



Universität Bern, 19th September 2018

**INDUSTRIAL AND SERVICE ROBOTICS:
STATE OF THE ART AND FUTURE TRENDS**

**Arturo Baroncelli
Past President IFR
Engelberger Prize**

International Federation of Robotics

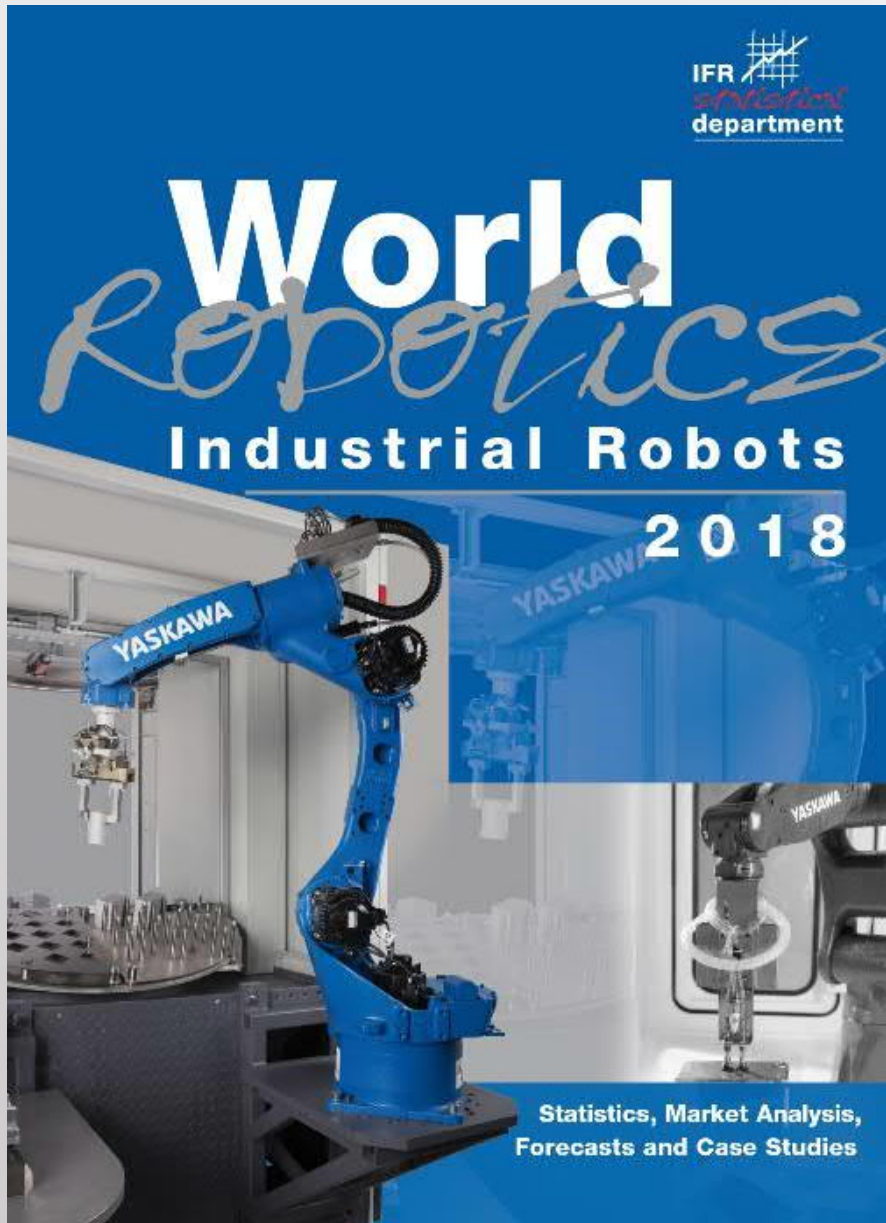
Representing the global robotics industry

- Robotics turnover 2017: about \$50 billion
- More than 50 members:
 - National robot associations
 - R&D institutes
 - Robot suppliers
 - Integrators
- Sponsor of the annual International Symposium on Robotics (ISR)
- Co-sponsor of the IERA Award
- Primary resource for world-wide data on use of robotics – IFR Statistical Department



Structure of Presentation

- Industrial Robots
- Service Robots

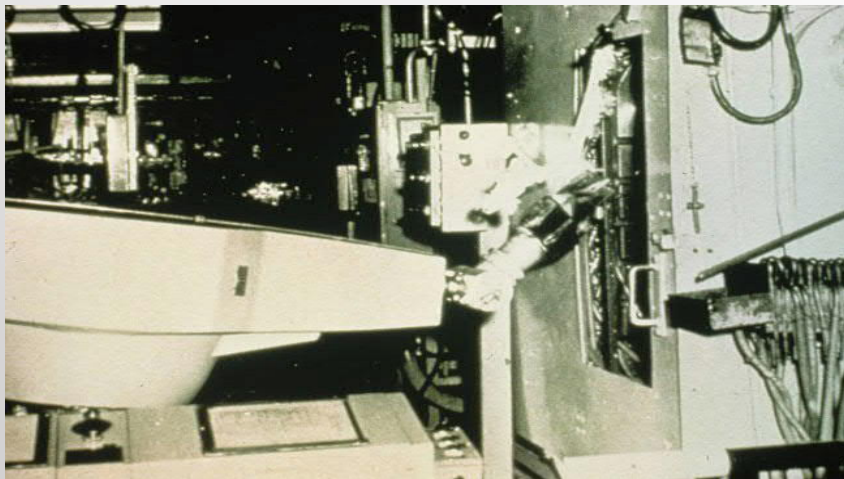


Preview on World Robotics 2018

- Industrial Robots 2017
 - Global installations
 - Regions
 - Main Markets
 - Main Customers
 - Challenges of the Robotics Industry

Some figures of the presentation were taken from previous edition of World Robotics

The Birth of Real Industrial Robotics

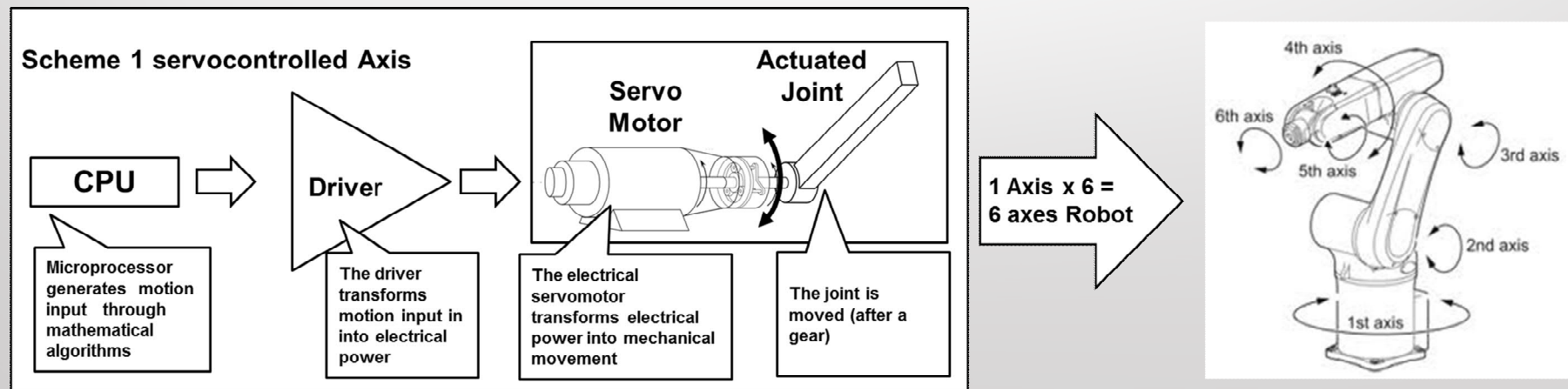


- First robot installed
- 1961 in GM plant, Trenton NJ
- Handled various hot pieces of diecast metal and stacked them
- Weight 2 tons
- Hydraulically driven
- Controlled by a program on magnetic drums
- Developed by George Devol and Joe Engelberger, 2 pioneers of Robotics

