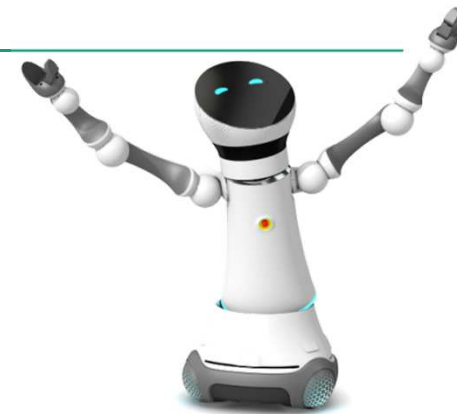

Robotics impacts Industry and Society: What are the Numbers and Trends?

ROS-Industrial Conference 2018; Stuttgart, 11-13 December 2018



Martin Hägele

Robot and Assistive Systems

Fraunhofer IPA

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The Fraunhofer-Gesellschaft Locations in Germany

- 72 institutes and research units
- 25,327 staff
- € 2.3bn research volume (2017)



Fraunhofer IPA

Technology consultant and innovation driver since 1959

- Operating budget 2017: 63 million Euro
- Total investment budget: 4 million Euro
- Total industrial revenues:>24 million Euro
- More than >450 FTE engineers/scientists



New technical center "Gebäude D" in Stuttgart

Note: key figures for 2017, all locations



Fraunhofer Institute Center in Stuttgart

Technical equipment and laboratories



Application Center
Industrie 4.0



Motion laboratory



Biomufacturing
laboratory



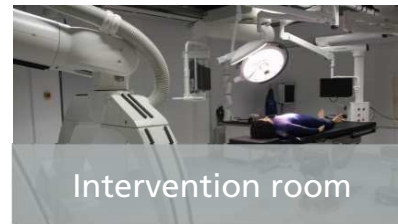
Factory planning and
production laboratory



Future Work Lab



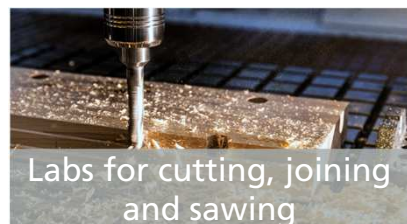
Electroplating
laboratory



Intervention room



Labs for additive
manufacturing



Labs for cutting, joining
and sawing



Coating technology
center



Machine vision
laboratories



nCLAS
Laboratory automation



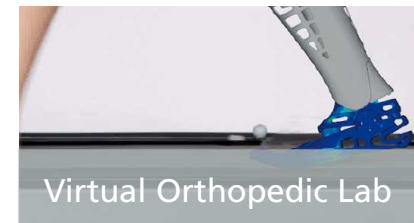
Cleanrooms &
cleanliness rooms



Robotics
experimentation area



Model factory for
functional coatings

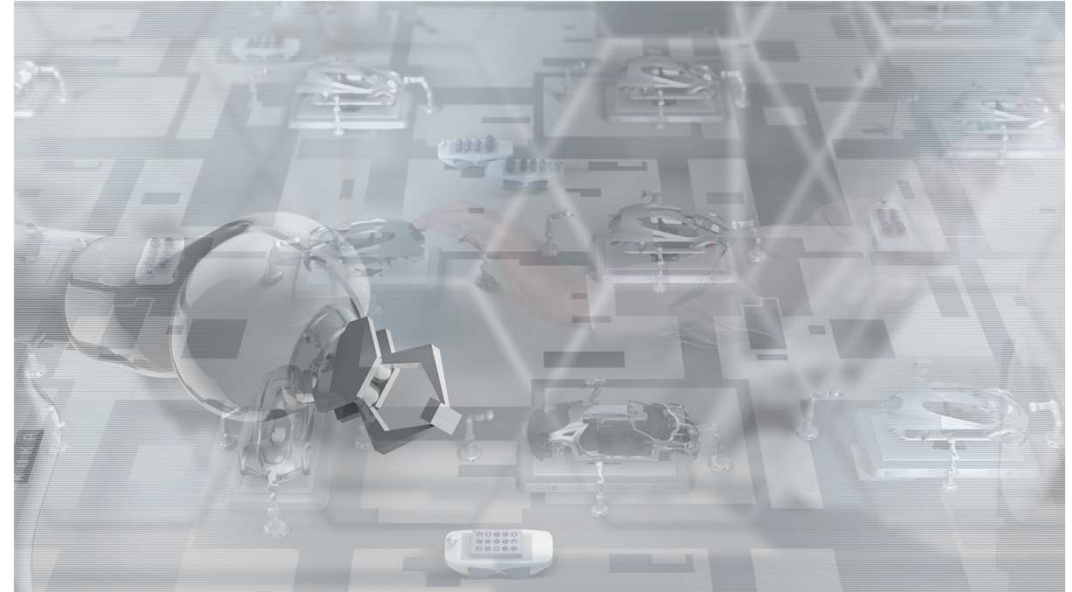


Virtual Orthopedic Lab

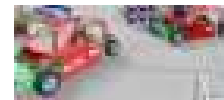
Research Factory **ARENA**2036

Active Research Environment
for the **Next** generation of
Automobiles: A complete
research factory starting
operation in Jan 2017

www.arena2036.de



Changeable (agile)
Assembly



Changeable (agile)
body assembly



Changeable
(agile) Logistics



Personalized
surfaces



Worldwide shipments of industrial robotics in 2017

Most relevant industrial application areas and processes

Handling (47%)



