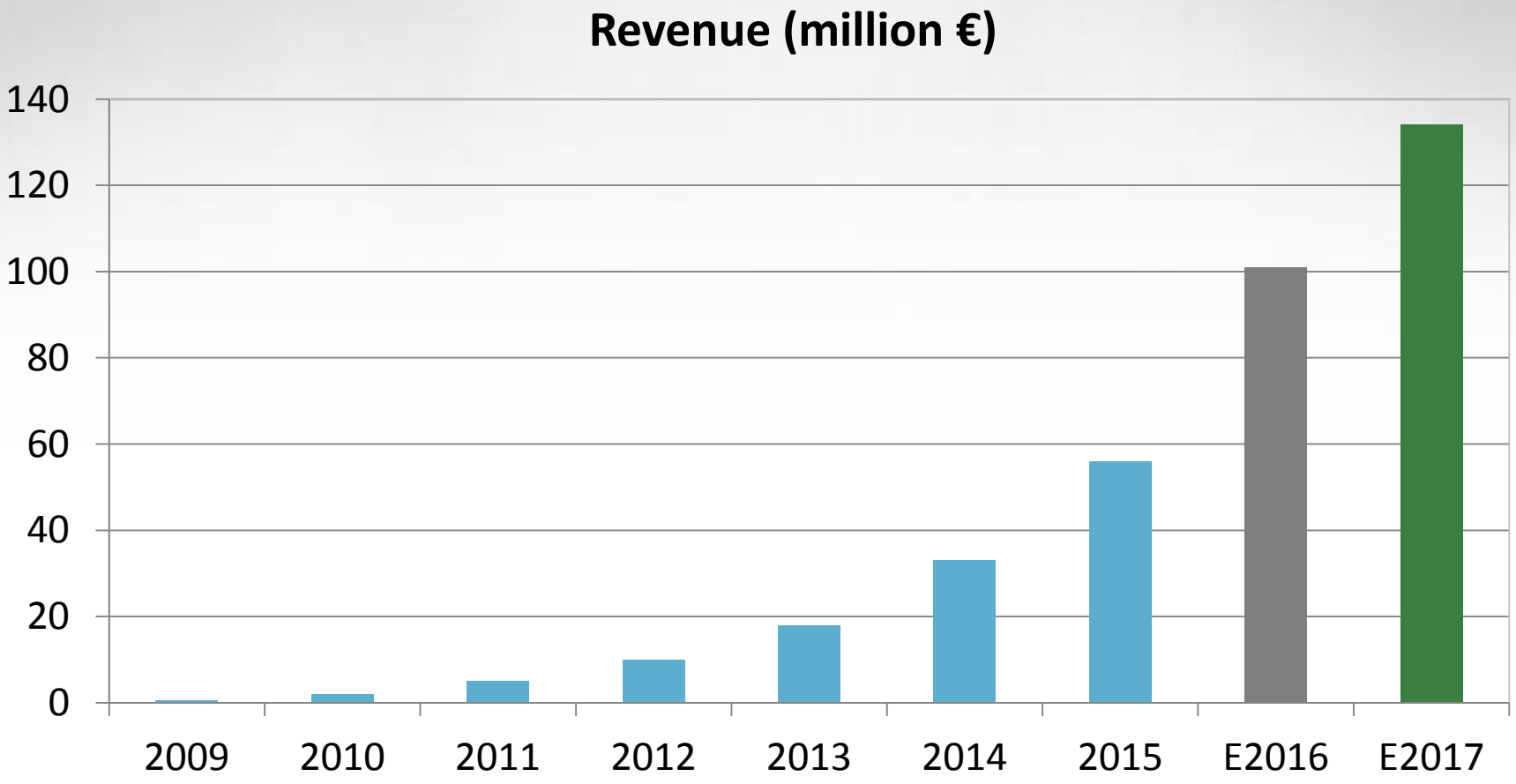
Hot off the press – TS 15066 released on Feb. 15, 2016