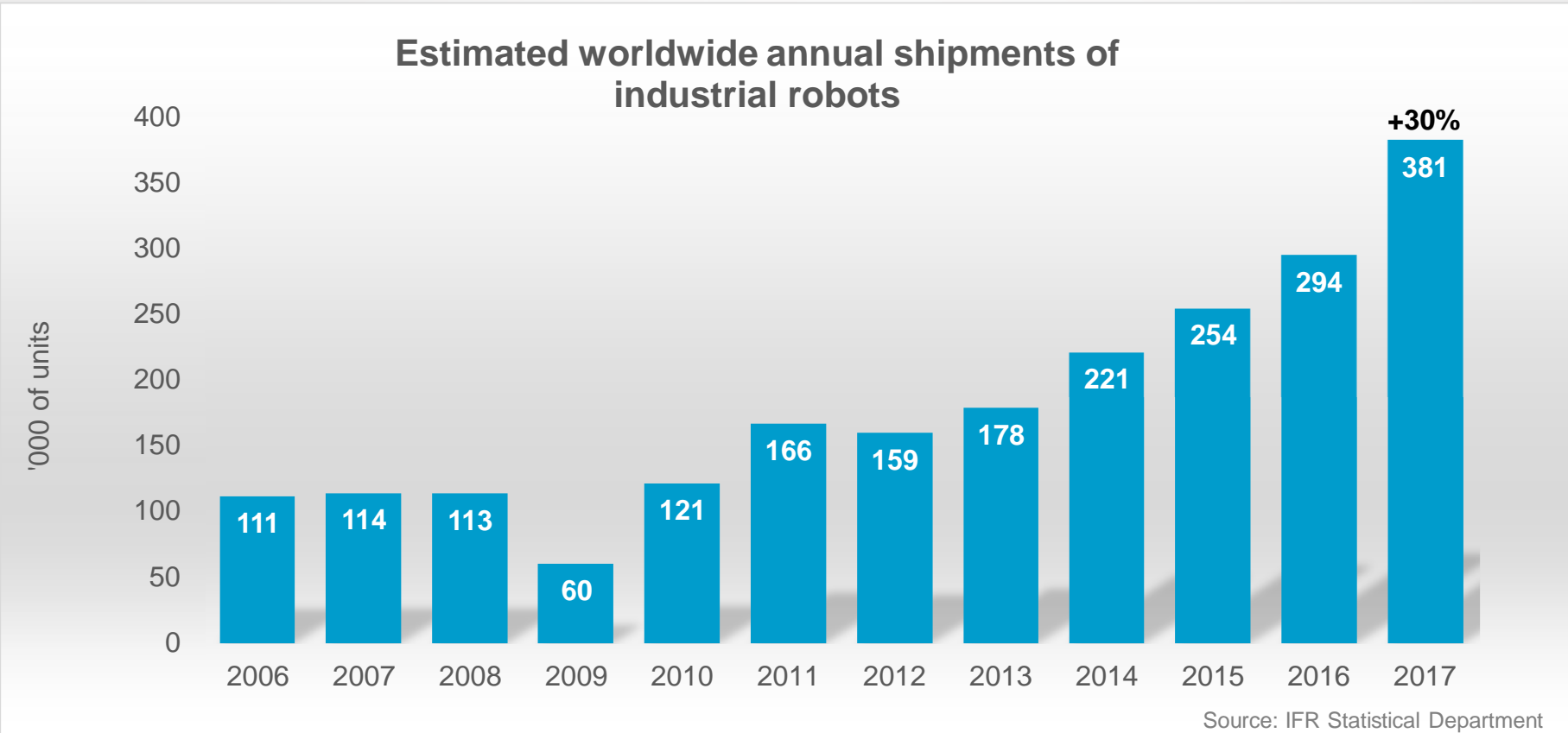
Technical definition of industrial Robot

ISO definition 8373 of a robot:

- An automatically controlled, reprogrammable, multipurpose manipulator programmable in **three or more axes**, which may be either fixed in place or mobile for use in industrial automation applications.
- Reprogrammable: whose programmed motions or auxiliary functions may be changed without physical alterations;
- Multipurpose: capable of being adapted to a different application with physical alterations;
- Physical alterations: alteration of the mechanical structure or control system except for changes of programming cassettes, ROMs, etc. o Axis: direction used to specify the robot motion in a linear or rotary mode



2017: record growth of industrial robots

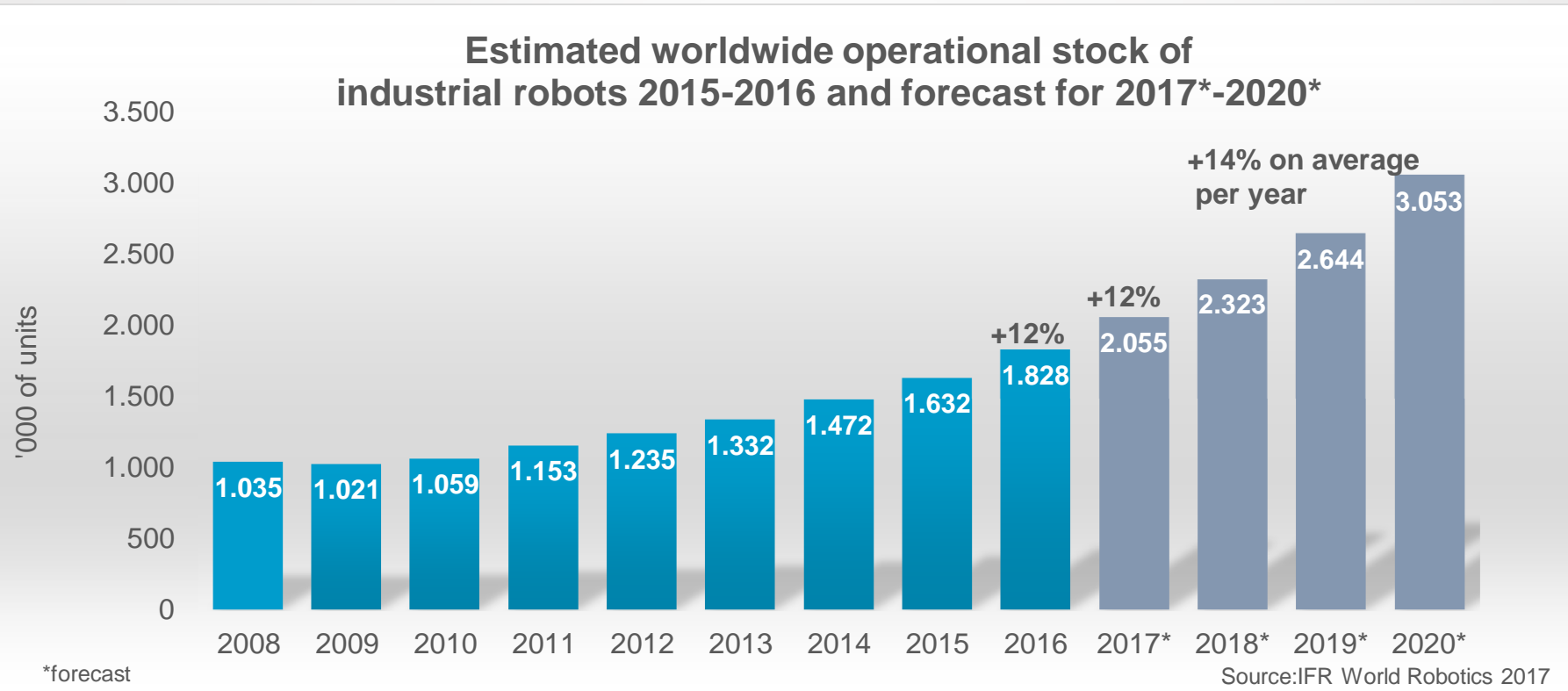


N.1 1961



2020: 3 million industrial robots in operation

Estimated worldwide operational stock of industrial robots 2015-2016 and forecast for 2017*-2020*

