robolab

Robotika, naša prihodnost

prof. Marko Munih

MEDNARODNA KONFERENCA

»VARNOST IN ZDRAVJE PRI DELU V SPREMINJAJOČEM SE SVETU DELA«

Zdravo delovno okolje

Petek, 16. junij 2017

Kongresni center Brdo

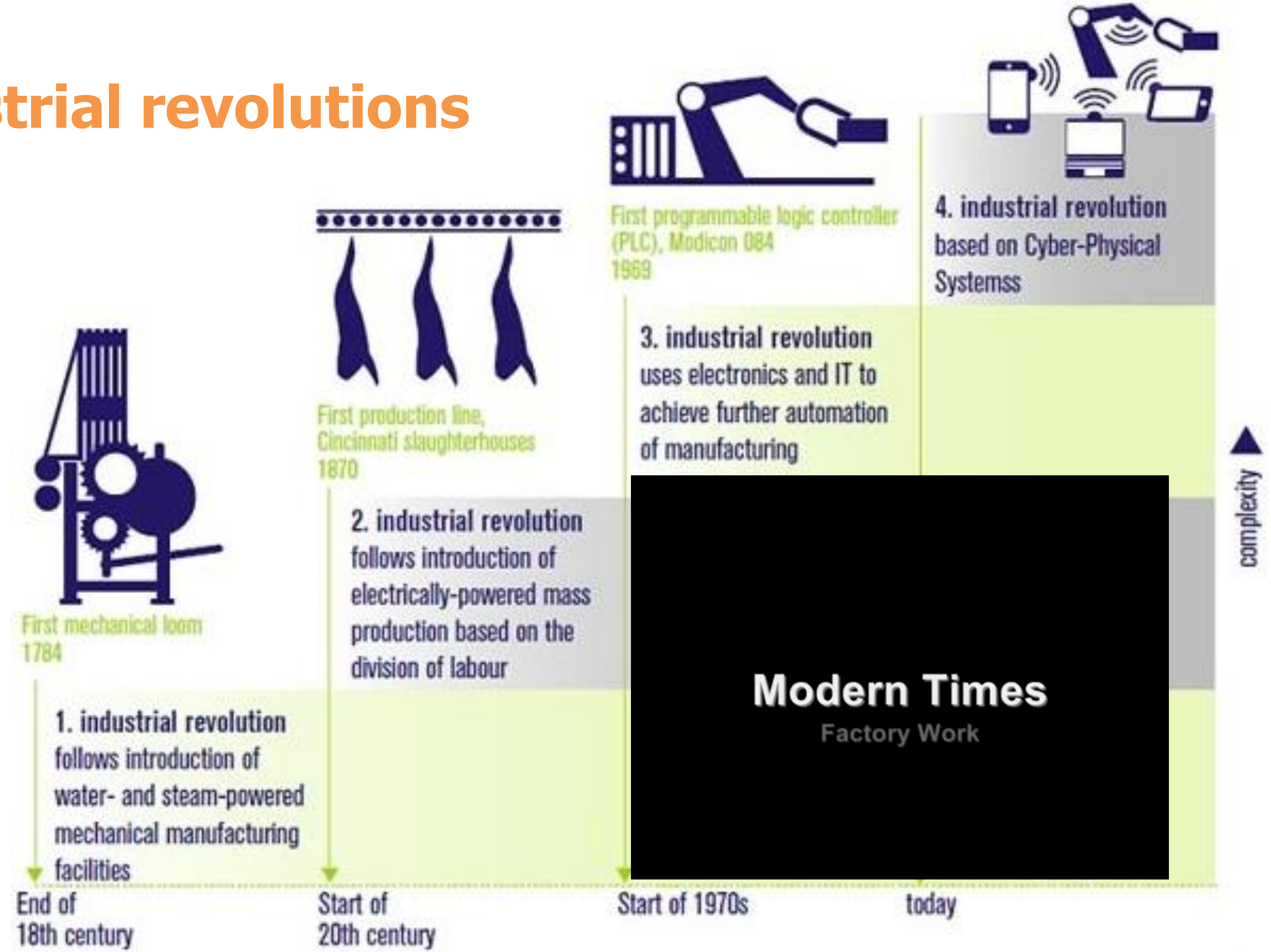
Dvorana Grandis

REPUBLIKA SLOVENIJA
MINISTRSTVO ZA DELO, DRUŽINO, SOCIALNE ZADEVE IN ENAKE MOŽNOSTI

University *of Ljubljana*
Faculty *of Electrical Engineering*

2017

Industrial revolutions



Electrical engineering steps

1860 Maxwell

1906 Vacuum tube

1925 FET tranzistor

1939 p-n junction

1959 Integrated circuit

1965 ARPAnet

1971 Microprocessors

1973 Mobile phone

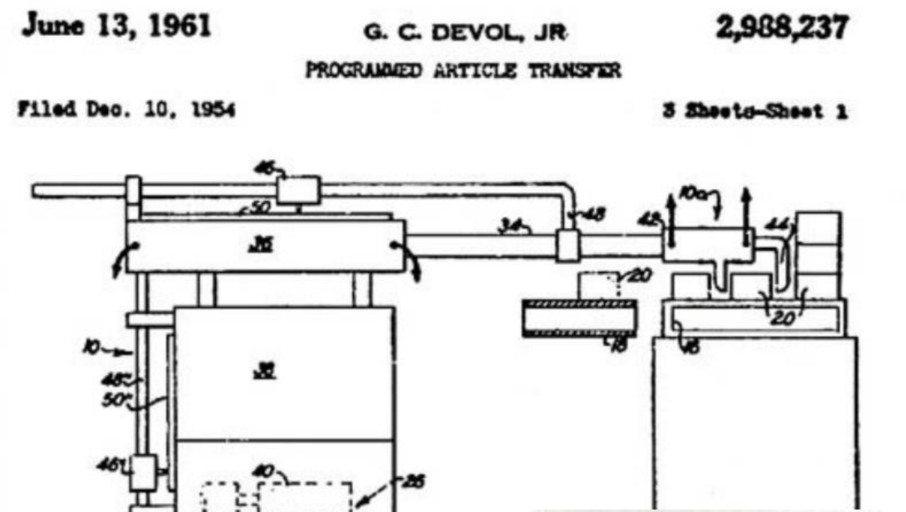
1991 www

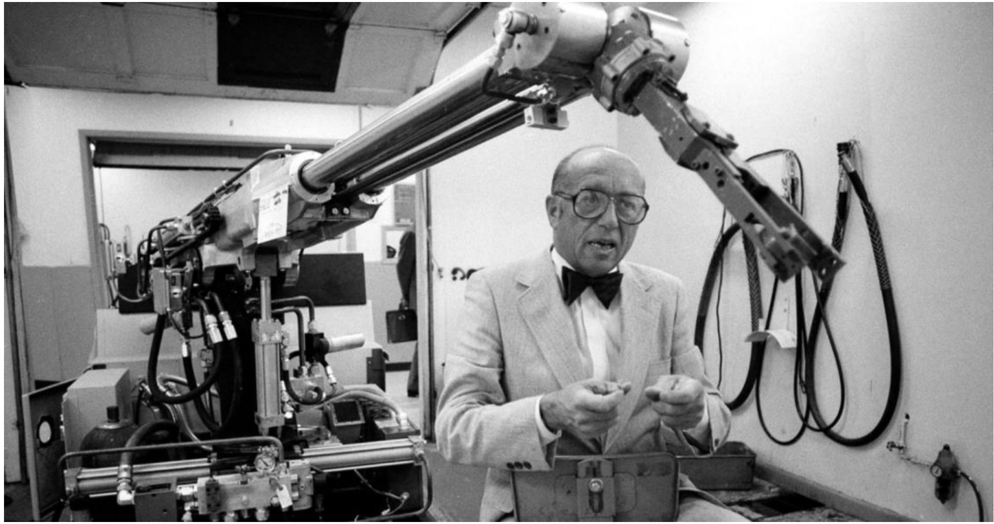
1999 Internet of things, IOT

1958

Robot invention

- George Devol (applied 1954), Joseph Engelberger, Unimate (1956)





Robot timeline

- 1920 Karel Čapek, “robot”
- 1961 George Devol, robot-patent
- 1974 ASEA, IRB6, Magnusson, First electric robot
- 1984 robot boom
- 1995+ haptic robot
- 2008+ UR5-Universal robots,
  Baxter-Rodney Brooks

2017

Robot numbers

Operational stock

Country	2015*	2018*
America	**272,000**	**343,000**
Brazil	10,300	18,300
North America (Canada, Mexico, USA)	259,200	323,000
Other America	2,500	1,700
Asia/Australia	**914,000**	**1,417,000**
China	262,900	614,200
India	14,300	27,100
Japan	297,200	291,800
Republic of Korea	201,200	279,000
Taiwan	50,500	67,000
Thailand	27,900	41,600
other Asia/Australia	60,000	96,300
Europe	**433,000**	**519,000**
Czech Rep.	11,000	18,200
France	32,300	33,700
Germany	183,700	216,800
Italy	61,200	67,000
Spain	28,700	29,500
United Kingdom	18,200	23,800
other Europe	97,900	130,000
Africa	**4,500**	**6,500**
not specified by countries**	40,500	41,500
Total	**1,664,000**	**2,327,000**

Sources: IFR, national robot associations.