Clean Room (11%)



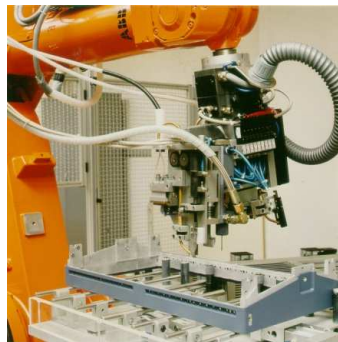
Welding (22%)



Assembly (12.75%)



Machining (1.6%)



Dispensing (3.1%)

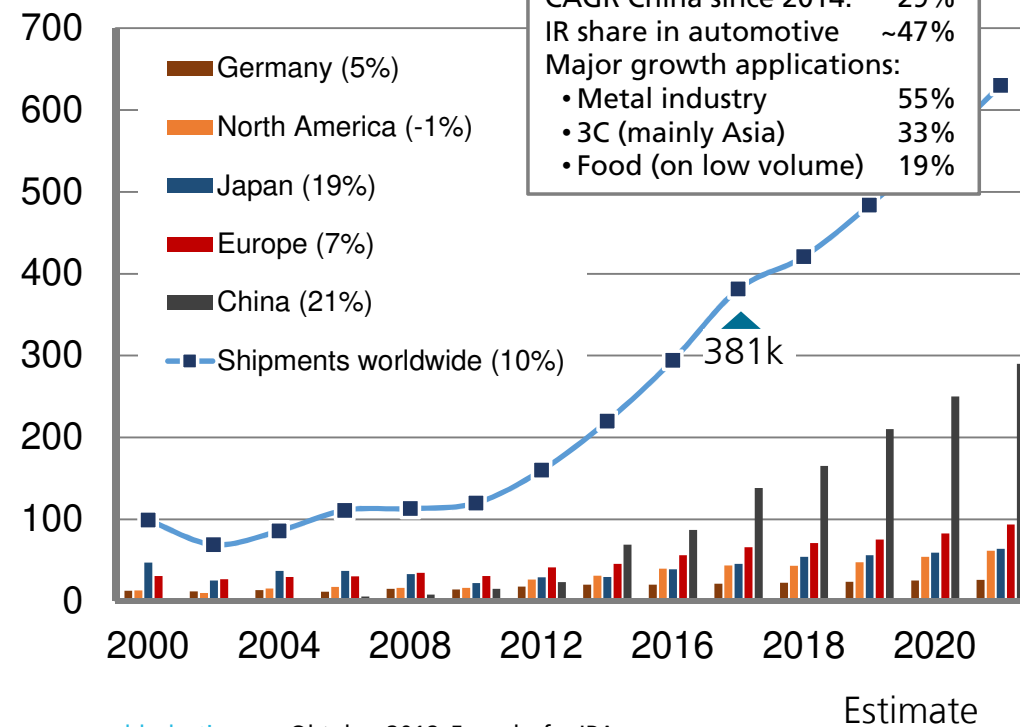


World Robotics Report; www.worldrobotics.org, Oct. 2018

Industrial robot shipments (new installations)

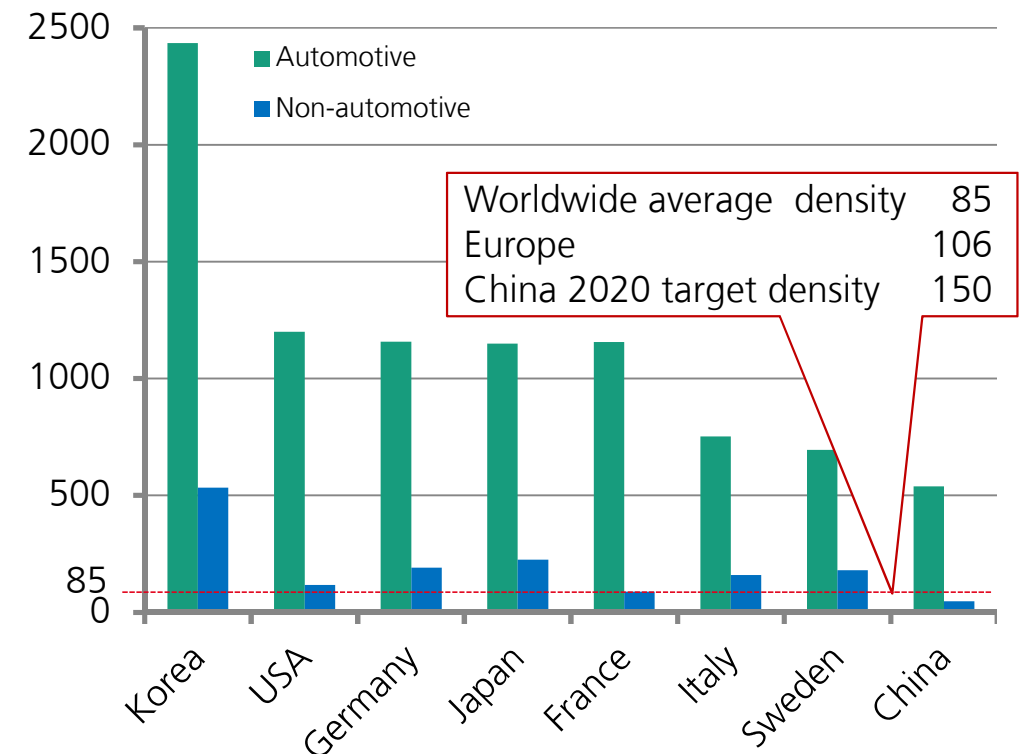
All time high in 2017 and positive prospects