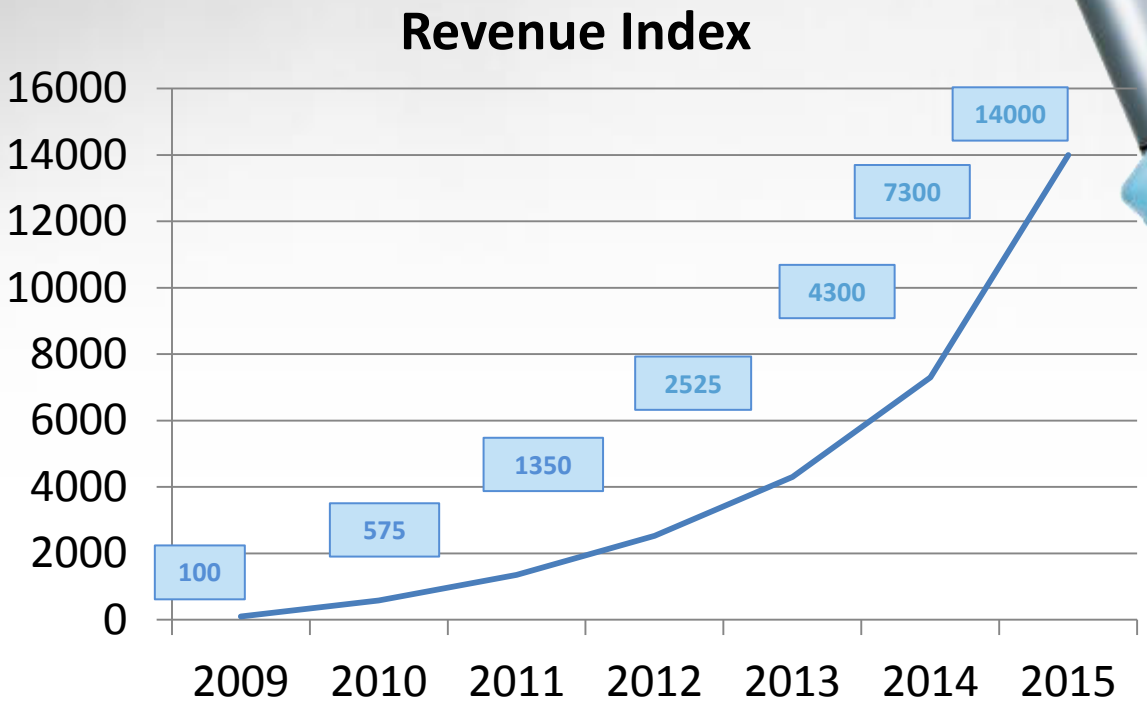
Robot Safety (now)

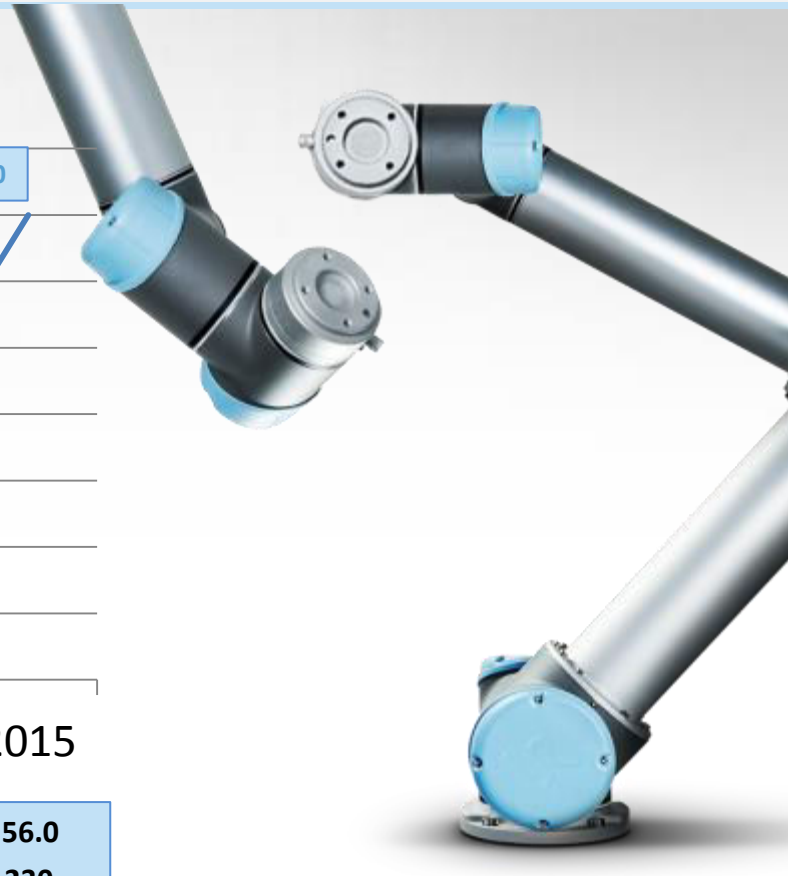
Locomotive Act, Red Flag Act, England, 1861

Global Distribution Network

- UR Headquarters
- Universal Robots subdivisions
- Universal Robots distribution


Revenue (million €)
140
120
100
80
60
40
20
0
2009
2010
2011
2012
2013
2014
2015
E2016
E2017





Revenue MEUR	**0.4**	**2.3**	**5.4**	**10.1**	**17.2**	**29.2**	**56.0**
Employees	**5**	**10**	**23**	**50**	**93**	**130**	**230**

Universal Robots India Pvt. Ltd.