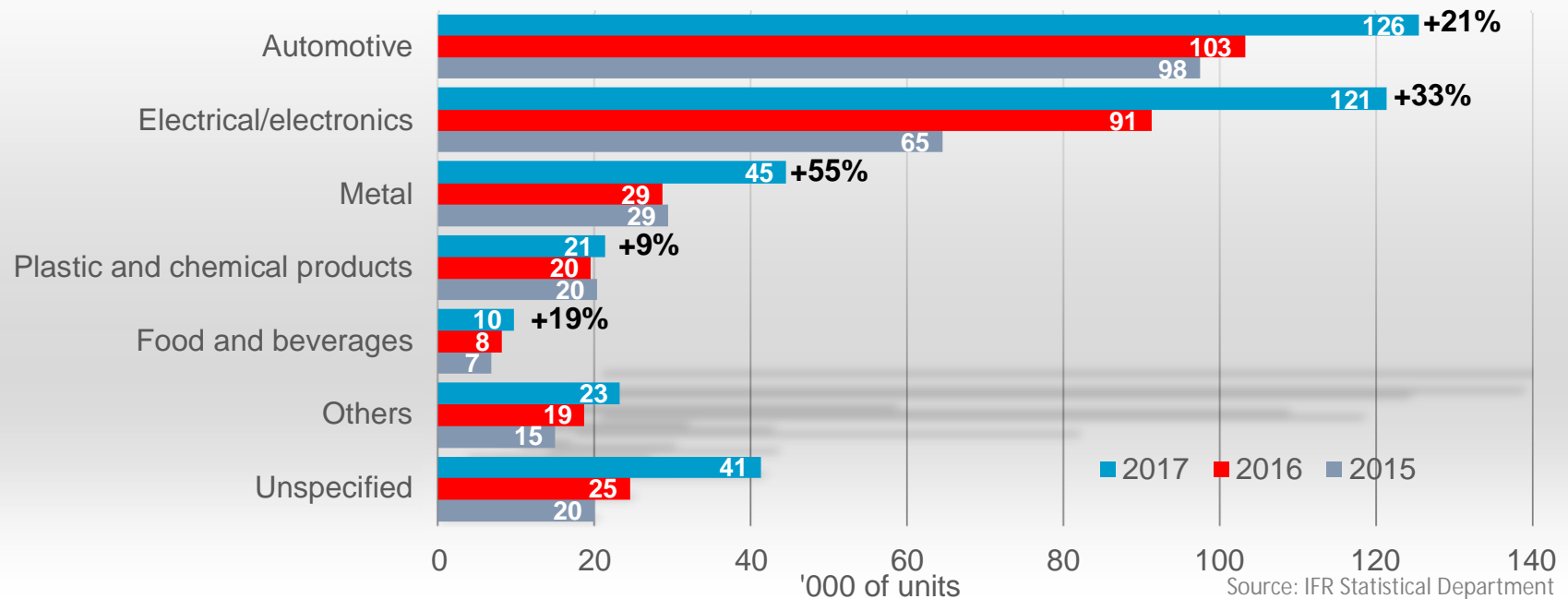


N.1 1961



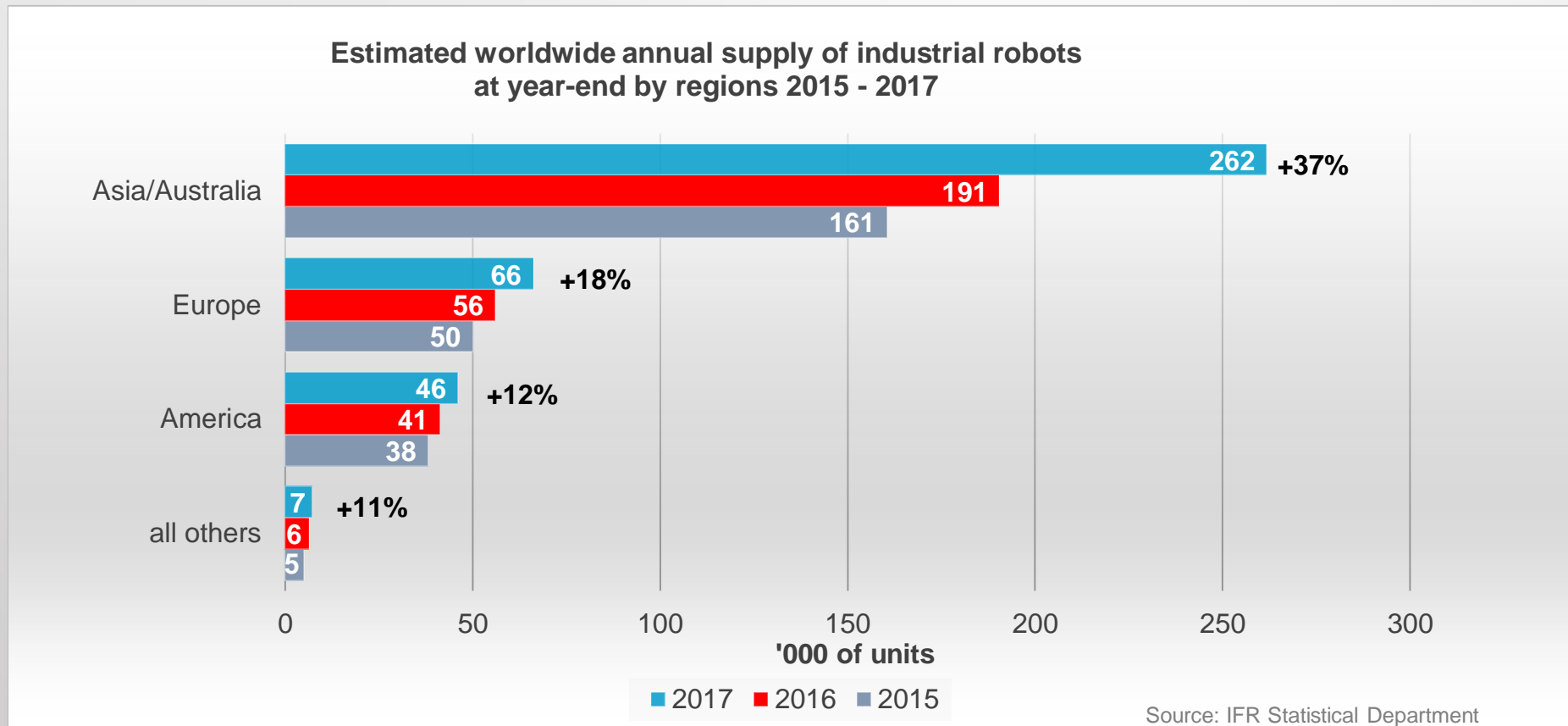
2017: electronics, automotive and metal industry are main drivers

Estimated annual supply of industrial robots at year-end
by industries worldwide 2015-2017

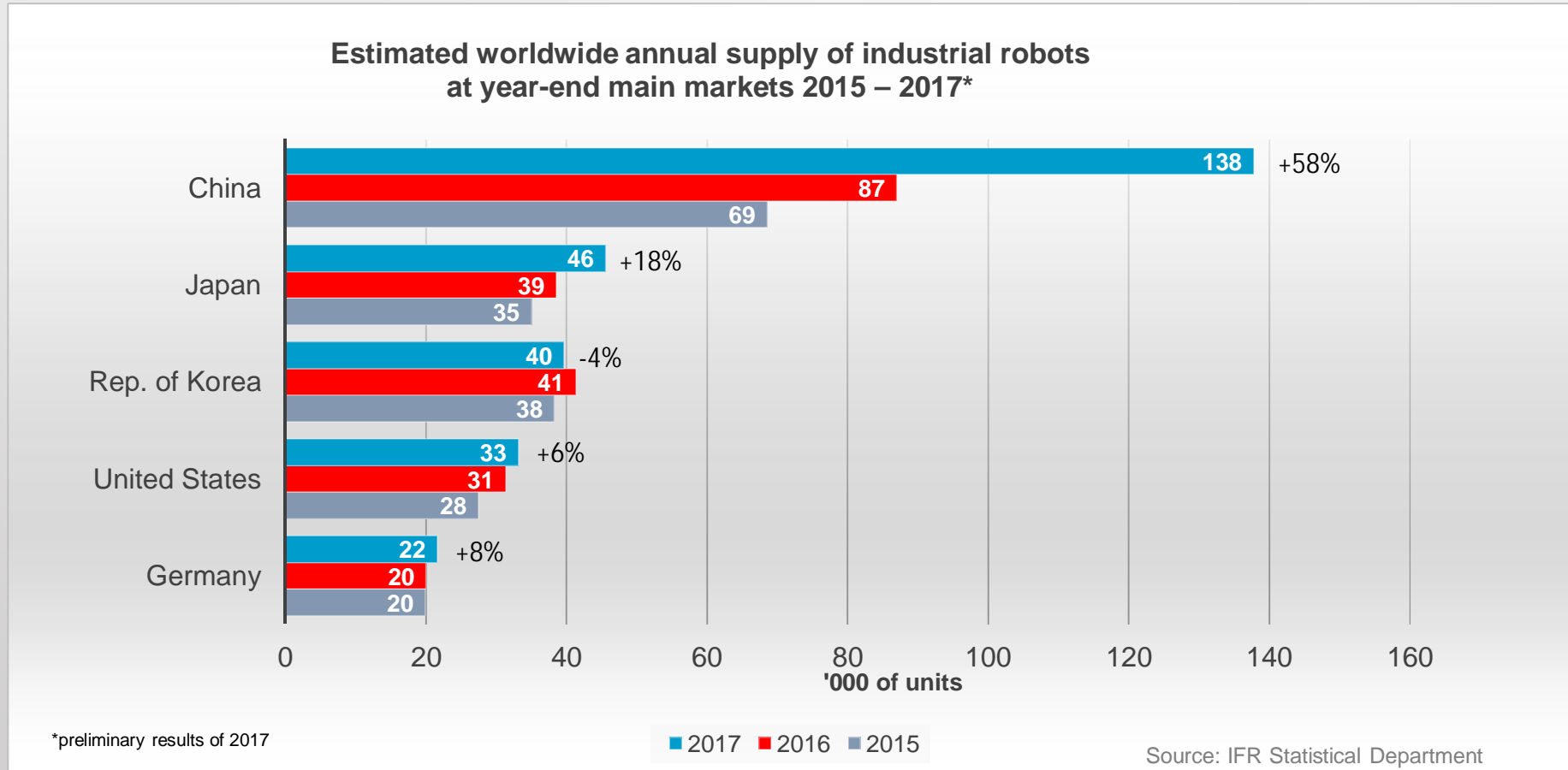


Source data August 2018

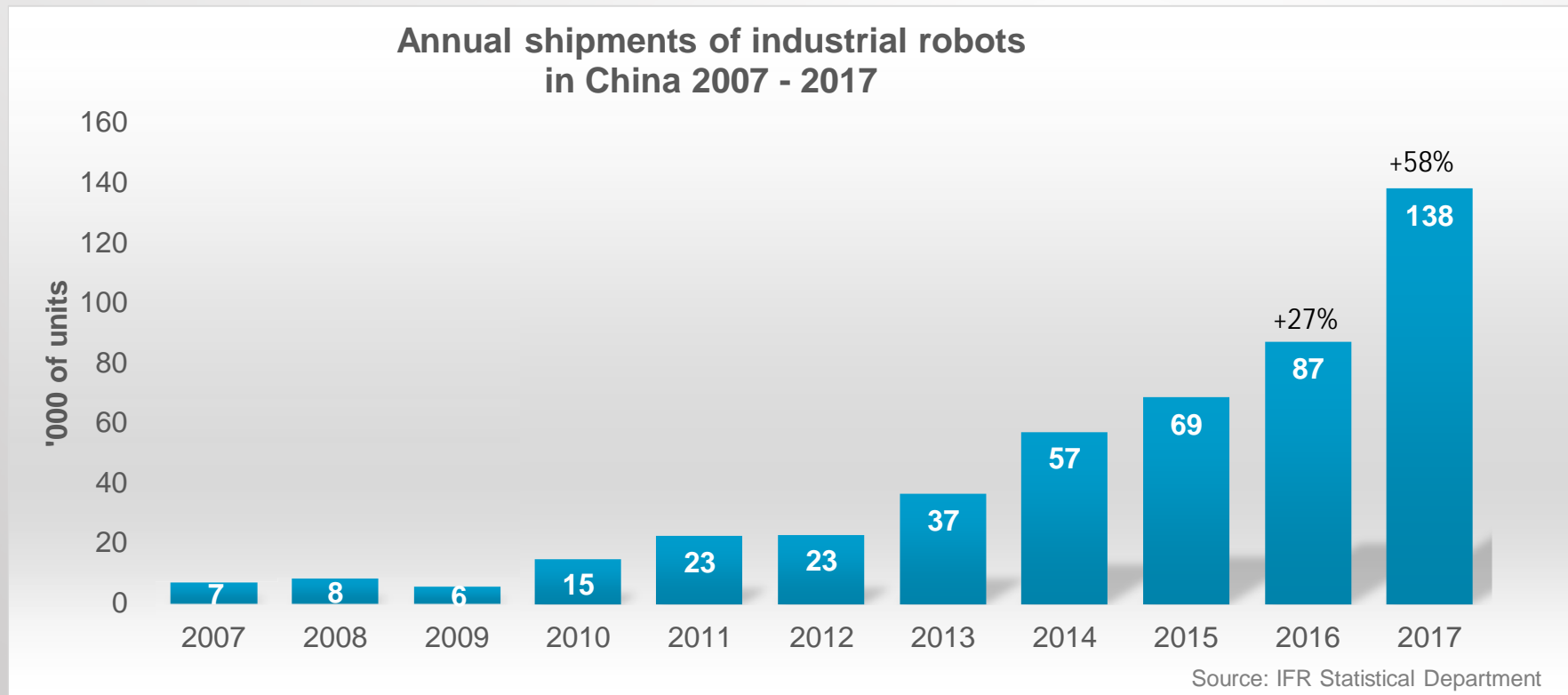
2017: considerable increase in all regions