New instalations

Country	2016*	2019*
America	**40,200**	**50,700**
Brazil	1,800	3,500
North America	38,000	46,000
Rest of South America	400	1,200
Asia/Australia	**190,200**	**285,700**
China	90,000	160,000
India	2,600	6,000
Japan	38,000	43,000
Republic of Korea	40,000	46,000
Taiwan	9,000	13,000
Thailand	3,000	4,500
other Asia/Australia	7,600	13,200
Europe	**54,200**	**68,800**
Central/Eastern Europe	7,550	11,300
France	3,300	4,500
Germany	21,000	25,000
Italy	7,200	9,000
Spain	4,100	5,100
United Kingdom	1,800	2,500
other Europe	9,250	11,400
Africa	**400**	**800**
not specified by countries**	5,000	8,000
Total	**290,000**	**414,000**

Sources: IFR, national robot associations.

Slovenia

Operational cca 2.000

NM Company	Number
REVOZ d.d.	474
TPV d.o.o.	90
KRKA, d.d.	62
Siliko d.o.o.	20
Other	71
Total	717

Population:

Japan	120 M
Korea	80 M
Europe	750 M
USA	324 M

Robot numbers

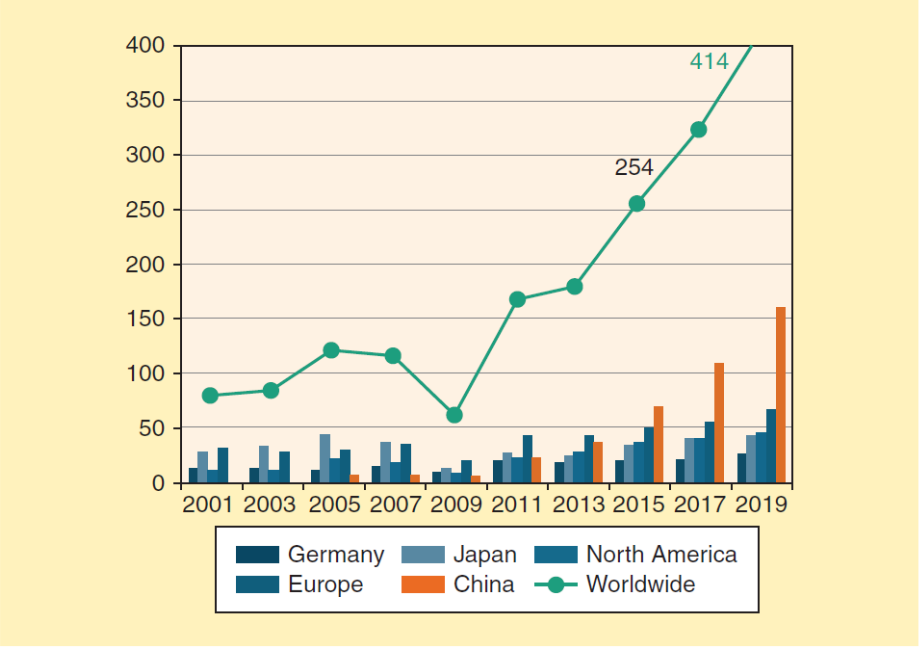


Figure 1. The industrial robot shipments worldwide in thousands of units (2016+ estimated).

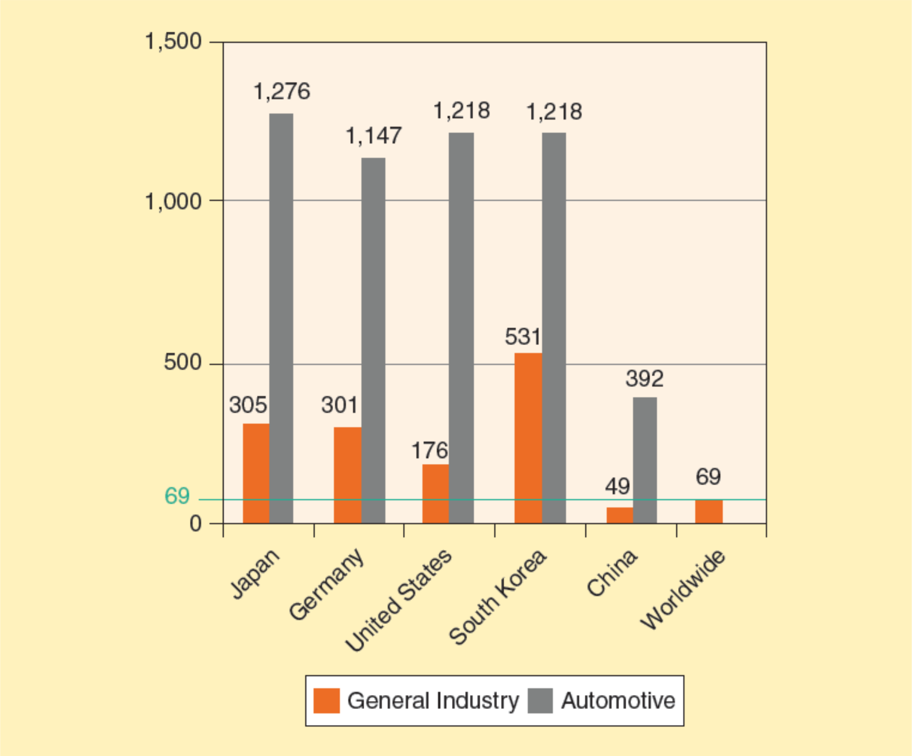
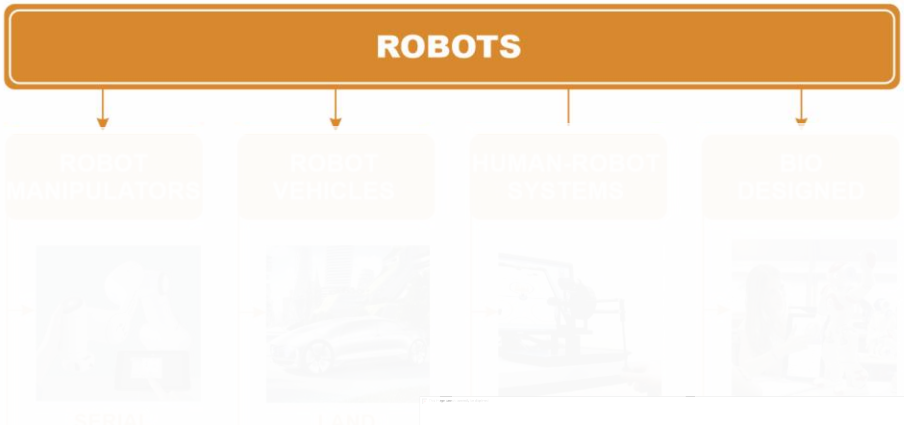


Figure 2. The industrial robot density worldwide in selected regions (in 2015).

Slovenia:
Automotive: 636, General 110

Source: www.ifr.org


ROBOTS
ROBOT MANIPULATORS
ROBOT VEHICLES
HUMAN-ROBOT SYSTEMS
BIO DESIGNED

2004 Grand Challenge (240 km),
2005 Grand Challenge,
2007 Urban Challenge (George Air Force Base)

Mercedes S (2014)
Vrhnika – Ljubljana autonomous drive

Berta test,
100 km without driver, Mannheim to Pforzheim
Cars will communicate with other cars, trafic infrastructure and smart phones of others in trafic.