- Four years of passive presence; official launch event on Feb 18, 2016

The Danish Ambassador to India, H.E. Peter Taksøe-Jensen (Right) programs our collaborative robot with founder and CTO of Universal Robots, Esben Østergaard (Left) during the launch event in India

Founder and CTO of Universal Robots, Esben Østergaard (Right) along with General Manager India, Pradeep David (Left) during the launch

Universal Robots' take on safety

- 15 Advanced & Adjustable Safety Functions (ISO 13849-1, PLd), limiting (some patented): Force, Speed, Power, Momentum, Position, Tool Orientation
- Monitored in TCP and Joint space
- Connectors for external safety equipment
- Lightweight Robot with no Sharp Edges
- Low "Frequency of Exposure", Risk assessment (ISO 12100)
- Main robot-related Hazards:
  - Clamping/Quasi-static impact: Force limiting
  - Impact/Dynamic impact: Speed, Power & Momentum limiting

About the Company

200+ Employees
17 Nationalities
Over 300 Distributors
17 International Awards
Over 7000 cobots sold

50 Smartest Companies 2015

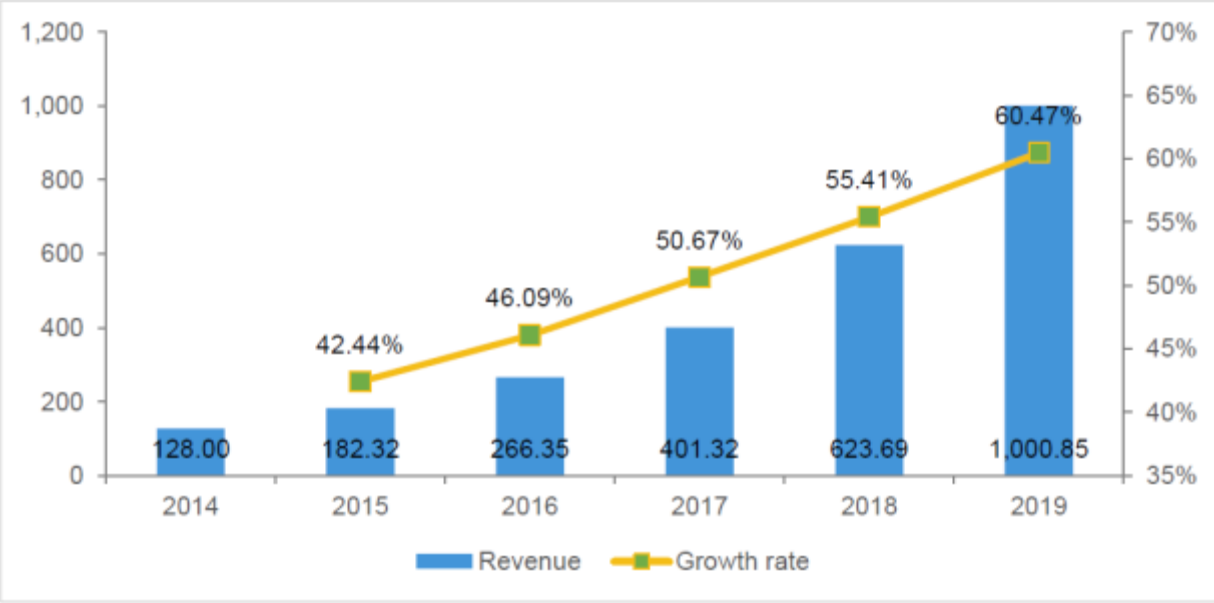
MIT Technology Review

1 Tesla Motors	2 Xiaomi	3 Illumina	4 Alibaba	5 Counsyl	6 SunEdison	7 Tencent	8 Juno Therapeutics	9 SolarCity	10 Netflix
11 OvaScience	12 Google	13 Amazon	14 AliveCor	15 Gilead Sciences	16 Apple	17 Voxel8	18 IDE Technologies	19 Amgen	20 Aquion Energy
21 Baidu	22 SpaceX	23 Sakti3	24 Freescale Semiconductor	25 Universal Robots	26 Bristol-Myers Squibb	27 Teladoc	28 Nvidia	29 Facebook	30 Alnylam
31 Rethink Robotics	32 Philips	33 Cellectis	34 Bluebird Bio	35 ThyssenKrupp	36 Slack	37 Line	38 Improbable	39 Enlitic	40 Coinbase
41 HaCon	42 3D Systems	43 Generali	44 Intrexon	45 DNAnexus	46 IBM	47 Snapchat	48 Microsoft	49 Imprint Energy	50 Uber

Market size and forecast

The global collaborative robots market was valued at $128 million in 2014 and will likely reach $1 billion by 2019, growing at a CAGR of 50.88%.

Exhibit 05: Global collaborative robots market 2014-2019 ($ millions)



Source: Technavio, 2015

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UR3 Technical Specifications

Item no. 110103

6-axis robot arm with a working radius of 500 mm / 19.7 in

Weight:	11 kg / 24.3 lbs
Payload:	3 kg / 6.6 lbs
Reach:	500 mm / 19.7 in
Joint ranges:	+/- 360° Infinite rotation on end joint
Speed:	All wrist joints: 360 degrees/sec. Other joints: 180 degrees/sec. Tool: Typical 1 m/s. / 39.4 in/s.
Repeatability:	+/- 0.1 mm / +/- 0.0039 in (4 mils)
Footprint:	Ø118 mm / 4.6 in