Top 5 countries represent 73% of total sales in 2017

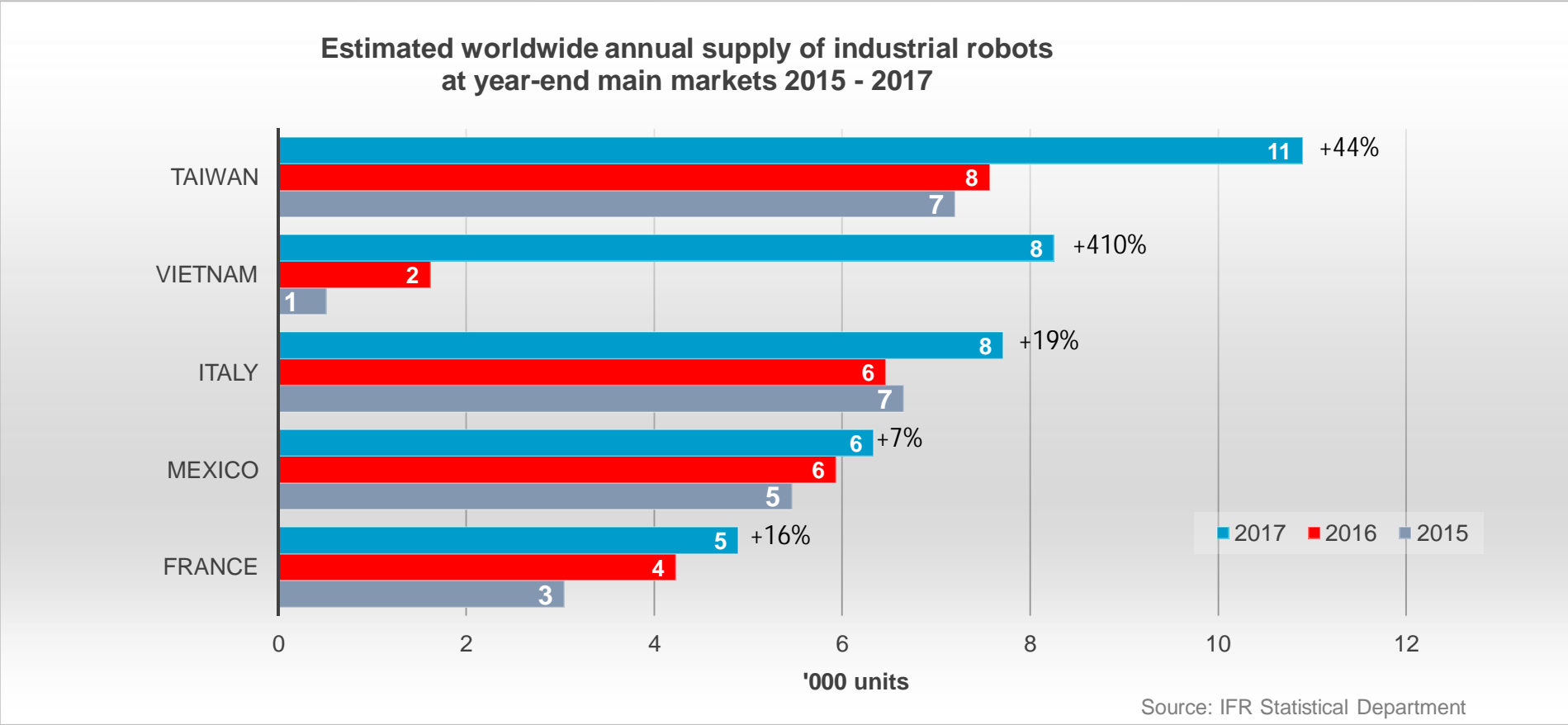


China: Main driver of growth in 2017

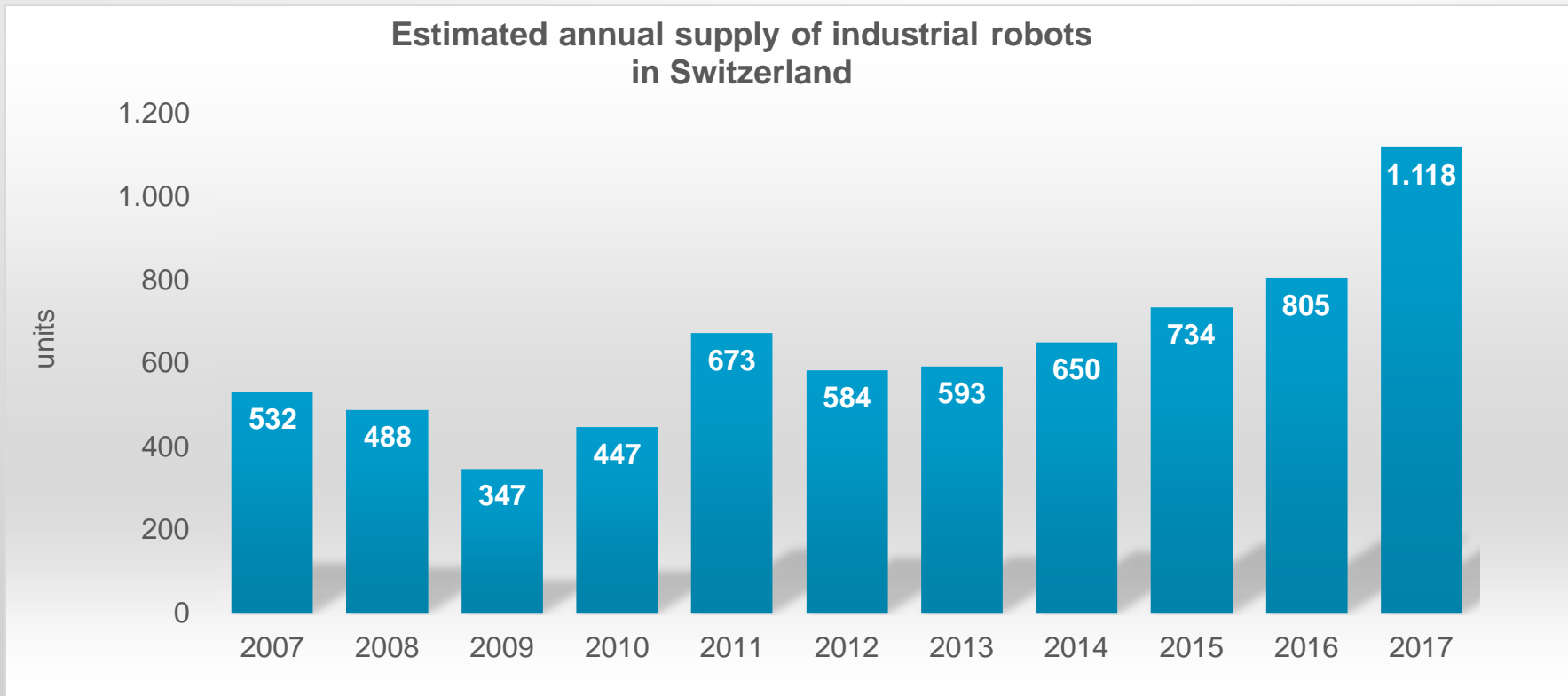


Source data August 2018

Vietnam now 7th largest destination



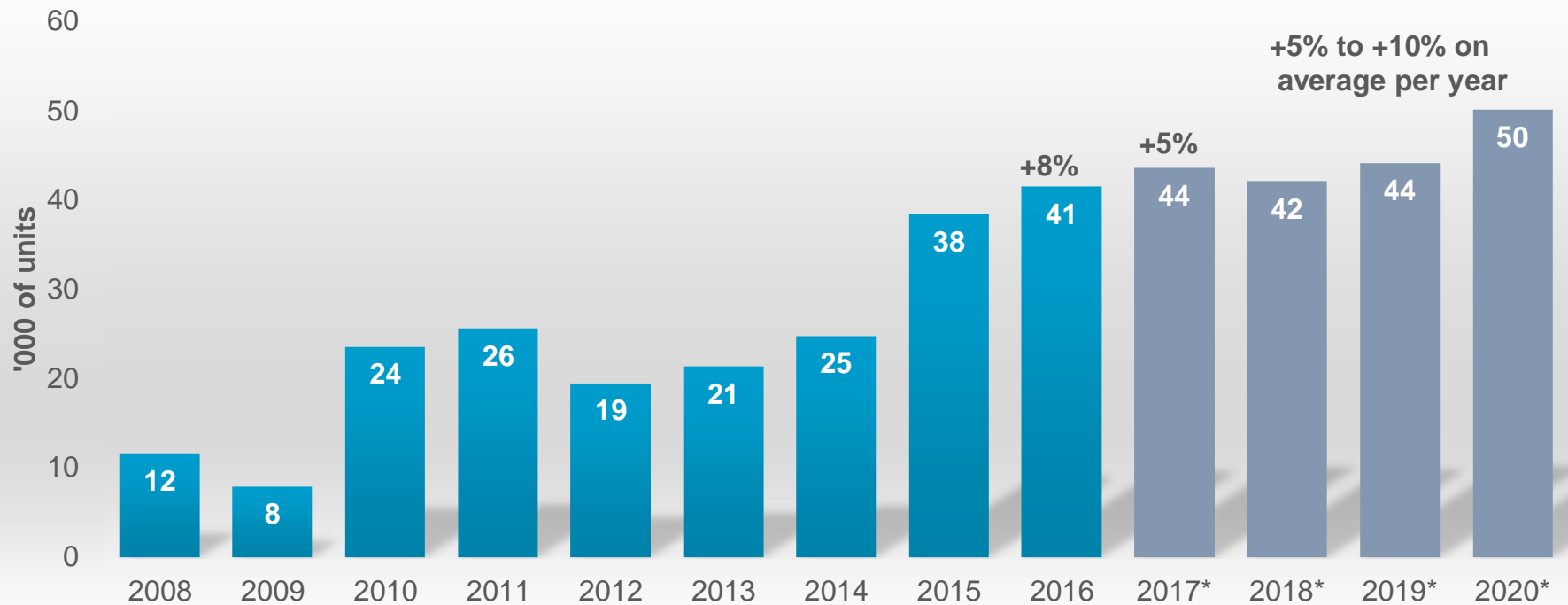
Considerable increase in Switzerland