Apple, Audi, BMW, Ford, General Motors, Google, Honda, Mercedes, Nissan, Nvidia, Tesla, Toyota, Volkswagen, Volvo

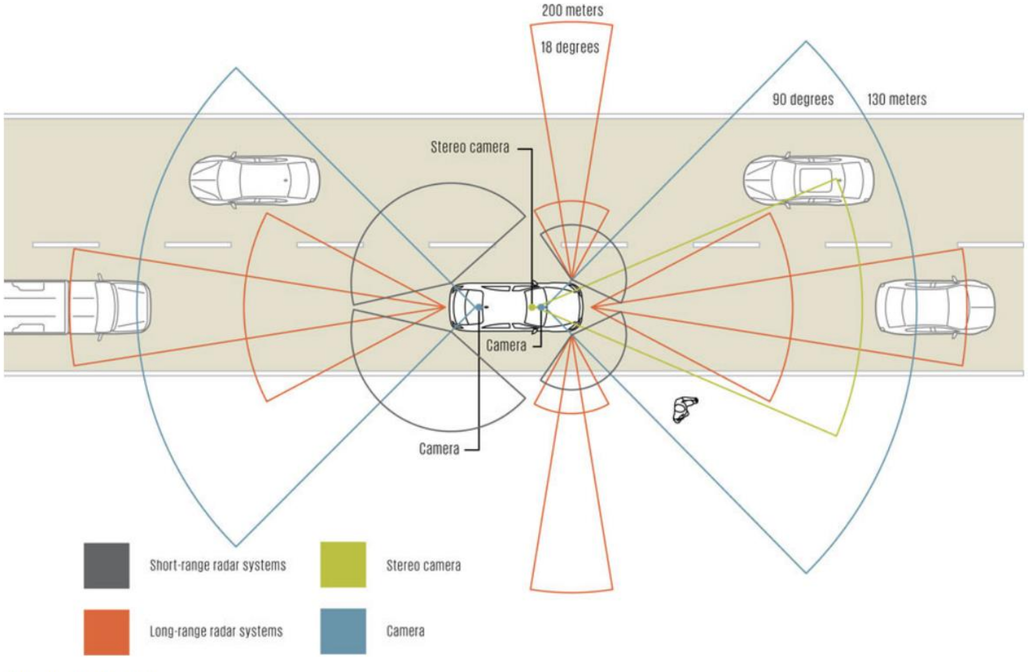


Illustration: John MacNeill

Sensors of different capabilities cover 360 degrees, with overlapping fields of view.

2. From Legged Robots to Walking Excavators - *active balancing of an all-terrain chassis*

"Revolutionizing actuation and control for hydraulic legged chassis"

… by intelligent, force controlled valves and optimal contact force distribution

- **Simplified operation** due to active adaptation
- **Increased stability** and guaranteed safety
- **Lower peak loads** at contacts and structure
- **Simple maintenance** thanks to modular setup

Marco Hutter, ETH Zurich

Stefan Tagmann, Menzi Muck AG

Gonzalo Rey, Moog inc.

1. Robirds

from an idea to an animal-friendly revolution in bird control

ir. Geert Folkertsma

ir. Wessel Straatman

Nico Nijenhuis, BSc

prof. dr. ir. Stefano Stramigioli

european Robotics Forum 2016

CLEAR FLIGHT SOLUTIONS

UNIVERSITY OF TWENTE.

RAM ROBOTICS AND MECHATRONICS

Robotics projects resulting from H2020 – LEIT ICT 23 Call 1

Project Summaries

January 2015

- AEROARMS
- AEROWORKS
- Centauro
- CogIMon
- COMANOID
- EurEyeCase
- FLOBOT
- Flourish
- RETRAINER
- RobDREAM
- RoMaNS
- SARAFun
- secondHands
- Smokebot
- SoMa
- SWEEPER
- WiMUST

http://www.aeroworks2020.eu/

+ Sherpa

Unmanned aerial vehicles

videos

AEROWORKS:
Collaborative Aerial Robotic Workers


Flourish
Aerial data collection and automated ground intervention for precision farming
Feeding the World
• By 2050 we'll need to feed two billion more people
• Around 30% of the food is lost in the field
• Chemicals inputs have disastrous ecological impact
→ Robotics can contribute to solve these pressing challenges

Link

Robotics projects resulting from H2020 – LEIT ICT 24 2015 and FoF 2015

Project Summaries

January 2016

ICT: AEROBI
- BabyRobot
- Bots2ReC
- ColRobot
- DeTOP
- EDEN2020
- EndoVESPA
- INPUT
- MuMMER
- MURAB
- RAMPup
- RockEU2
- SafeLog
- SoftPro
- SPEXOR
- TrimBot2020
- TT-NET
- UP-Drive
- XoSoft

FoF: HORSE
- ReconCell

Development of an automated valet parking service for city environments, aimed at relieving a car driver from the burden of finding a parking space in city centres.

Link ...