Industrial robot shipments worldwide [*1000 units]



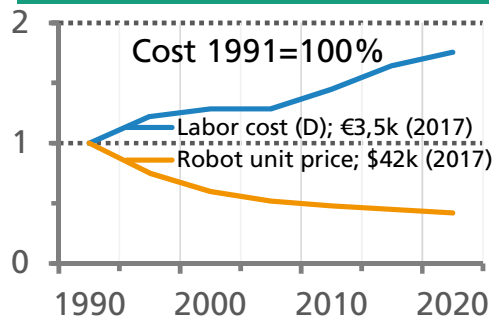
www.worldrobotics.org, Oktober 2018, Fraunhofer IPA

Robot density 2018: Number [units] of installed industrial robots per 10,000 employees in the respective domains



Technology Trends in Industrial Robotics

Cost effectiveness



Human-Robot Collaboration



Networked → Industrie4.0



Robot Optimization by AI/Machine Learning

1 Processes, tasks

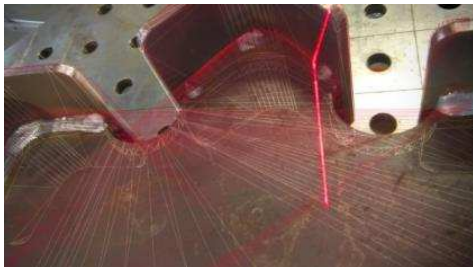
- Physical interaction
- Learning control
- Strategies, skills

2 Program generation

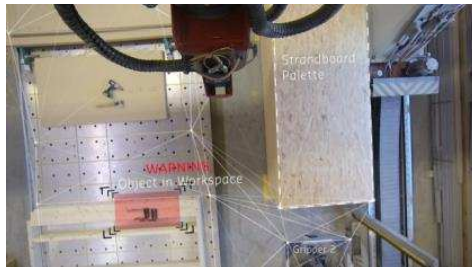
- Planning
- HMI
- Behavior explanation

3 Robot performance

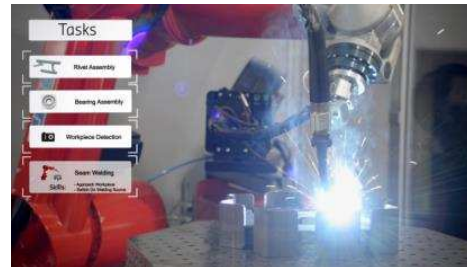
- Accuracy
- Dynamics
- Durability etc.



Sensors



Cognitive capabilities

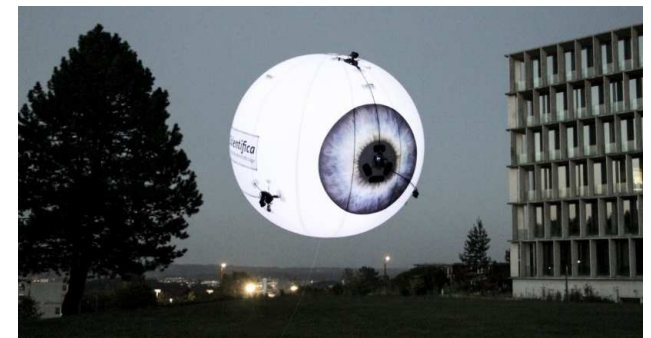
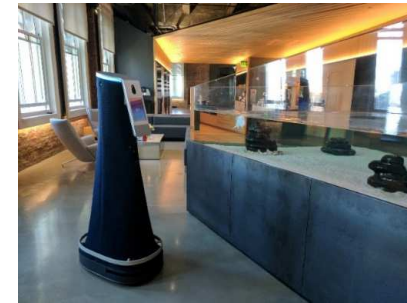