Source data August 2018

Rep. of Korea: considerable increase since 2010

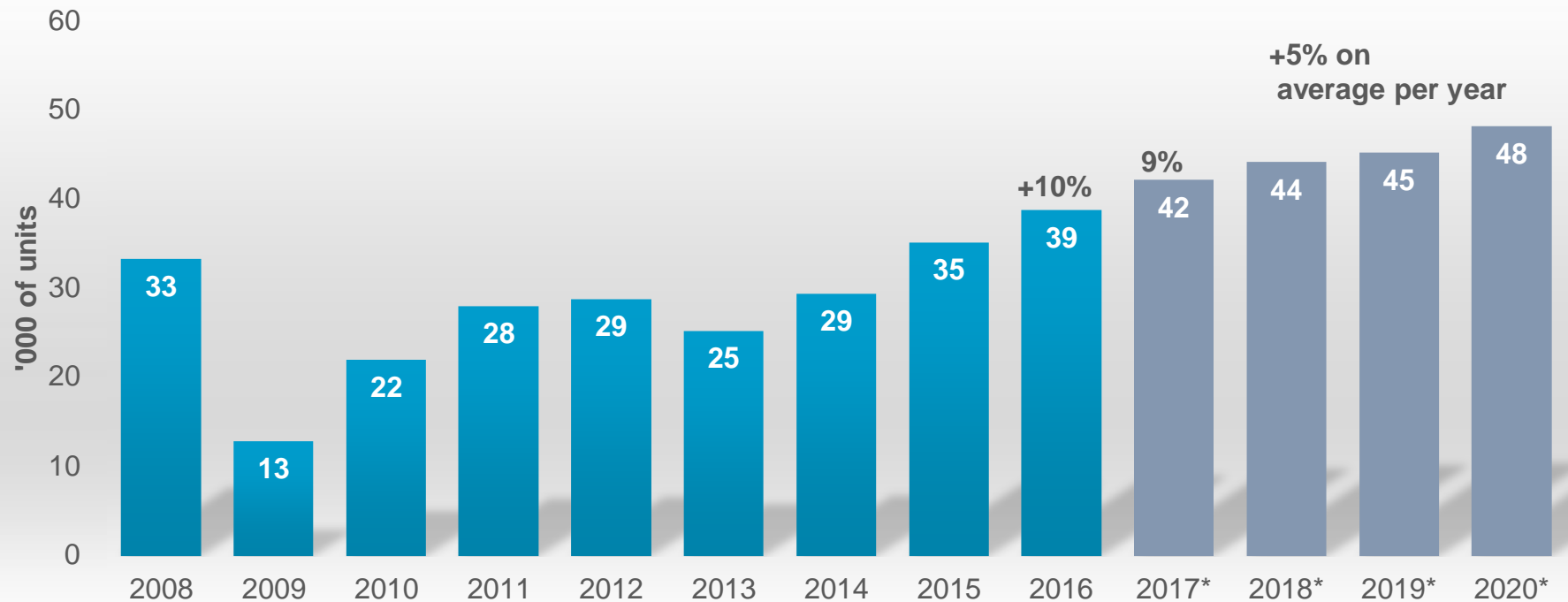
Estimated annual supply of industrial robots
in the Rep. of Korea 2008-2016 and 2017*-2020*



Source: IFR World Robotics 2017

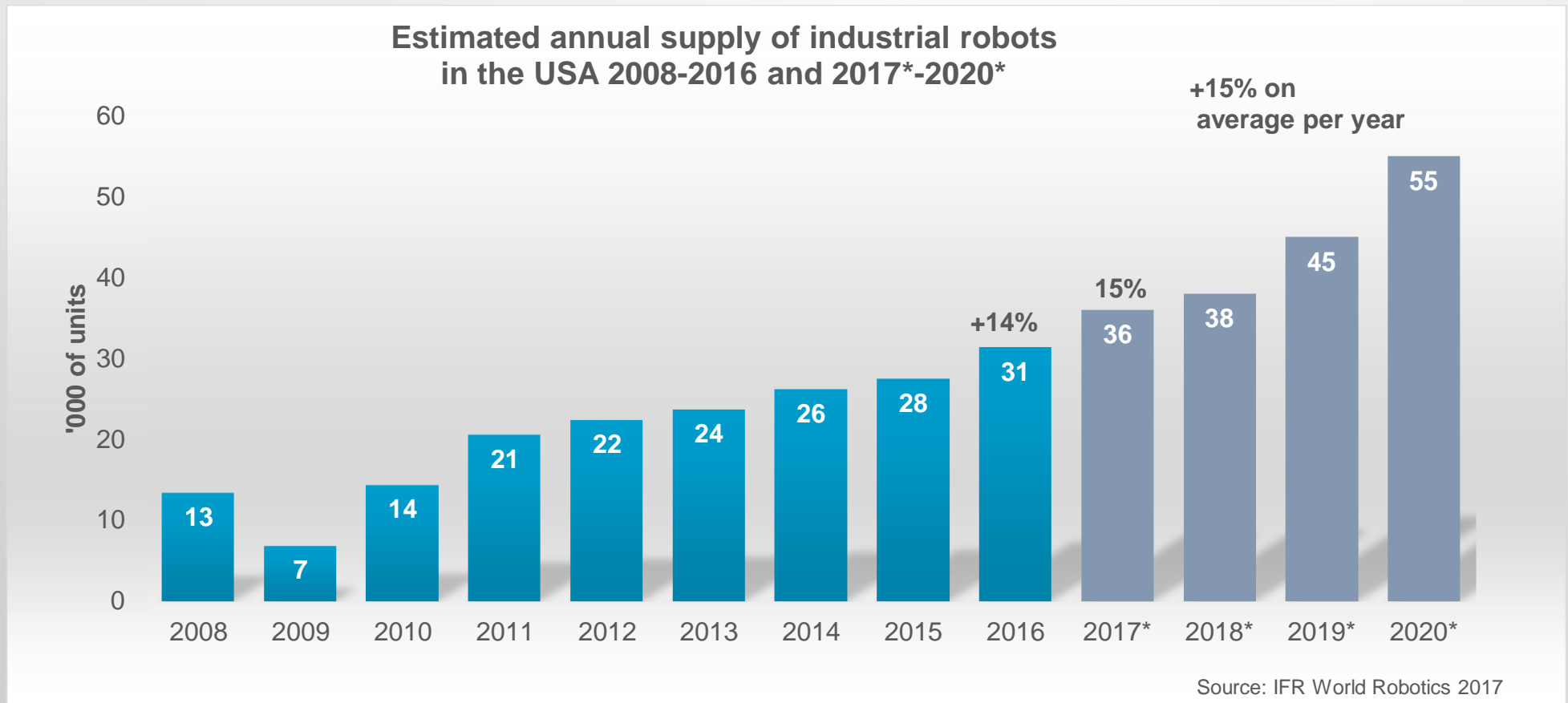
Japan: significant recovery and continued growth