Degrees of freedom:	6 rotating joints
Control box size (WxHxD):	475 mm x 423 mm x 268 mm / 18.7 x 16.7 x 10.6 in
I/O ports:	Digital in: Controlbox 16, Tool conn. 2 Digital out: Controlbox 16, Tool conn. 2 Analog in: Controlbox 2, Tool conn. 2 Analog out: Controlbox 2, Tool conn. -
I/O power supply:	24 V 2A in control box and 12 V/24 V 600 mA in tool
Communication:	TCP/IP 100 Mbit: IEEE 802.3u, 100BASE-TX Ethernet socket & Modbus TCP
Programming:	Polyscope graphical user interface on 12 inch touchscreen with mounting
Noise:	Comparatively noiseless
IP classification:	IP64
Power consumption:	Approx. 100 watts using a typical program
Collaboration operation:	15 advanced adjustable safety functions
Materials:	Aluminum, PP plastic
Temperature:	The robot can work in a temperature range of 0-50°C*
Power supply:	100-240 VAC, 50-60 Hz
Cabling:	Cable between robot and control box (6 m / 236 in) Cable between touch screen and control box (4.5 m / 177 in)

*) At high continuous joint speed, ambient temperature is reduced.

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Denmark
+45 89 93 89 89

www.universal-robots.com
sales@universal-robots.com

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UR5 Technical specifications

Item no. 110105

6-axis robot arm with a working radius of 850 mm / 33.5 in

Weight:	18.4 kg / 40.6 lbs
Payload:	5 kg / 11 lbs
Reach:	850 mm / 33.5 in
Joint ranges:	+/- 360°
Speed:	All joints: 180°/s. Tool: Typical 1 m/s. / 39.4 in/s.
Repeatability:	+/- 0.1 mm / +/- 0.0039 in (4 mils)
Footprint:	Ø149 mm / 5.9 in
Degrees of freedom:	6 rotating joints
Control box size (WxHxD):	475 mm x 423 mm x 268 mm / 18.7 x 16.7 x 10.6 in
I/O ports:	Controlbox / Tool conn. Digital in 16 / 2 Digital out 16 / 2 Analog in 2 / 2 Analog out 2 / -
I/O power supply:	24 V 2A in control box and 12 V/24 V 600 mA in tool
Communication:	TCP/IP 100 Mbit: IEEE 802.3u, 100BASE-TX Ethernet socket & Modbus TCP
Programming:	Polyscope graphical user interface on 12 inch touchscreen with mounting
Noise:	Comparatively noiseless
IP classification:	IP54
Power consumption:	Approx. 200 watts using a typical program
Collaboration operation:	15 Advanced Safety Functions Tested in accordance with: EN ISO 13849:2008 PL d EN ISO 10218-1:2011, Clause 5.4.3
Materials:	Aluminum, PP plastic
Temperature:	The robot can work in a temperature range of 0-50°C
Power supply:	100-240 VAC, 50-60 Hz
Cabling:	Cable between robot and control box (6 m / 236 in) Cable between touchscreen and control box (4.5 m / 177 in)