Skill-based, intuitive robot instruction

Service Robots for Professional Use I

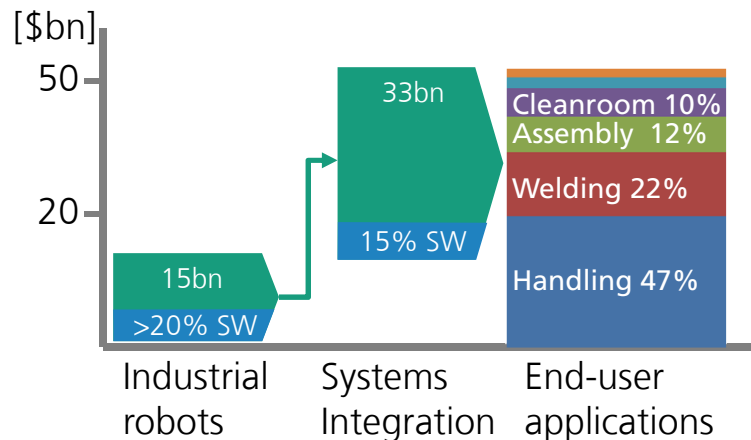


Service Robots for Professional Use II



Industrial and service robotics supply industries

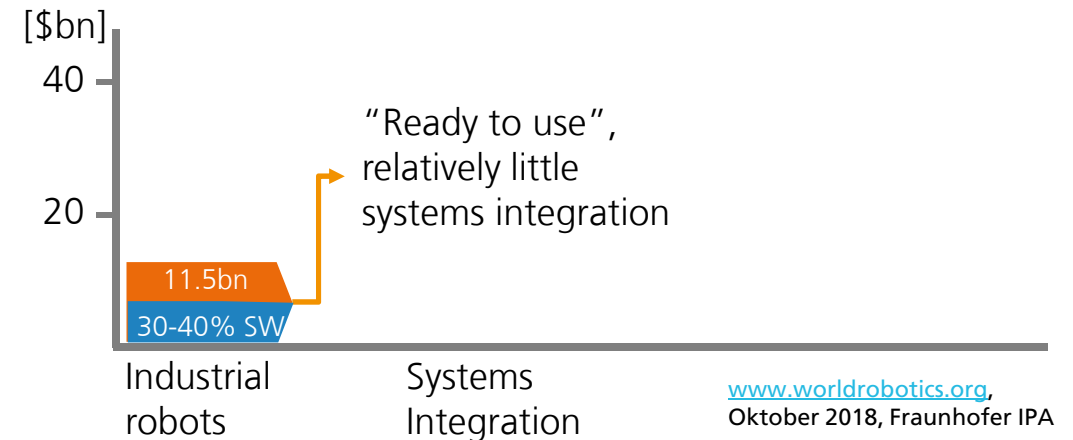
Industrial Robotics annual turn-over



Key figures Industrial Robotics IR (est.)

- US\$15bn turn-over Industrial Robots (IR)
- 55 IR manufacturers worldwide
- 1k systems integrators
- \$50bn total turnover IR industries
- 15% CAGR until 2020+ (estimated)
- Average unit price US\$53k (2012) → 42k (2017)