Estimated annual supply of industrial robots
in Japan 2008-2016 and 2017*-2020*

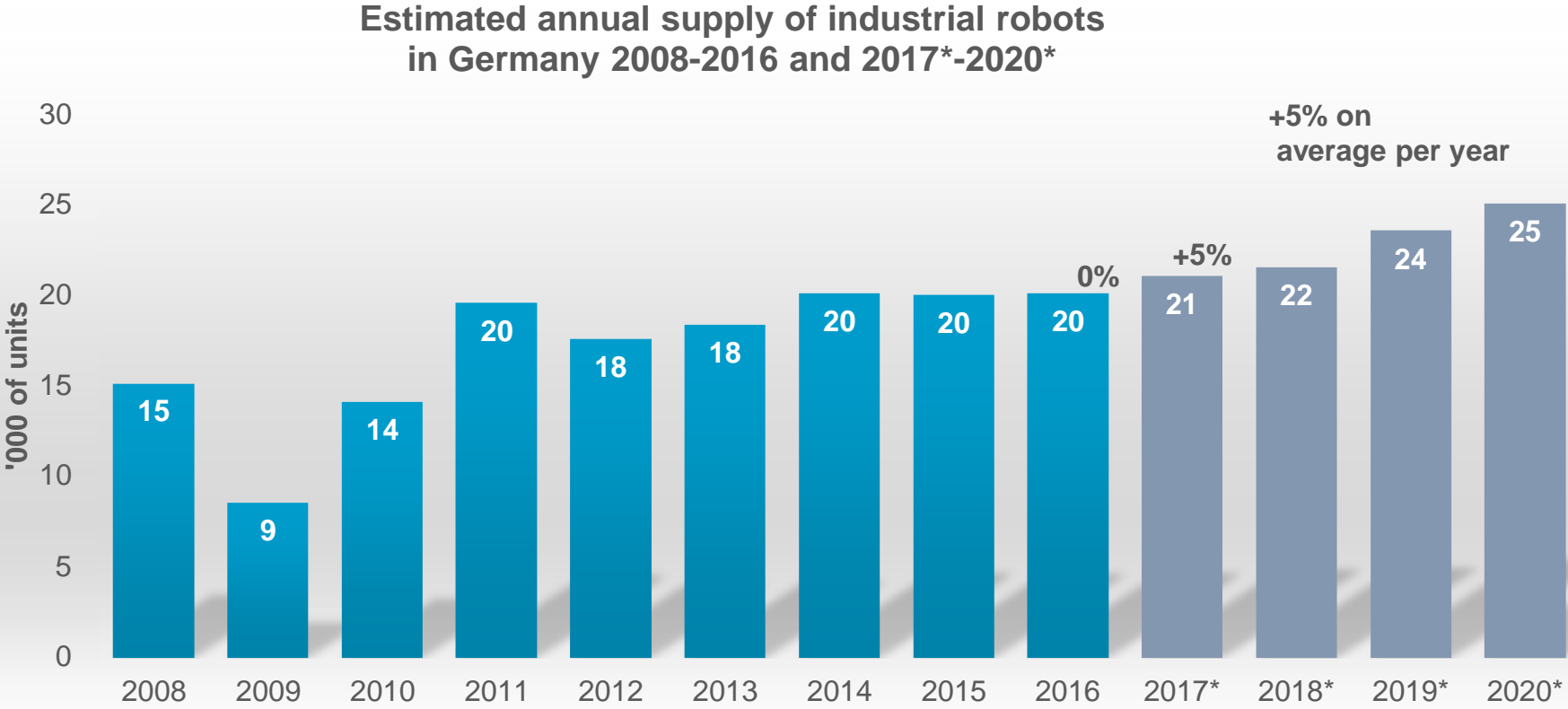


Source: IFR World Robotics 2017

USA: considerable increase since 2010



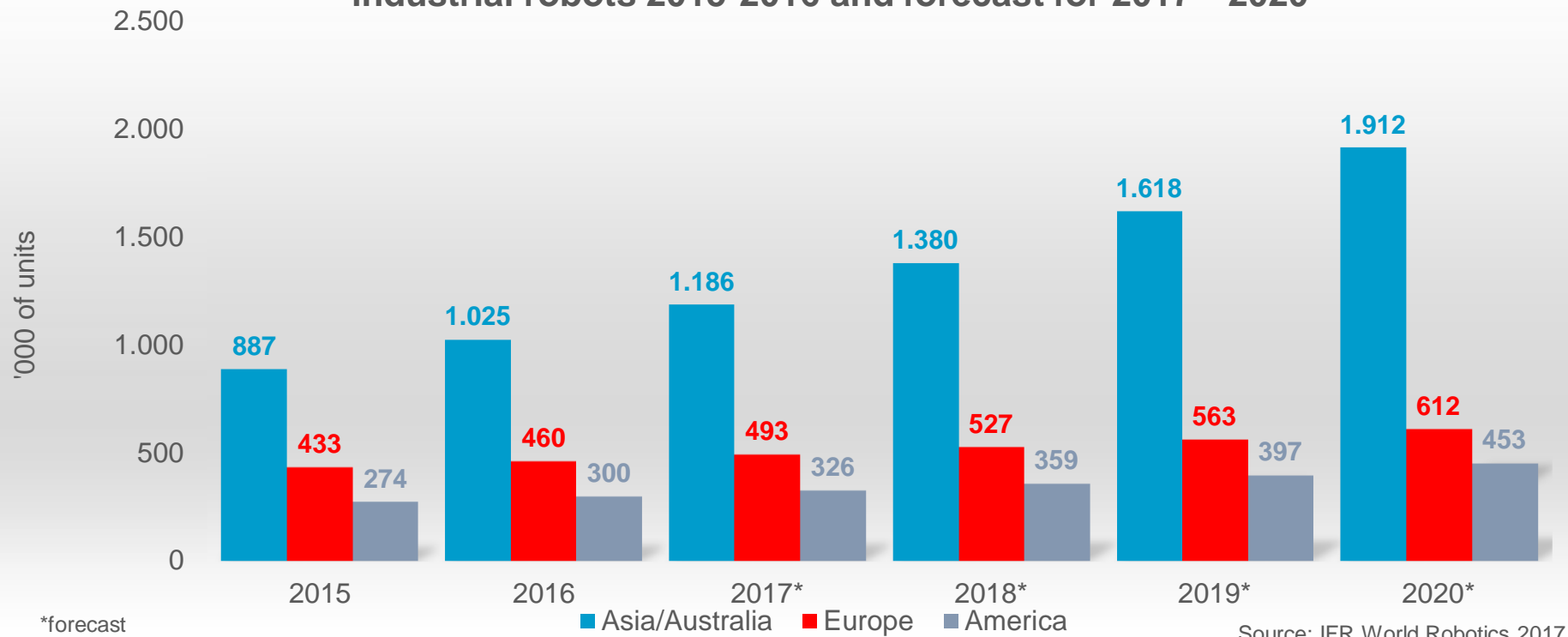
Germany: moderate increase at record levels



Source: IFR World Robotics 2017

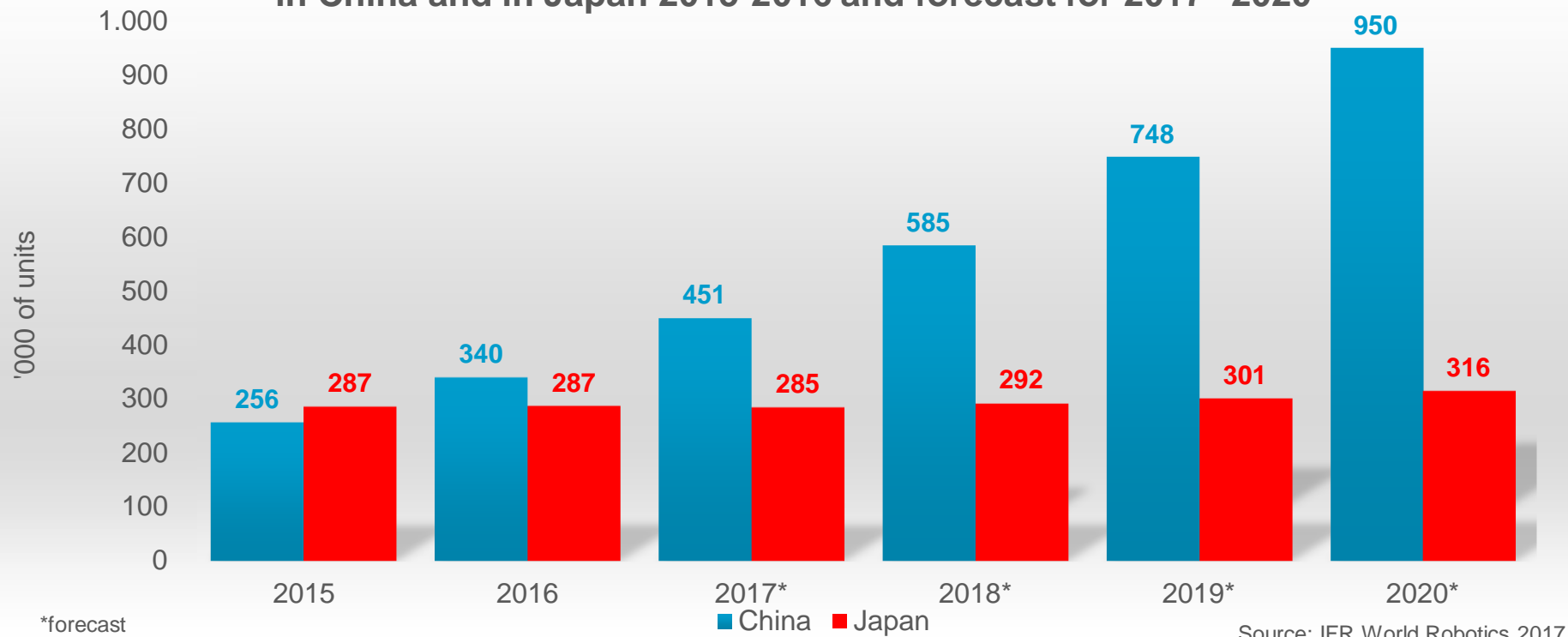
2020: 1.9 million operating in Asian factories

Estimated worldwide operational stock of industrial robots 2015-2016 and forecast for 2017*- 2020*



2020: 950,000 robots operating in China

Estimated operational stock of industrial robots
in China and in Japan 2015-2016 and forecast for 2017*-2020*