Robotics projects resulting from H2020 – LEIT ICT-25&26&35-2016

Project Summaries

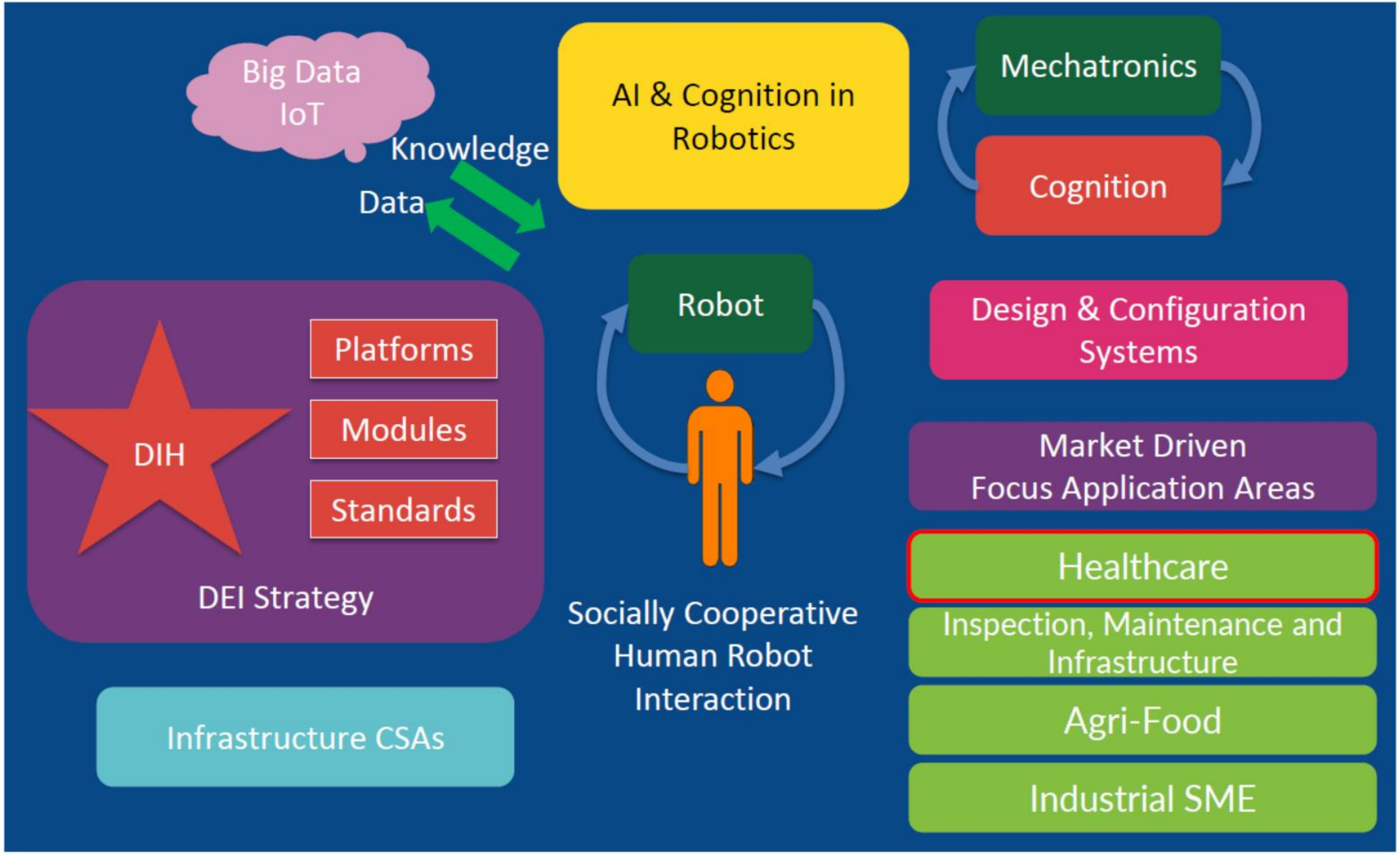
December 2016

University *of Ljubljana*
Faculty *of Electrical Engineering*

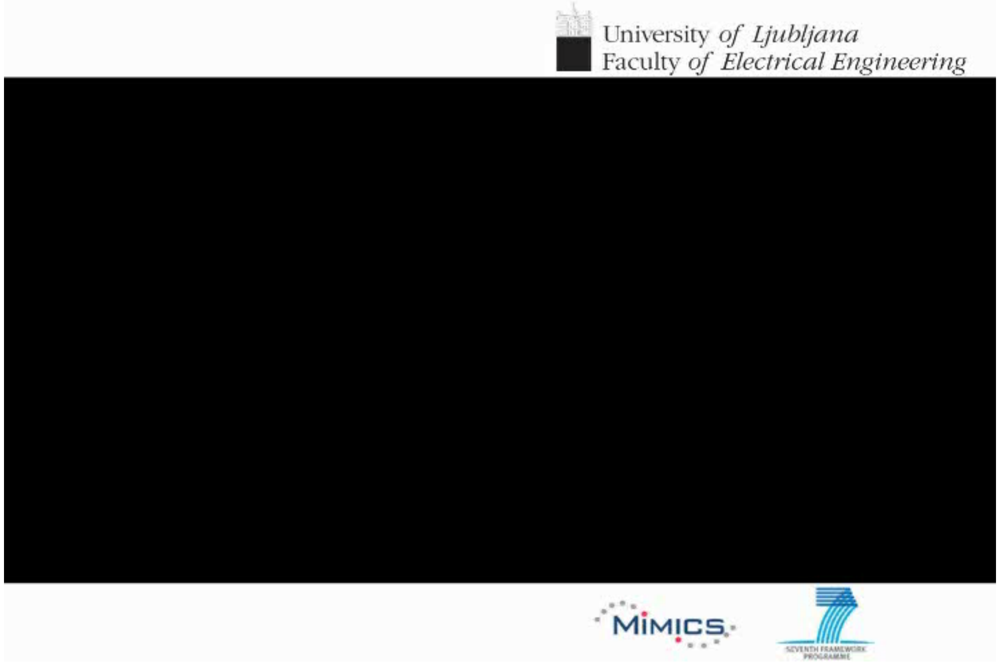
An.Dy: Safety **certified robots** with the ability to react to unintentional contacts (co-bots)
Badger: **Autonomous underground robotic system** that can drill, manoeuvre, localise, map and navigate in the underground space
Co4Robots: Different multi-tasking robots with varying capabilities deployed to provide services such as object handling/transportation, or pickup and delivery operations.
CYBERLEGs Plus Plus: **powered robotic ortho-prosthesis** to help restore mobility allowing amputees to perform physical activity
Dreams4Cars: Focusing on rare events, such as near miss car accidents the robots can develop safe behaviours for hypothetical/unexperienced situations.
HEPHAESTUS: Cable-robots using 3D to help with high risk and critical **construction tasks** such as prefab wall installation
ILIAD: Flexible and rock-solid reliable intra-logistic systems, which can be quickly deployed and integrated in current warehouse facilities, in particular in the food sector, yet guaranteeing safe operation in environments shared with humans
IMAGINE: The project seeks to enable robots to understand the structure of their environment and how it is affected by its actions
MoveCare: A multi-actor platform to supports the independent living of the elderly at home by monitoring, assist and promoting activities to counteract decline and social exclusion
MULTIDRONE: **multi-drone platform** for media production to cover outdoor events with improved robustness, security and safety mechanisms
REELER: Tackling major societal concerns the project will formulate guidelines in the REELER Roadmap for distributed responsibility among roboticists, users/affected stakeholders and policy-makers by closing the current gap between these
REFILLS: A robotic systems able to address the **in-store logistics** needs of the retail market
RobMoSys: The project proposes composable models and software for robotics systems building an open and sustainable, agile and multi-domain European robotics software ecosystem
ROSIN: The project aims to create a step change in the availability of **high-quality intelligent robot software** components for the European industry by building on the existing open-source “Robot Operating System” (ROS) framework and leveraging its worldwide community
ROPOD: Cost-effective and human-friendly automated guided vehicles (AGVs) for logistic tasks
SMARTsurg: Smart wearable robotic tele operated surgery focusing on real-world surgical scenarios of urology, vascular surgery, and soft tissue orthopaedic surgery
VERSATILE: Flexible robotic cells with dual robot arms that can adapt automatically to the high number of different products in industries such as automotive, aerospace and handling and packaging

Work Programme 2018-2020

Trends in robotics



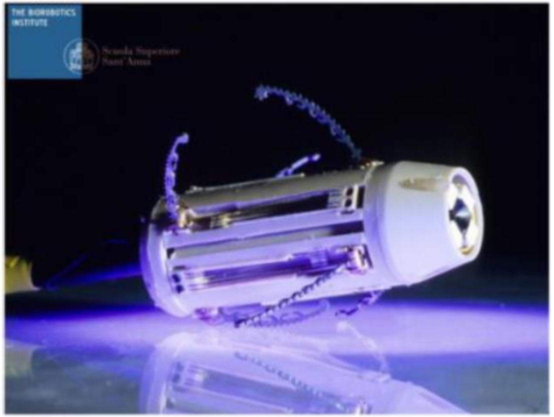
Rehabilitation robotics

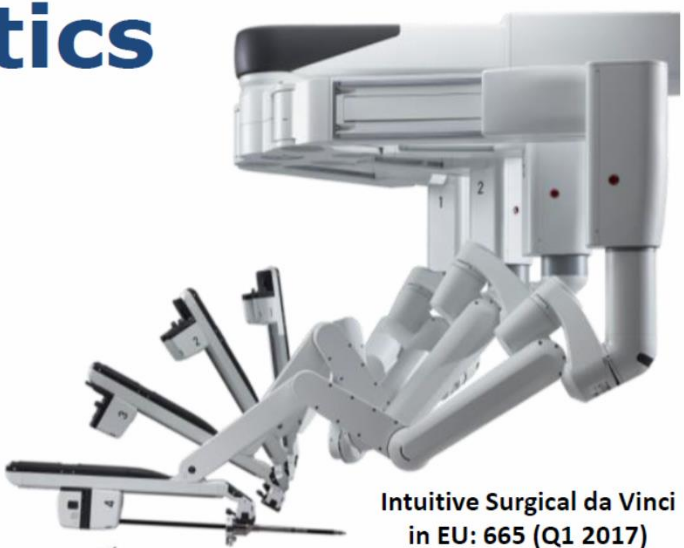


Locomat

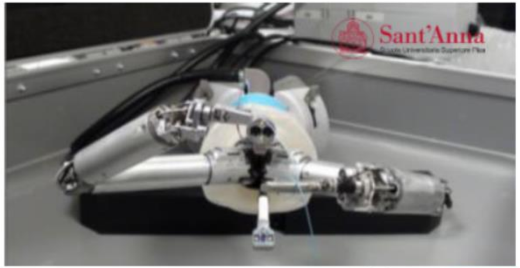
MIMICS River video

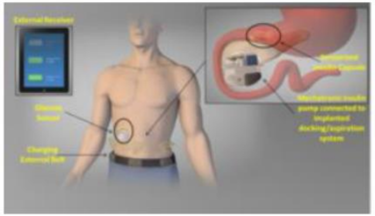
Surgical Robotics

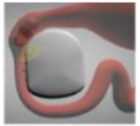




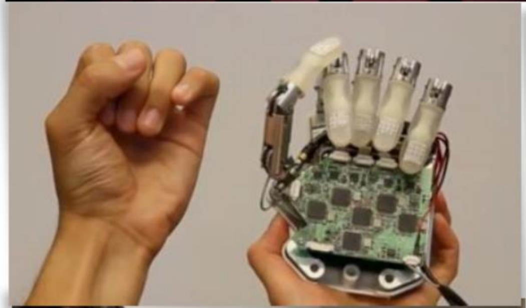
Intuitive Surgical da Vinci
in EU: 665 (Q1 2017)

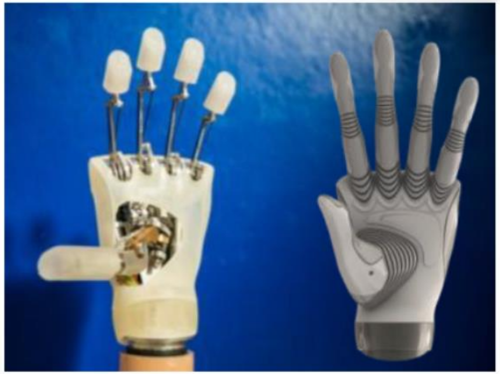






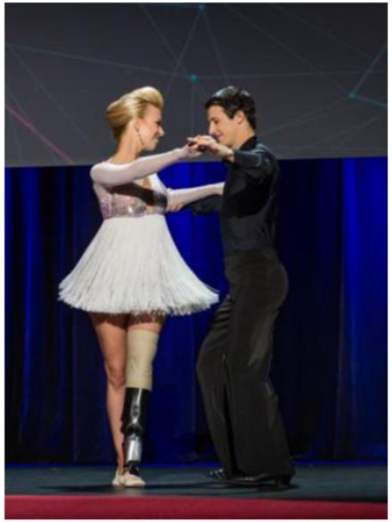
Bionic Prostheses





ottobock.