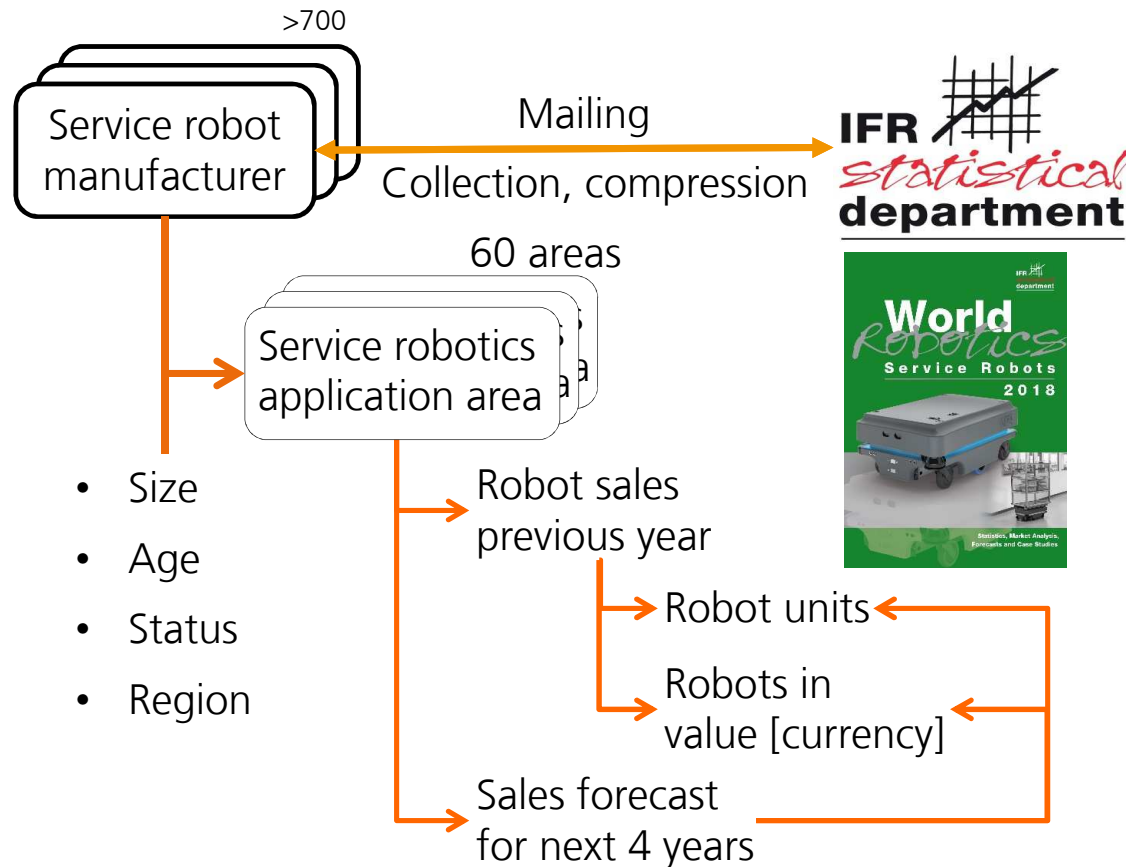
Service Robotics annual turn-over



Key figures Service Robotics SR

- >\$11.5bn turn-over (US\$8.7bn professional service robotics, 2.6bn in "domestic/personal")
- 720 suppliers/manufacturers of SR, 30% start-ups (max 5 years)
- 70% use ROS in one form or the other (estimated)
- 14% (since 2009) CAGR for professional SR
- 23% CAGR for domestic/personal SR

Statistics Scheme and Classification of Service Robots by Application Areas



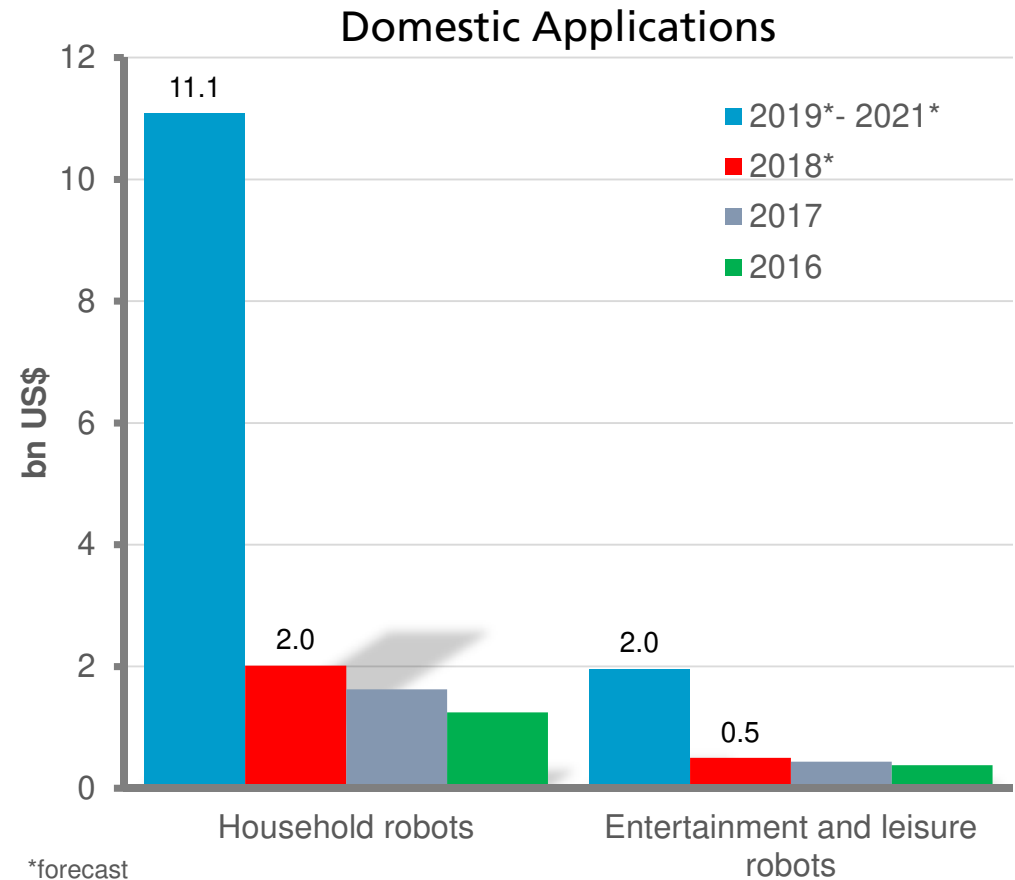
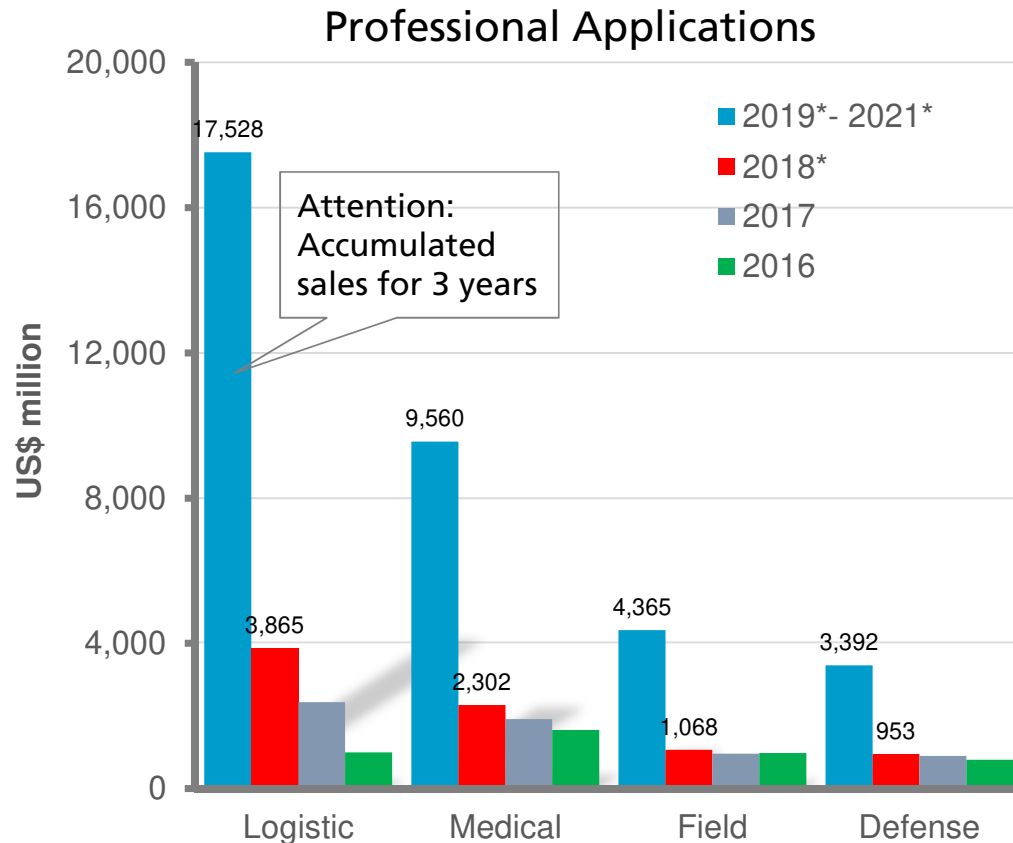
www.worldrobotics.org,
Oktober 2018, Fraunhofer IPA