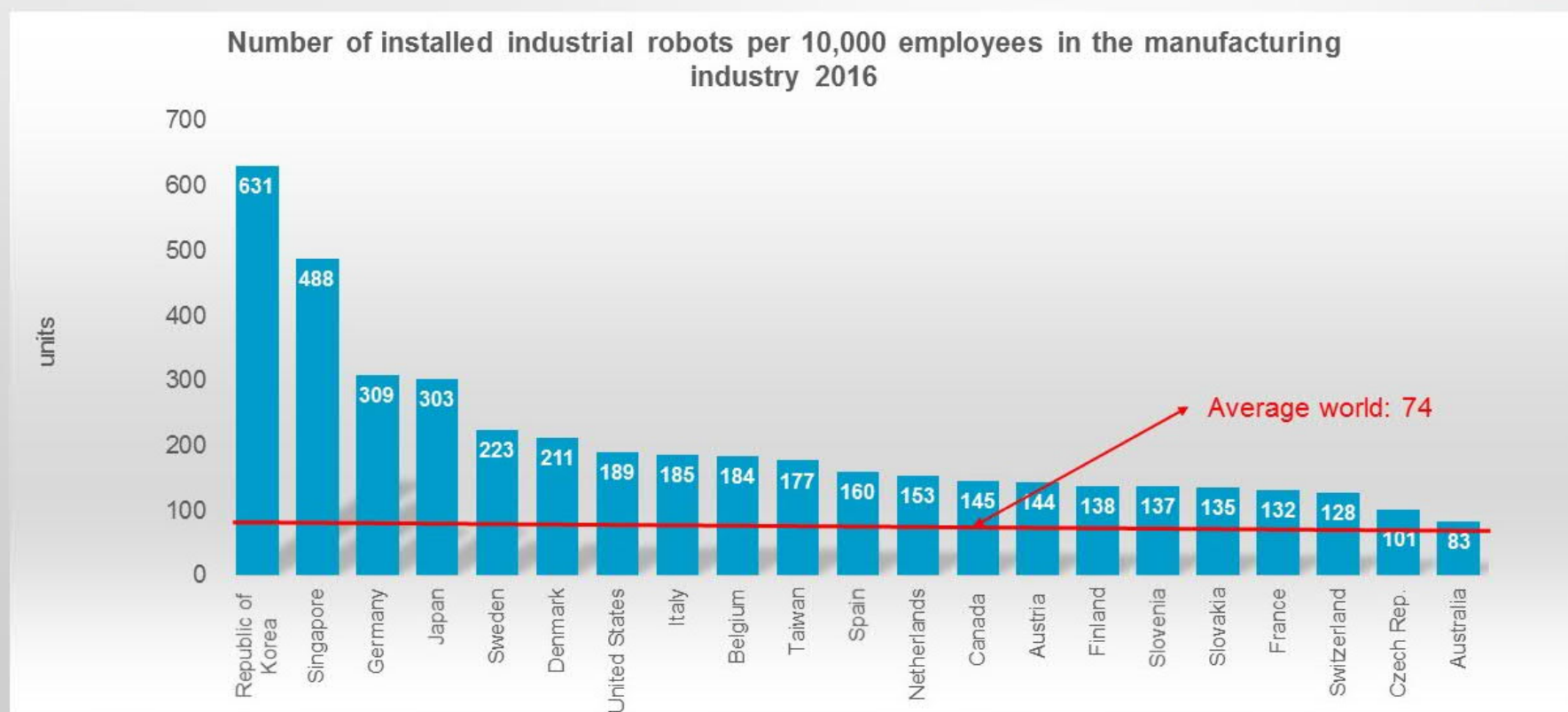
Density of Robots

Density of Robots = Robots / 10.000 Manufacturing Employees

World average = 74

Republic of Korea at the top = 631

China = 49 . Enormous potential to further growth.



Source: World Robotics 2017

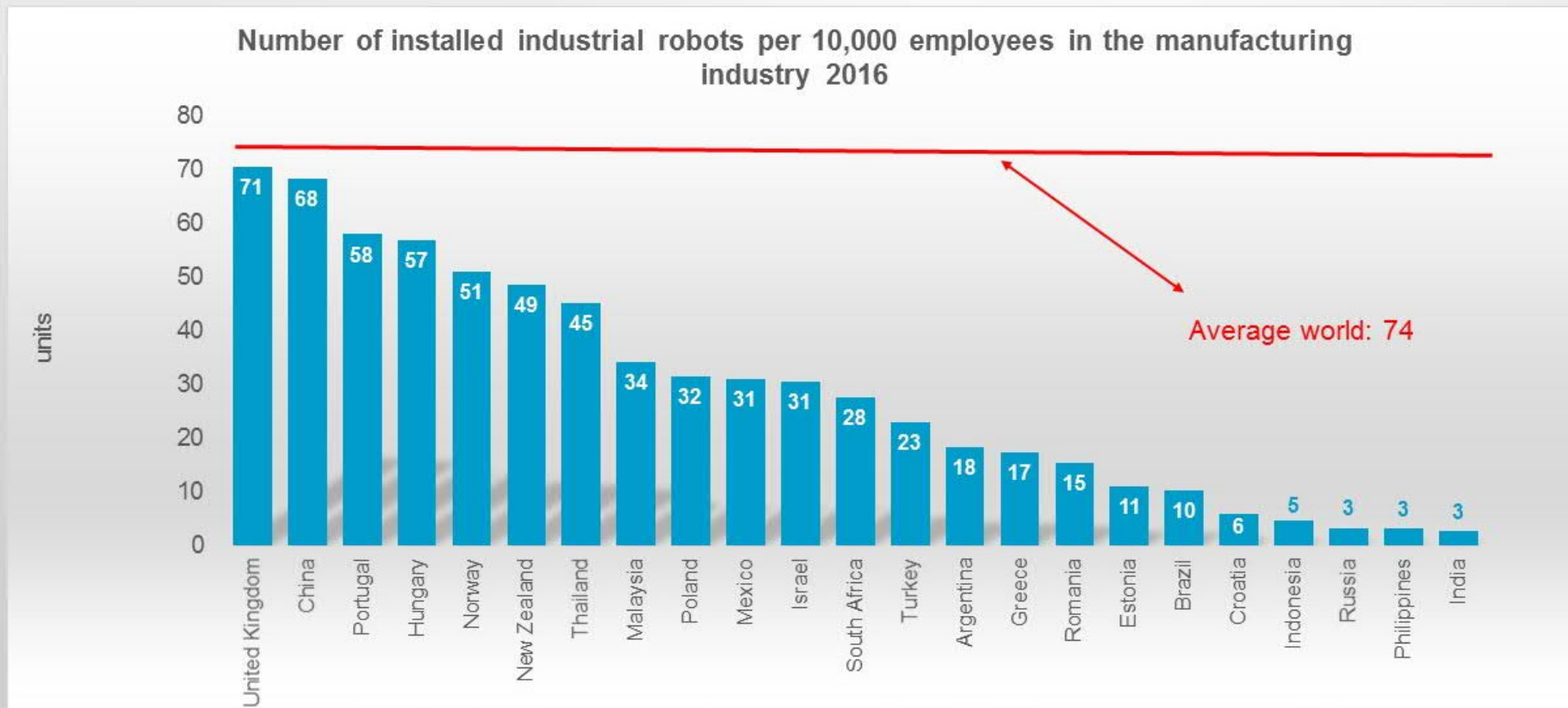
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Source: World Robotics 2017



Today's trends, tomorrow's robots!

The Changing Nature of Manufacturing & Work

- Shift from high volume/low mix to low volume/high mix is having a profound impact on manufacturing.
- Many industries facing acute shortages of skilled labor.
- Quicker automation ROIs and rising wages bringing an end to labour arbitrage.
- Increasing focus on workplace safety.

Addressing these Realities : a Huge Opportunity

The Trends

The Challenges

The Enablers



Low volume high mix

Automation complexity and unpredictability

Collaborative automation for greater flexibility



Shorter cycles, faster launches

Shop floor disruptions and high engineering costs

Better software for engineering efficiency



Increased need for automation and scalability in SMEs

Lack of robot integration and programming expertise

Easier to use robots with more intuitive programming



Rising cost of downtime

Higher lifetime TCO due to increase in planned downtime

Advanced analytics and services for greater reliability



Increased and sporadic human intervention

Lost productivity to maintain safety

Collaborative automation to maintain safety and productivity

**The Answers to these challenges lie in
Simplification, Digitalisation and Collaboration**

Simplification

- Robots which are easier to install, program and operate will unlock entry barriers to the large, untapped market of small and medium enterprises (SMEs).
- Trend towards having production closer to the end consumer driving the importance of standardisation & consistency across global brands.

Digitalisation

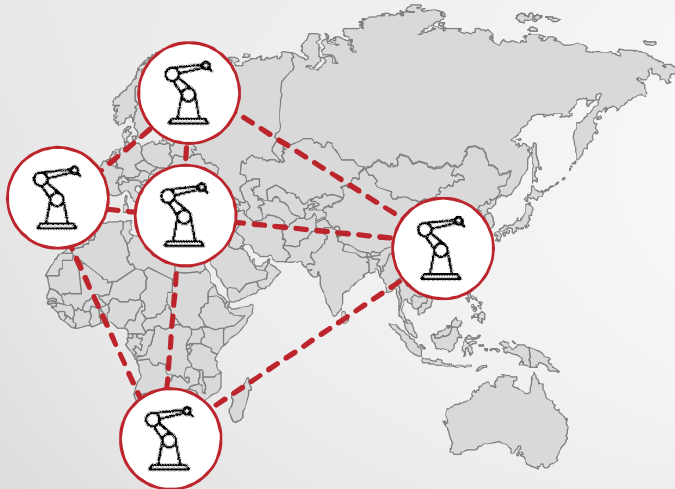
- Industry 4.0, linking the real-life factory with a virtual one, will play an increasingly important role in global manufacturing.
- Vision and sensing devices, coupled with analytics platforms, will pave the way for new industry business models.
- Machine Learning will drive many robotics developments over the coming years.