ÖSSUR



Assistive Robotics

THE BIOROBOTICS INSTITUTE
Scuola Superiore Sant'Anna

ExCITE project


II.
Examples of European robotic
I&M services and systems
TAUROB
VERTIDRIVE
Eelume
SUBSEA INTERVENTION
CYBERHAWK
aeroarms-project.eu
ASCENDING
TECHNOLOGIES
petrobotproject.eu
ALSTOM
ROSEN
empowered by technology
InnoTecUK
innospection
© Wälischmiller
Engineering GmbH
OCRobotics
www.sevendof.com
tubetech
International
eu ROBOTICS

Robotics in agro-food: the opportunities

- Support or replace human labour:

Addressing: labour shortage

Robotics in agro-food: the opportunities

- Do things more precise and/or more often:

Precision weeding

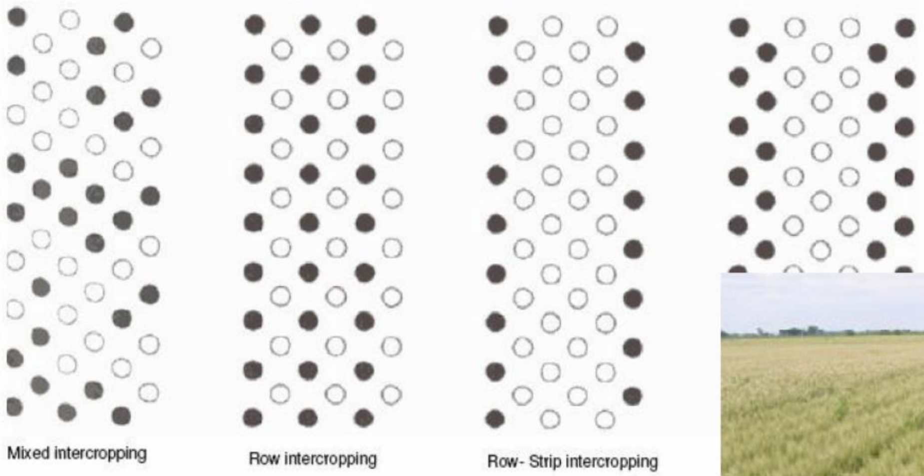
Sorting and packing

Addressing for instance :

- Reduced or zero use of crop protection chemicals
- Effective use of resources (water, fertilizers)
- More uniform or improved product quality
- ...

Robotics in agro-food: the opportunities

- Redesign the production system:

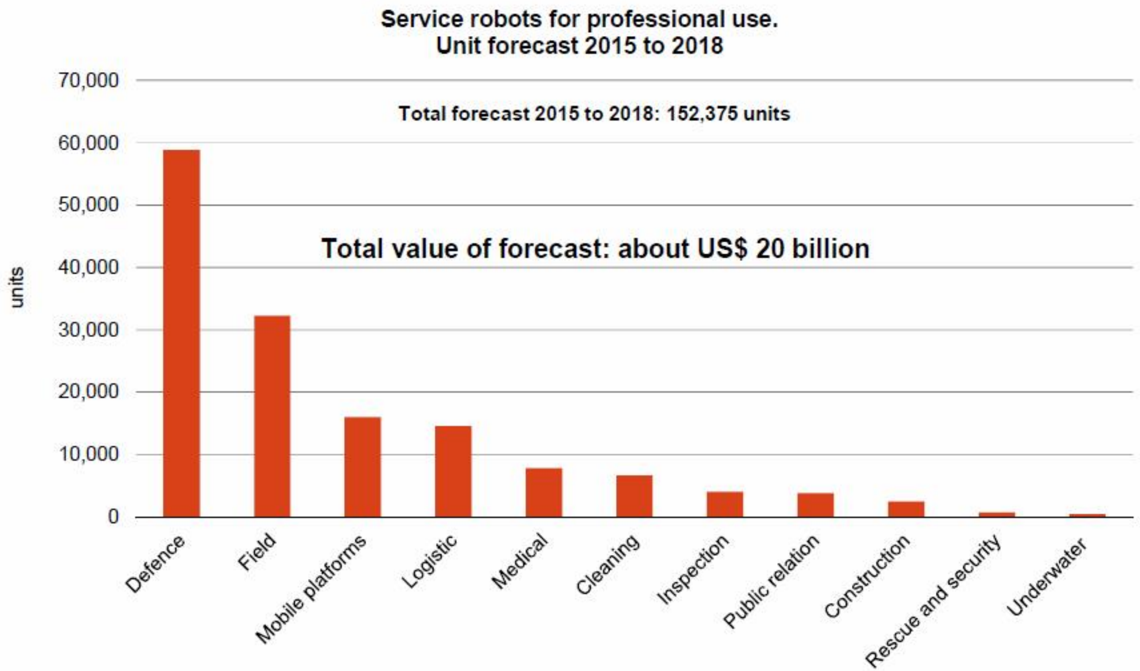


1:10

Addressing for instance:

- Less pesticide use
- Less fertilizer use

2015-2018: about 152,400 new service robots for professional use

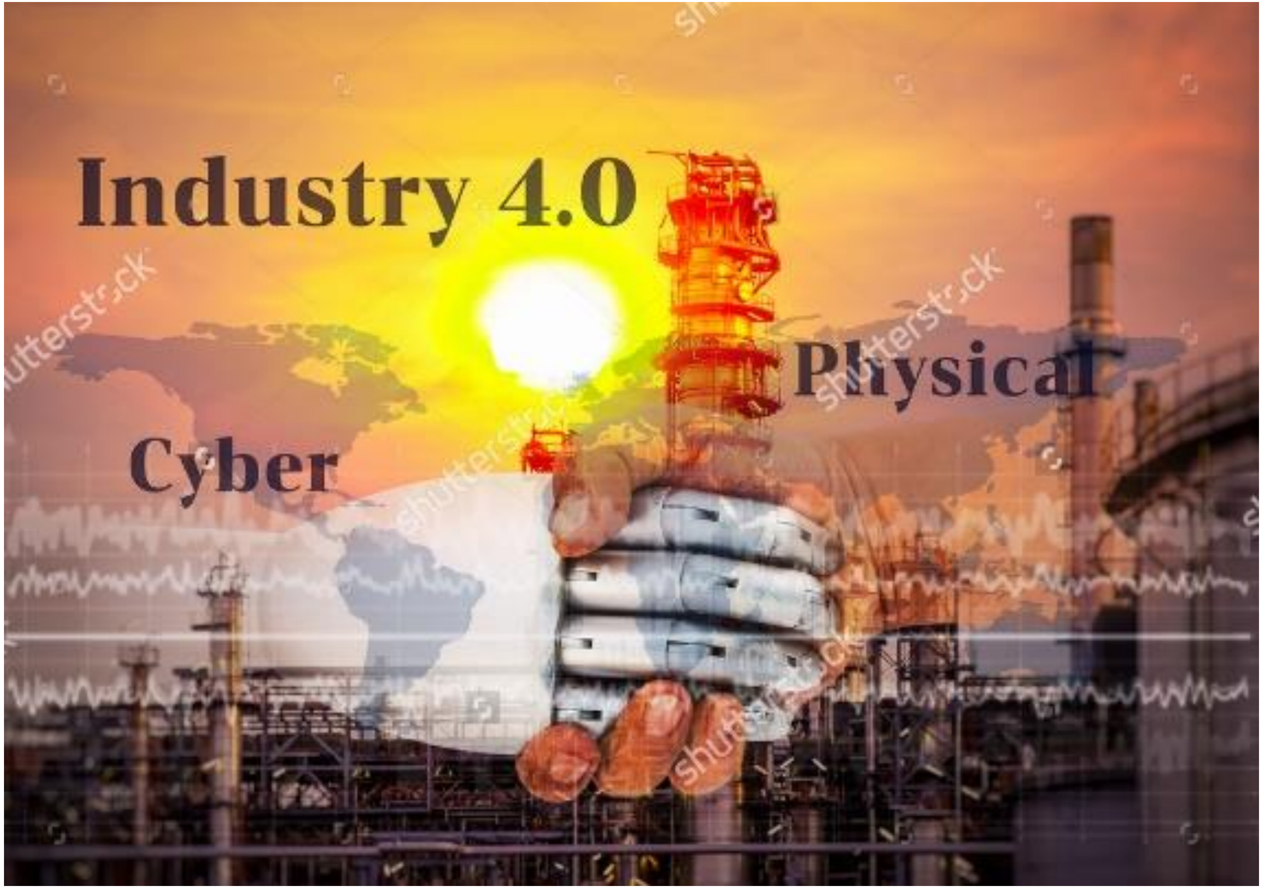


Source: IFR World Robotics 2015

IFR statistical department

Hosted by VDMA

IV.