Professional use

- 16-21 Field robotics
- 22-26 Professional cleaning
- 27-29 Inspection, maintenance systems
- 30-33 Construction and demolition
- 34-38 Logistic systems
- 39-42 Medical robotics
- 43-45 Rescue & security applications
- 46-50 Defense applications
- 51 Underwater systems (civil/general use)
- 52 Powered Human Exoskeletons
- 53 Mobile Platforms in general use
- 54-58 Underwater systems (civil/general use)
- 59 Other

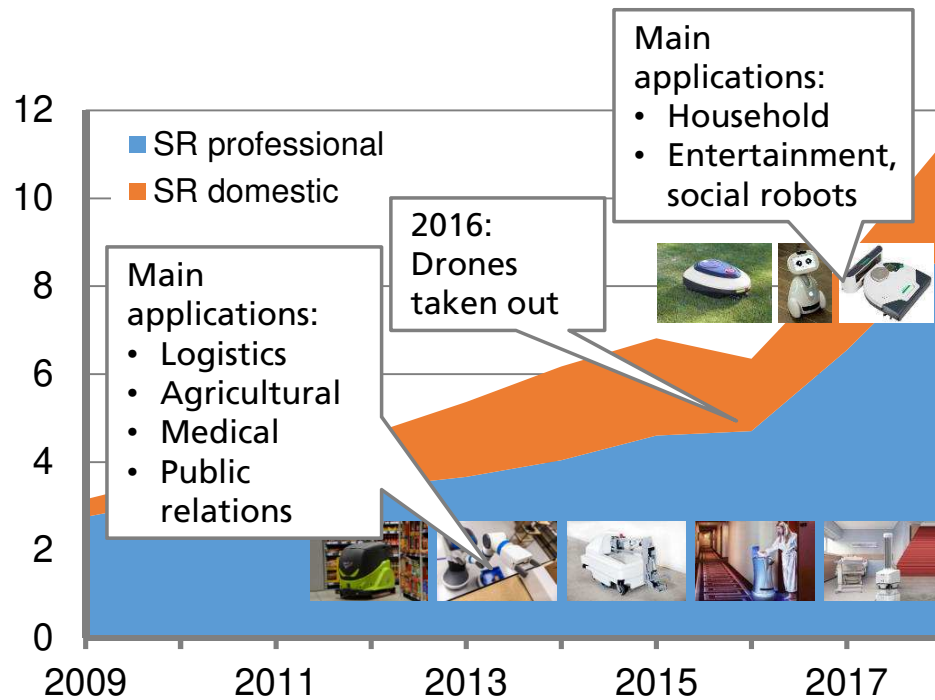
Service Robots for Professional and Domestic Use (Main Applications)