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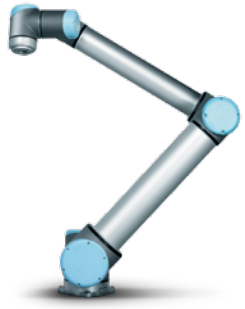
UR10 Technical specifications

Item no. 110110

6-axis robot arm with a working radius of 1300 mm / 51.2 in

Weight:	28.9 kg / 63.7 lbs
Payload:	10 kg / 22 lbs
Reach:	1300 mm / 51.2 in
Joint ranges:	+/- 360°
Speed:	Base and Shoulder: 120°/s. Elbow, Wrist 1, Wrist 2, Wrist 3: 180°/s. Tool: Typical 1 m/s. / 39.4 in/s.
Repeatability:	+/- 0.1 mm / +/- 0.0039 in (4 mils)
Footprint:	Ø190 mm / 7.5 in
Degrees of freedom:	6 rotating joints
Control box size (WxHxD):	475 mm x 423 mm x 268 mm / 18.7 x 16.7 x 10.6 in
I/O ports:	Controlbox / Tool conn. Digital in: 16 / 2 Digital out: 16 / 2 Analog in: 2 / 2 Analog out: 2 / -
I/O power supply:	24 V 2A in control box and 12 V/24 V 600 mA in tool
Communication:	TCP/IP 100 Mbit: IEEE 802.3u, 100BASE-TX Ethernet socket & Modbus TCP
Programming:	Polyscope graphical user interface on 12 inch touchscreen with mounting
Noise:	Comparatively noiseless
IP classification:	IP54
Power consumption:	Approx. 350 watts using a typical program
Collaboration operation:	15 Advanced Safety Functions Tested in accordance with: EN ISO 13849:2008 PL d EN ISO 10218-1:2011, Clause 5.4.3
Materials:	Aluminum, PP plastic
Temperature:	The robot can work in a temperature range of 0-50°C
Power supply:	100-240 VAC, 50-60 Hz
Cabling:	Cable between robot and control box (6 m / 236 in) Cable between touchscreen and control box (4.5 m / 177 in)



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UNIVERSAL ROBOTS
Robotics as it should be
Simple • Flexible • Affordable

TECHNICAL SPECIFICATIONS: www.universal-robots.com/products

195 DAYS | AVERAGE PAYBACK PERIOD

Robotics Is Finally Within Your Reach

Universal Robots offers significant productivity and safety advantages, even for small operations. You get the fastest return in the industry for your automation investment.

Easy Programming
Patented technology lets operators with no programming experience quickly set up and operate our robots with intuitive, 3D visualization. Simply move the robot arm to desired waypoints or touch the arrow keys on the easy-to-use touchscreen tablet.

Fastest Payback in the Industry
Universal Robots gives you all the advantages of advanced robotic automation, with none of the traditional added costs associated with robot programming, set-up, and dedicated, shielded work cells. Finally, robotic automation is affordable for small and medium sized enterprises.

Collaborative & Safe
Now you can replace human operators in dirty, dangerous, and dull jobs to reduce repetitive strain and accidental injuries. Eighty percent of the thousands of UR robots worldwide operate with no safety guarding (after risk assessment), right beside human operators. The safety system of our robots is approved and certified by TÜV (The German Technical Inspection Association).

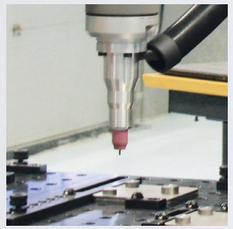
Fast Set-Up
Universal Robots has revolutionized robot set-up, reducing typical robotic deployment measured in weeks to a matter of hours. The average set-up time reported by our customers is only half a day. The out-of-box experience for an untrained operator to unpack the robot, mount it, and program the first simple task is typically less than an hour.

Flexible Re-Deployment
Don't be limited by dedicated robotics. Universal Robots are lightweight, space-saving, and easy to re-deploy to multiple applications without changing your production layout. Moving the robot to new processes is fast and easy, giving you the agility to automate almost any manual task, including those with small batches or fast change-overs. The robot is able to re-use programs for recurrent tasks.