Industry 4.0

8 main value drivers

Source: McKinsey

Main trends 2015 and 2018

- **Simplification of the use of robots**
  - essential for all industries to be able to sustain efficient and flexible manufacturing
  - High potential in small and medium sized companies
- **Mobile Robots**
  - support human-robot collaboration, and
  - flexible manufacturing
  - important tool for Industry 4.0

Source: Universal Robots

Source: KUKA

Source: IFR World Robotics 2015

IFR statistical department

Hosted by VDMA

Trends in the service robot market

- Logistic systems on the rise:
  - 2,700 units (mainly AGVs) installed in 2014, +27%
  - At least 14,500 units will be sold 2015-2018
- High growth potential for logistic systems
  - Human-Robot-Collaboration
  - Industrial and non-industrial sectors

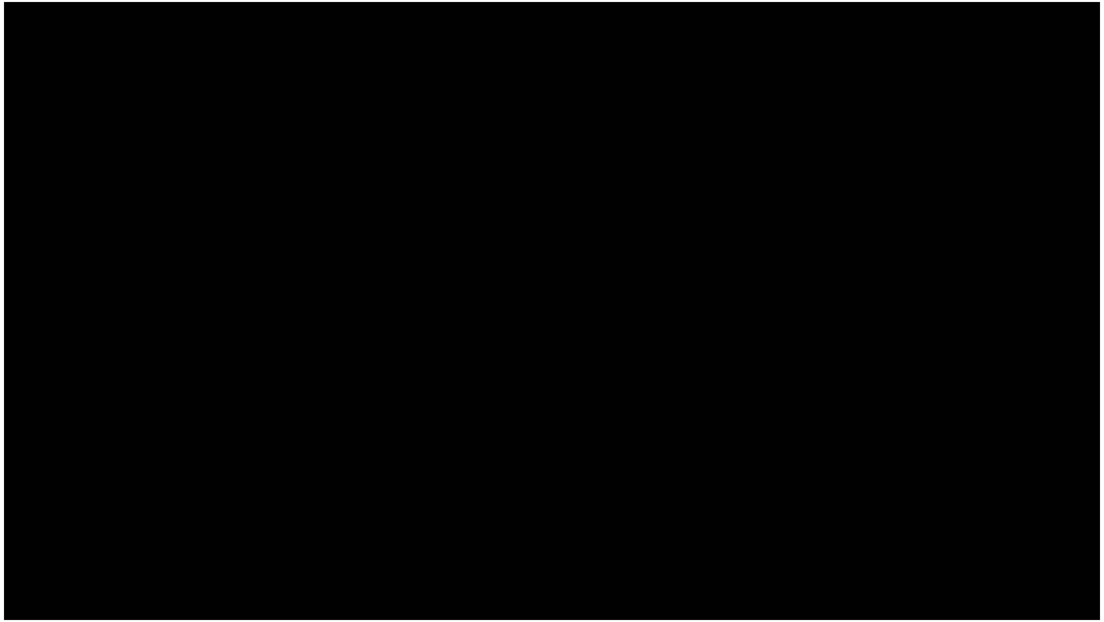
Main trends 2015 and 2018

- **Breakthrough of human-robot collaboration**
  - industrial robots assist workers in a variety of tasks
  - improve manufacturing quality and processes
  - increase productivity
  - assist an aging workforce, e.g. in physically demanding tasks

Source: IFR World Robotics

Collaborative robot safety functions:

. Workspace definition
. Hand Guiding
. Speed and Separation Monitoring
. Safety Monitored Stop
. Kinetic Energy and Force Limiting



Kuka LWR iiwa
(inteligent industrial work assistant)

Hand guiding
(ISO 10218-1:2011)

YASKAWA MOTOMAN HC10
HC – human collaborative

Distance metrics
(ISO 10218-2:2011)

Robots and robotic devices — Collaborative robots ISO/TS 15066

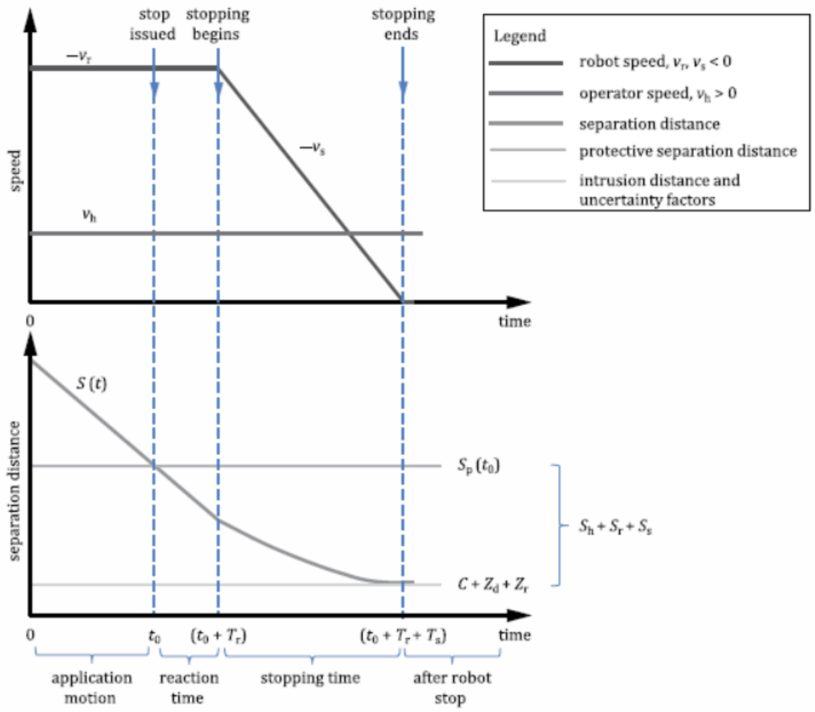
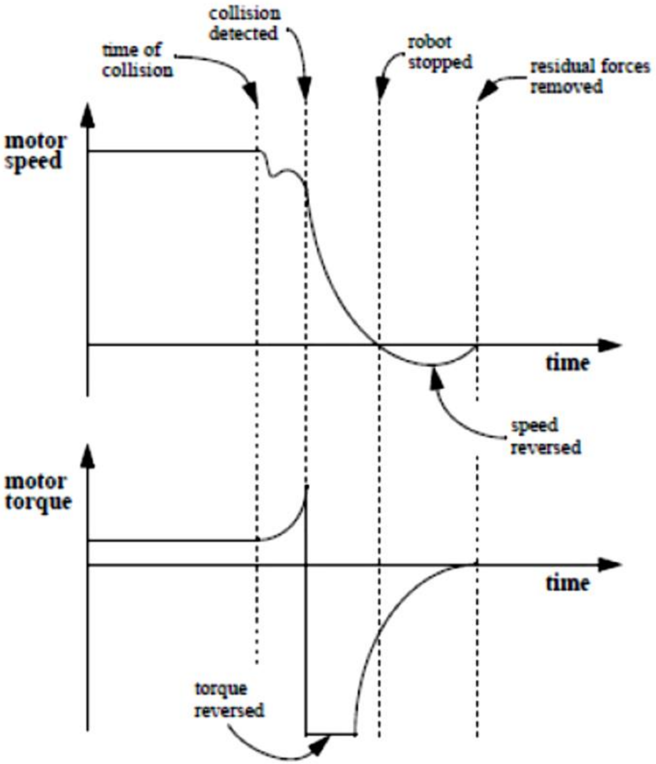


Figure 3 — Graphical representation of the contributions to the protective separation distance between an operator and a robot

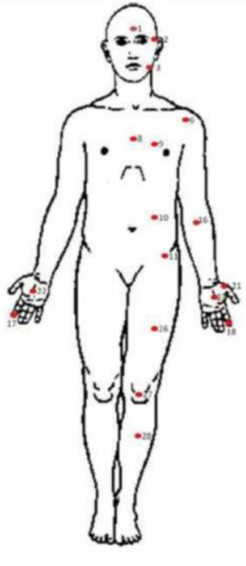
Fanuc CR Colaborative robot, Vision included

Motion supervision (ABB)



Power and force limiting by inherent design or control
Power/pressure/force

Robots and robotic devices — Collaborative robots ISO/TS 15066



Front

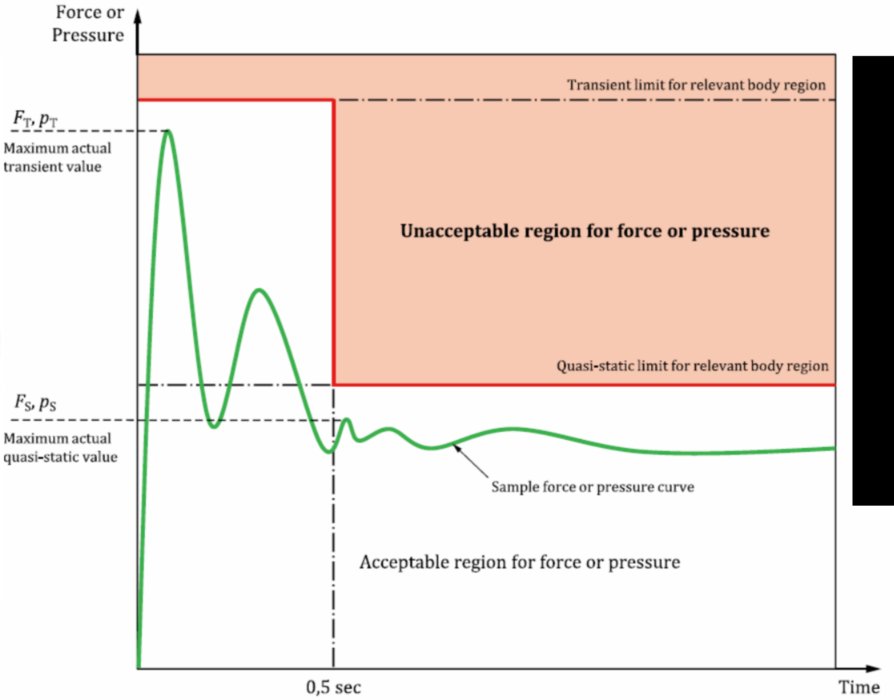
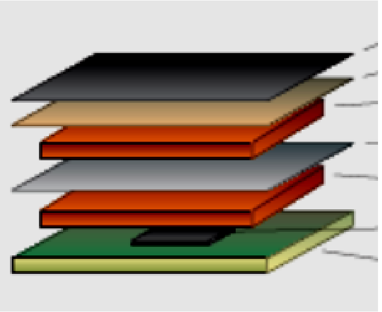