Estimated Values 2016 and 2017; forecasts(*) 2018 and 2019-2021



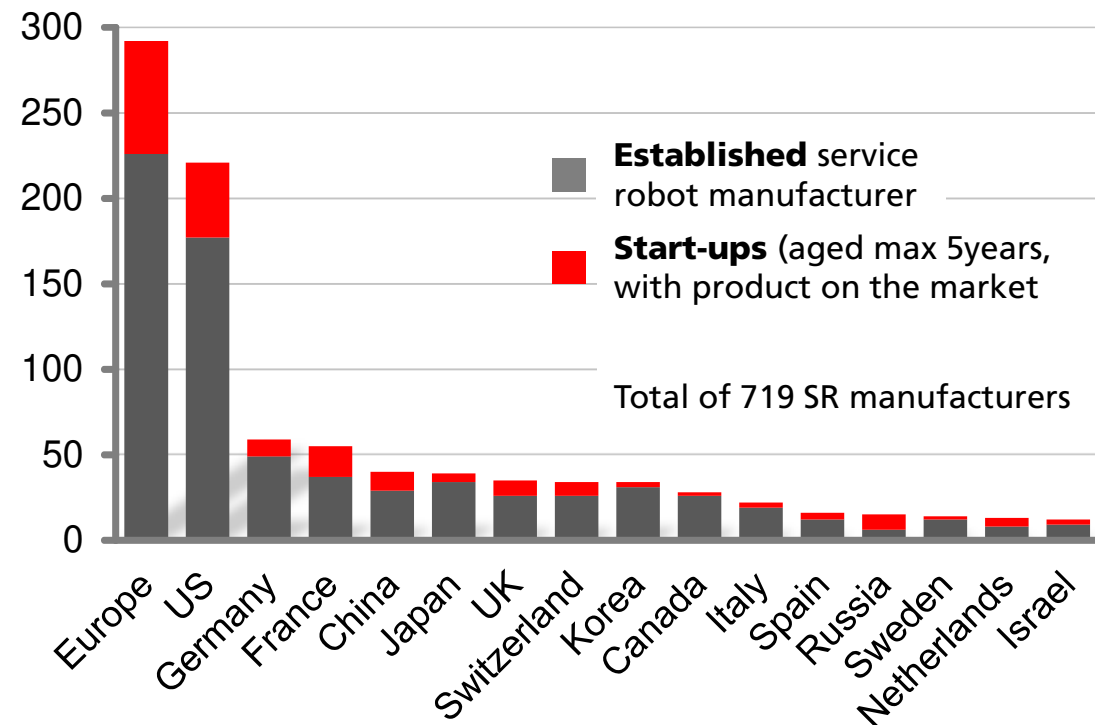
Robotics Outside the Manufacturing Scenario

Service robot (SR) annual sales worldwide for professional, domestic applications in [bnUS\$]