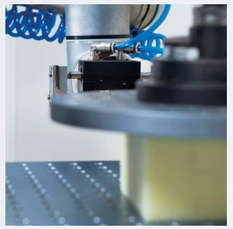
What Can You Automate?

If you've always thought robotic automation was beyond your reach, it's time to look again. Our collaborative robots fit into any size production environment. Get a competitive edge by using our flexible, user-friendly robots for small-batch, mixed-product assembly and materials handling. With an average payback period of only 195 days, what could you automate?

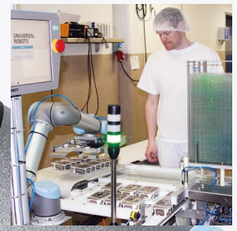
Welding



Materials Testing



Packaging & Palletizing

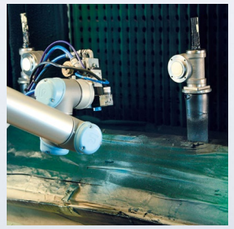


Machine Tending

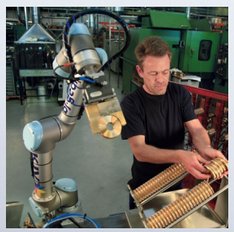
Assembly

Food Handling

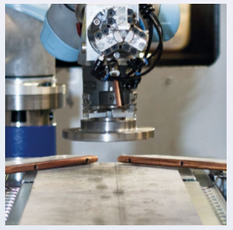
Painting



Pick & Place



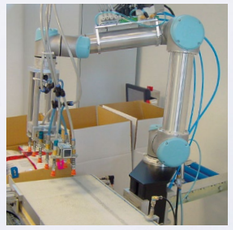
Polishing



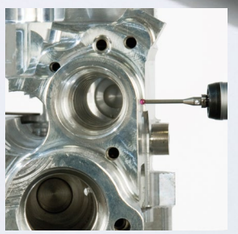
Gluing

Photo: BMW Group

Medical Processing



Quality Inspection



6-axis robot arm	UR5	UR10
Weight	18.4 kg / 40.6 lbs	28.9 kg/63.7 lbs
Payload	5 kg / 11 lbs	10 kg / 22 lbs
Reach	850 mm / 33.5 in	1300 mm / 51.2 in
Footprint	149 mm / 5.9 in	190 mm / 7.5 in

Meet Your New Robot Colleague

Force Control for Adaptive Safety

If the robots come into contact with a person, our patented technology limits the forces at contact. The robots can also be programmed to operate in reduced mode when a human enters the robot's work area and resume full speed when the person leaves.

"Before, you had to put your hands close to the brake press. There's always a risk of an accident happening. But with the Universal Robots, there is no chance of anyone getting injured."

Richard Clive, machine operator at Canadian shelving system manufacturer Etalex, says the UR10 has made the workplace "100% safer".

Precision Handling for Complex Applications

UR robot arms are quick and dexterous, operating at 1 m/s. (39.4 in/sec) with the ability to move each of the six joints 180° per second. The UR robot's repeatability is +/- 0.1 mm (.004 in) for quick-precision handling. True Absolute Encoders acquire absolute position immediately upon power-up, enabling automatic startup and easier integration into other machinery.

"We opted for the UR5 robot due to its unique features including the robot's ability to stay in the same position even when it is switched off. This is particularly important when using robots for testing the trajectory of hand movements in interventions requiring precision, accuracy, and safety."

Grzegorz Karpiel Ph.D. at AGH University of Science and Technology in Poland where the UR5 introduces stem cells into the body much more precisely than possible with the human hand.

Portability for Agile Production

Taking a robot out of its safety cage allows unmatched automation flexibility. Our lightweight robot arms are easily picked up and redeployed for other production tasks.

"Safety, mobility, and flexibility are crucial for us. We don't need to fence it in like a normal robot. And we can easily move it to different jobs, without the need for a programmer spending three days coding, plus three mechanics and a crane to move the robot."

Bo Detlefsen, factory manager at Danish glass manufacturer Gern Glas.

Dependability for Optimized Production

Minimum rated life for UR robots is 35,000 hours running with full payload and maximum speed. Replacing a joint can be done in less than one hour. Robot arms can withstand significant environmental impact and changes in temperature.

"Our facility operates 24/6. Finding the right skilled labor is becoming more and more challenging in Singapore and the cost of labor has also been steadily rising. We have to automate repetitive tasks in order to keep costs low."

William Kuek, operations manager with Sky Engineering in Singapore that now has the luxury of having one man tending two CNC machines at a time after deploying a UR robot.

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