Figure 4 — Graphical representation of acceptable and unacceptable forces or pressures

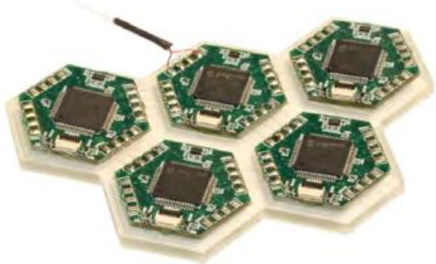
FRANKA

Robot skin

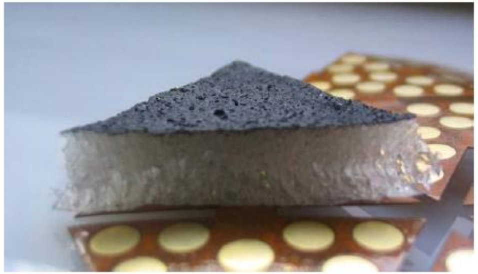
Multilayer capacitive



Skinware

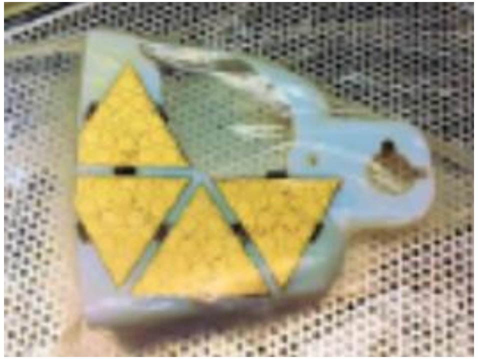


Roboskin

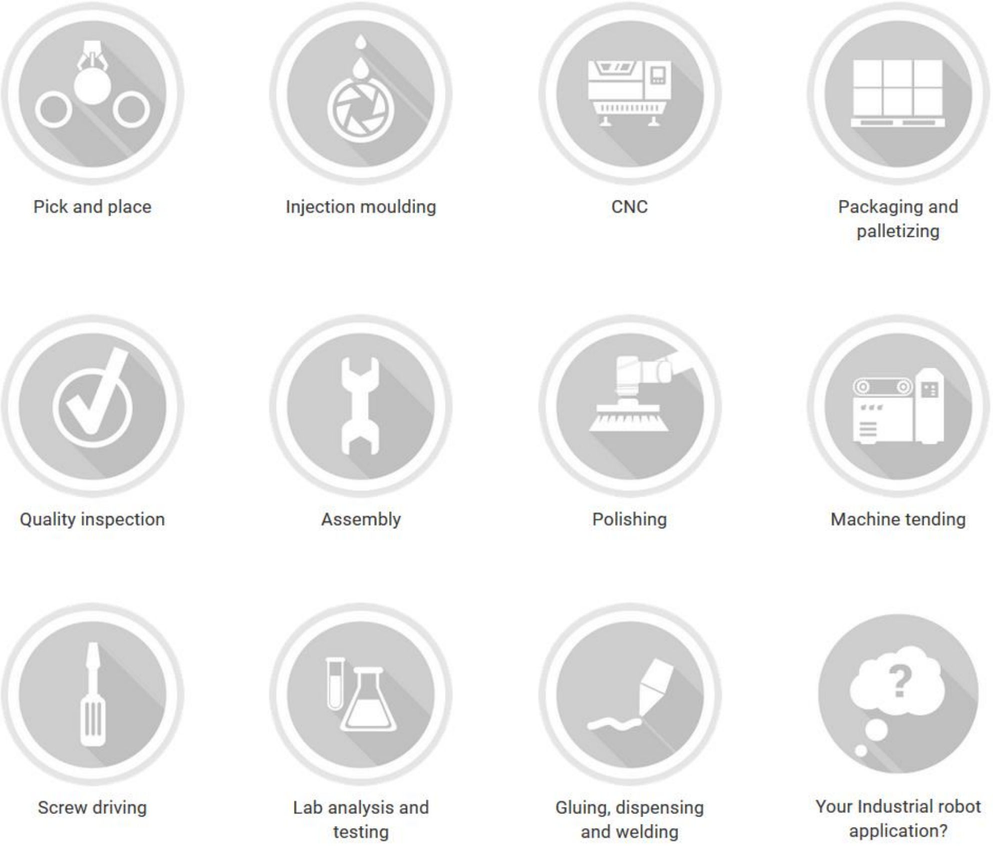


COMAU AURA

Aura – advanced use robotic arm



Collaborative robot use (UR robots)



UR robots
15 advanced adjustable safety functions
TüV NORD approved safety

Tested in accordance with:
EN ISO 13849:2008 PL d

REPORT with recommendations to the Commission on Civil Law Rules on Robotics

- EU parlament, Feb 16, 2017
- whereas there is a need to create a generally accepted definition of robot and AI that is flexible and is not hindering innovation;
- (ISO 8373:2012 - Robots and robotic devices) Manipulating industrial robot: An automatically controlled, reprogrammable, manipulative machine with several degrees of freedom, which may be either fixed in place or mobile for use in industrial automation applications.

REPORT with recommendations to the Commission on Civil Law Rules on Robotics

Maddy Delvaux, Reporteur, EU MP, LU

Civil liability for damage caused by a robot. This can either mean strict liability or a risk-based management, nevertheless, it should be ensured that the damage caused is compensated. Standardisation must be speeded up. To ensure the highest level of security possible, protocols need to be established.

The **enforcement of data protection rules** is one of the biggest challenges. Robots collect and receive masses of information of all kinds: who owns this data, who has access to it? The report proposes an ethics charter, a code of ethics for programmers. The report also insists on the necessity of transparency.

The deployment of robots will have an impact on all aspects of life and therefore on work. Studies diverge: **some predict a massive destruction of jobs, others are less pessimistic** and consider that the jobs destroyed will be compensated by the creation of new jobs. It is clear, however, that ways of working will change and that educational systems will face enormous challenges to ensure the re-qualification of those who are active and to train young people in professions that do not yet exist.

The **report is not technophobic**, it identifies the positive contributions: robots will be able to carry out hazardous or painful work, they will facilitate the work of many professionals, they will promote the integration of people with a disability. But no one can predict whether robots will destroy more jobs than they create.

EU Robotic agency.

Neccessary standards for flying, mobile and collaborative robots.