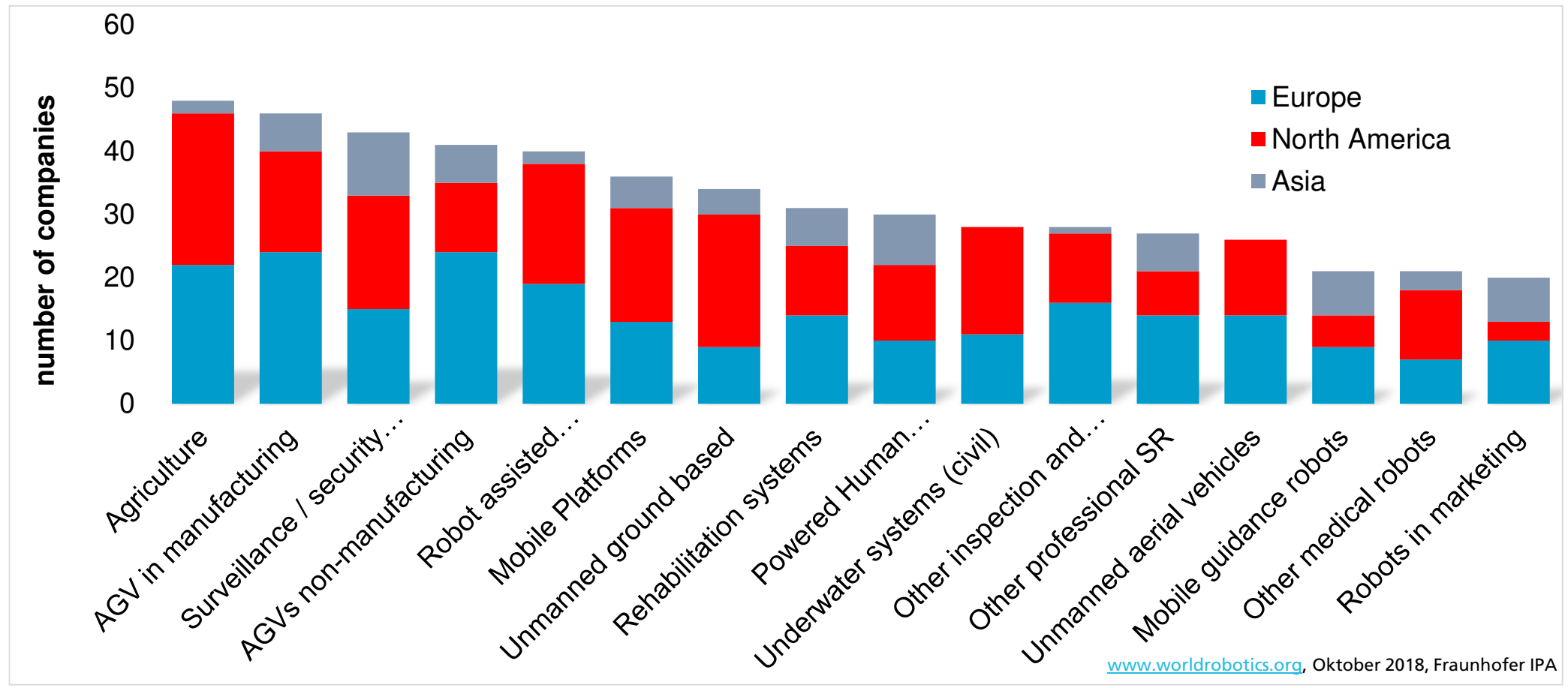


Source: World Robotics 2018; www.worldrobotics.org, Fraunhofer IPA

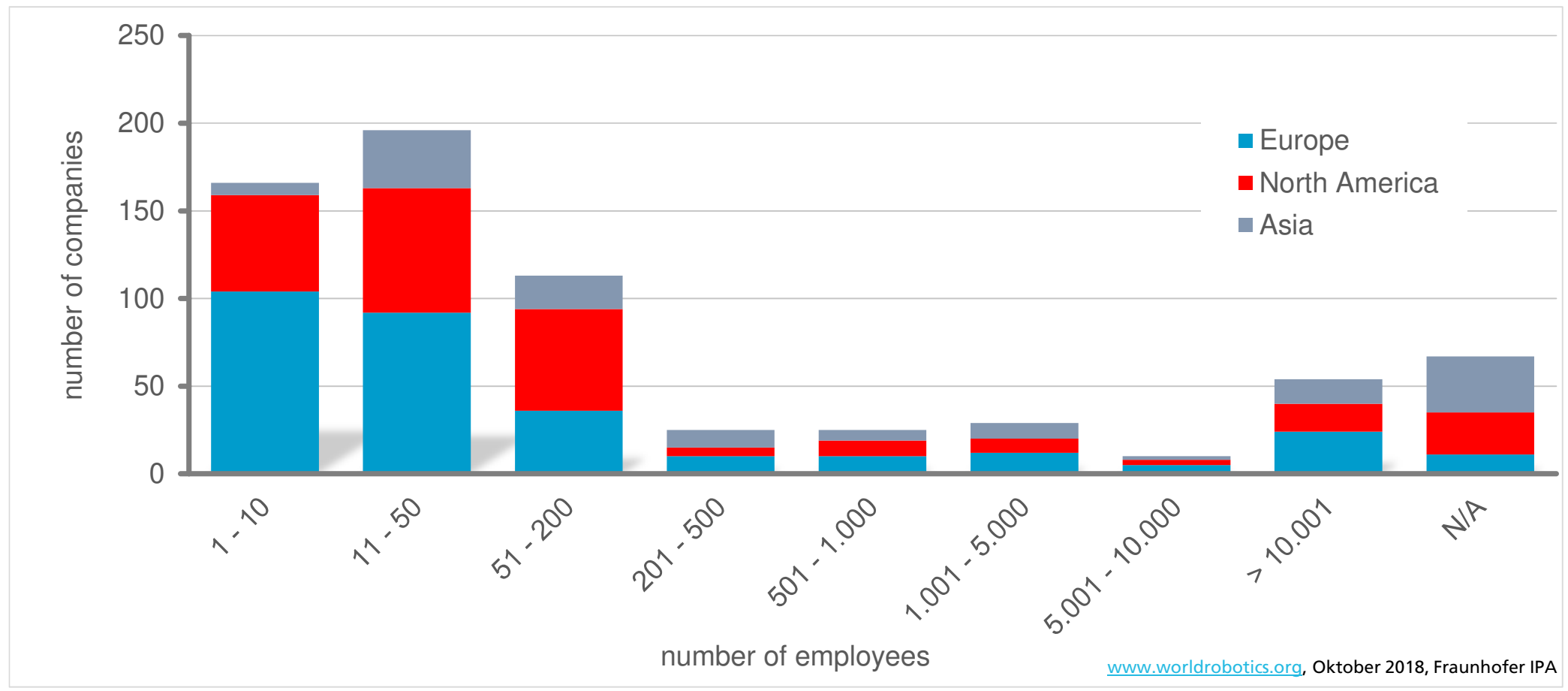
Number of service robot manufacturers (professional and domestic use) by country of origin (2018, excerpt)



Number of service robot manufacturers by main types (professional use) and by region of origin, status 2017 (selection)



Business sizes of service robots of all types in numbers of employees (by region of origin, 2017)





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