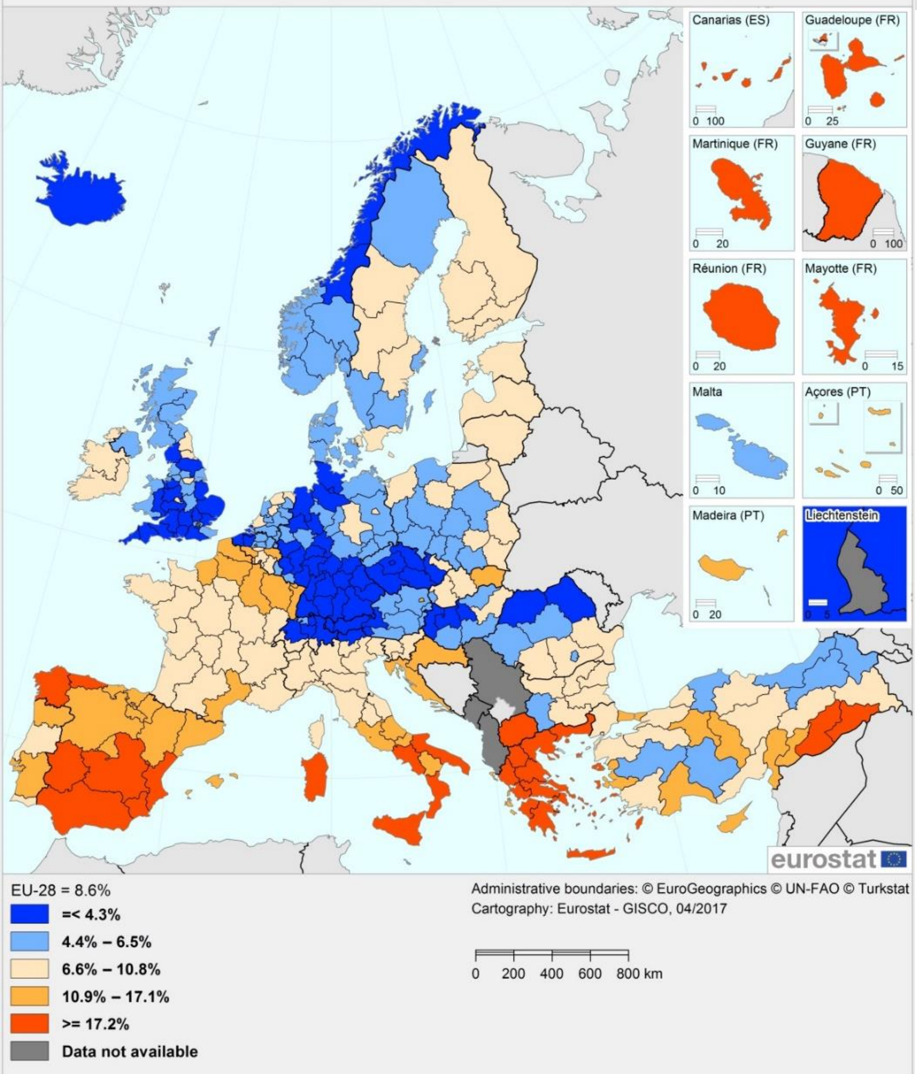
The robots are required in case of

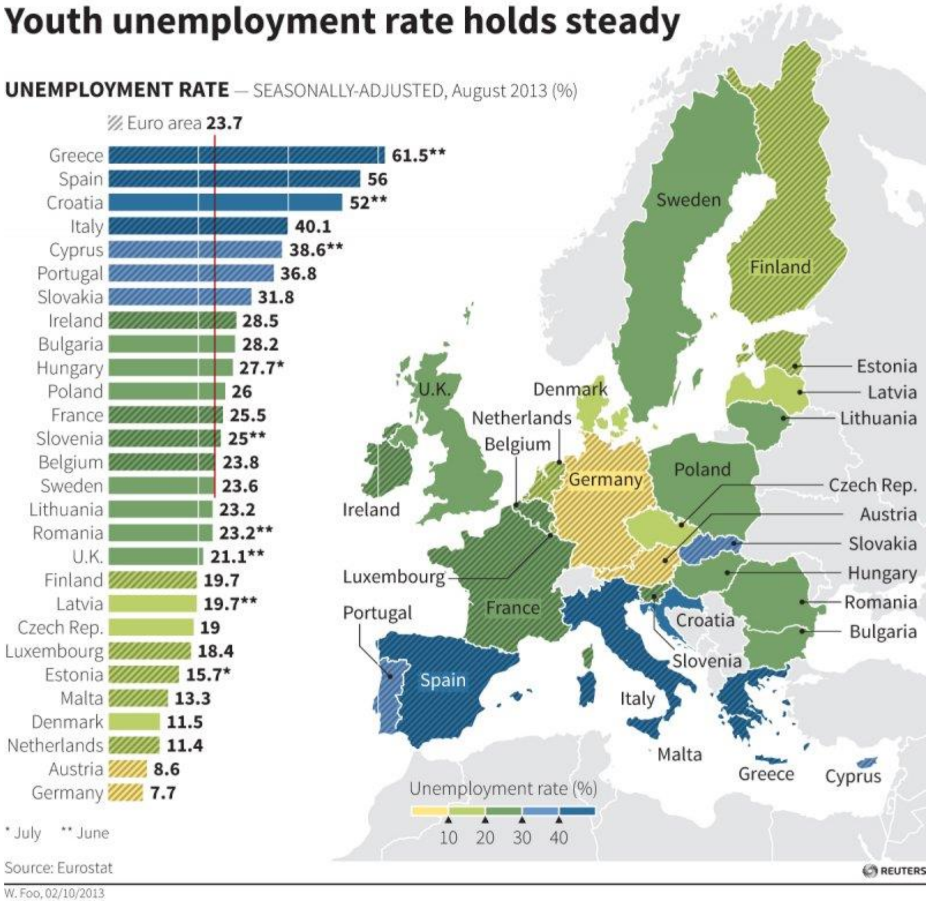
- **Unsatisfactory working conditions (health and safety), where robotics have replaced humans (Food and drink, Foundries, Chemicals, Rubber and Plastics, and Pharmaceuticals).**
- **The sophistication of the manufacturing operation, or its special needs. Clean rooms, Precision, Consistency and Cost (Electrical and Electronics, Automotive).**
- **The cost of labour.**

  For example, the cost of labor is relatively low throughout the world in the food sector, which results in lower use of robotics. In China where the cost of labor is low, there is a much greater likelihood of employing large teams for assembly work in any industry, rather than robots
- **Supporting employment of local industry.**
- **SME**

Source: www.ifr.org

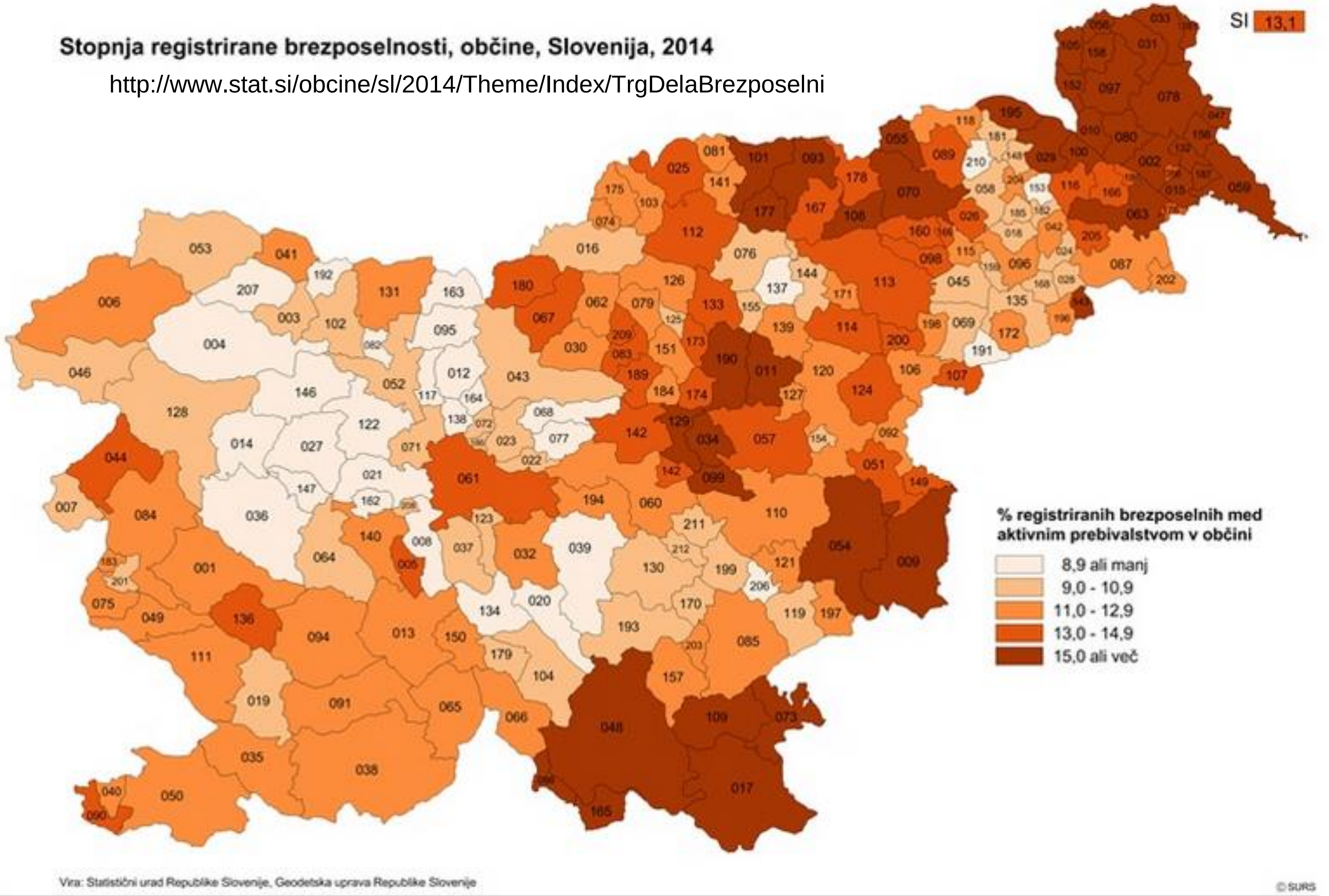
Unemployment rate 2015





Stopnja registrirane brezposelnosti, občine, Slovenija, 2014

http://www.stat.si/obcine/sl/2014/Theme/Index/TrgDelaBrezposelni



Robotics – a pivotal technology

Jobs are ***created***

- because robots
  raise productivity and competitiveness,
  enable also re-shoring of industries
- input: more demand & output: stronger market support
- when **robots or components are *produced***
- **staff is trained** for technological competence
- investment is getting less risky:
  →robots are getting cheaper
  →and easier to programme

Sources: IFR, OECD, Centre for Economic and Business Research, Deloitte, Boston Consulting, et al.

robolab

Video: Yaskawa & UL FS

Hvala za pozornost.