Collaboration

- Collaborative robots are shifting the traditional limits of “what can be automated?”
- Collaborative robots increase manufacturing flexibility as ‘low volume high mix’ becomes the new normal
- Collaboration is also about productivity with increased human/robot interaction

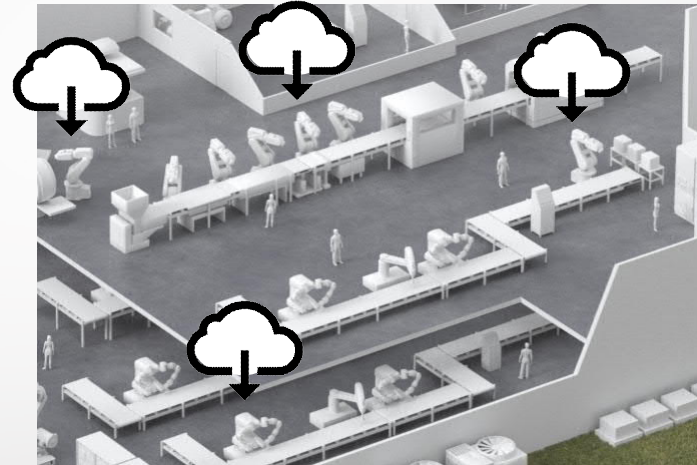
Robotics : the Connected Future

Self-optimising Production



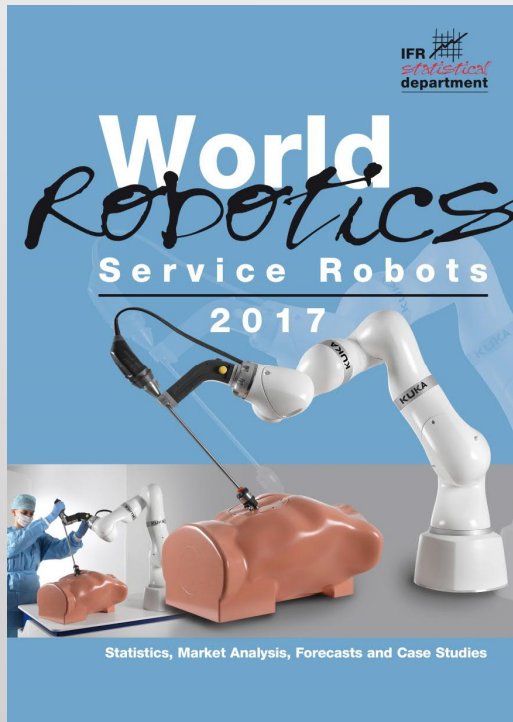
Robots doing the same task connect across all global locations so performance can be compared and improved at the click of a button.

Self-programming Robots



Robots automatically download what they need to get started from a cloud library and then start to optimise through “self-learning”.

Structure Of Presentation



- Industrial Robots
- **Service Robots**

Definitions of Service Robots

A **service robot** is a robot that performs useful tasks for humans or equipment excluding industrial automation application.

Note: The classification of a robot into industrial robot or service robot is done according to its intended application.

- A **personal service robot** or a service robot for personal use is a service robot used for a non-commercial task, usually by lay persons.

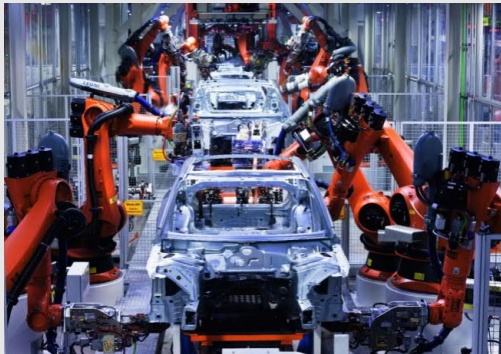
Examples are domestic servant robot, automated wheelchair, personal mobility assist robot, and pet exercising robot.

- A **professional service robot** or a service robot for professional use is a service robot used for a commercial task, usually operated by a properly trained operator.

Examples are cleaning robot for public places, delivery robot in offices or hospitals, fire-fighting robot, rehabilitation robot and surgery robot in hospitals. In this context an operator is a person designated to start, monitor and stop the intended operation of a robot or a robot system.

What is a service robot?

Industrial Robots



Industrial environments

Service Robots

Professional Use



Personal/domestic



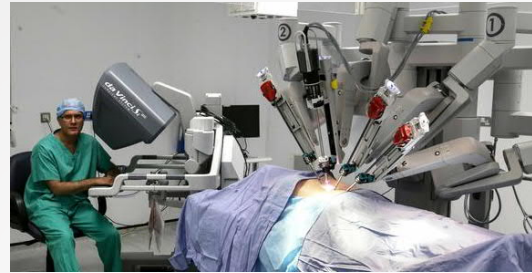
Non-industrial environments

Picture source: Goldbeck, ;KUKA AG, Bosch Bonirob, Hetwin, SMP Robotics, Omron, International Submarine Engineering , Robert Bosch Hausgeräte , Wonder Workshop

Professional Service Robots



Image credit
Lely



Source: Intuitive Surgical



Source: Rewalk

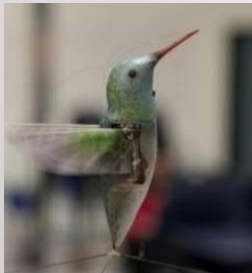


Image credit
AeroVironment



Image credit
Cobham



Image credit
Schilling Robotics



Source: BA Systems

Source: IFR World Robotics

Professional service robots: significant growth

2016: almost 60,000 units, +24%

Forecast 2017: +17% -almost 79,000 units

**Forecast 2018 -2020: about 400,000 units
20% to 25% on average per year**

Professional service robots: increasing turnover

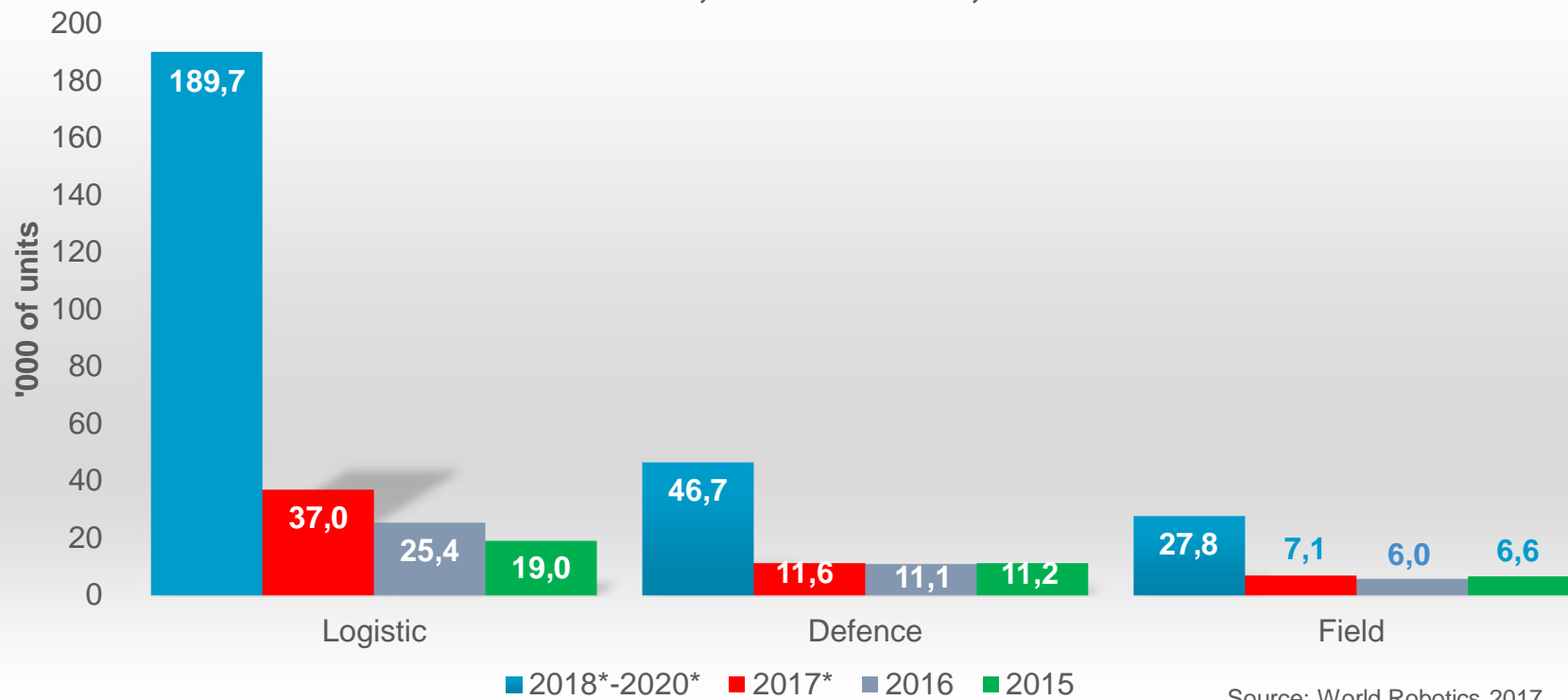
2016: 4.7 US\$bn, +2%

Forecast 2017: +12% - 5.2 US\$bn

**Forecast 2018 -2020: 26.8 US\$bn
20% to 25% on average per year**

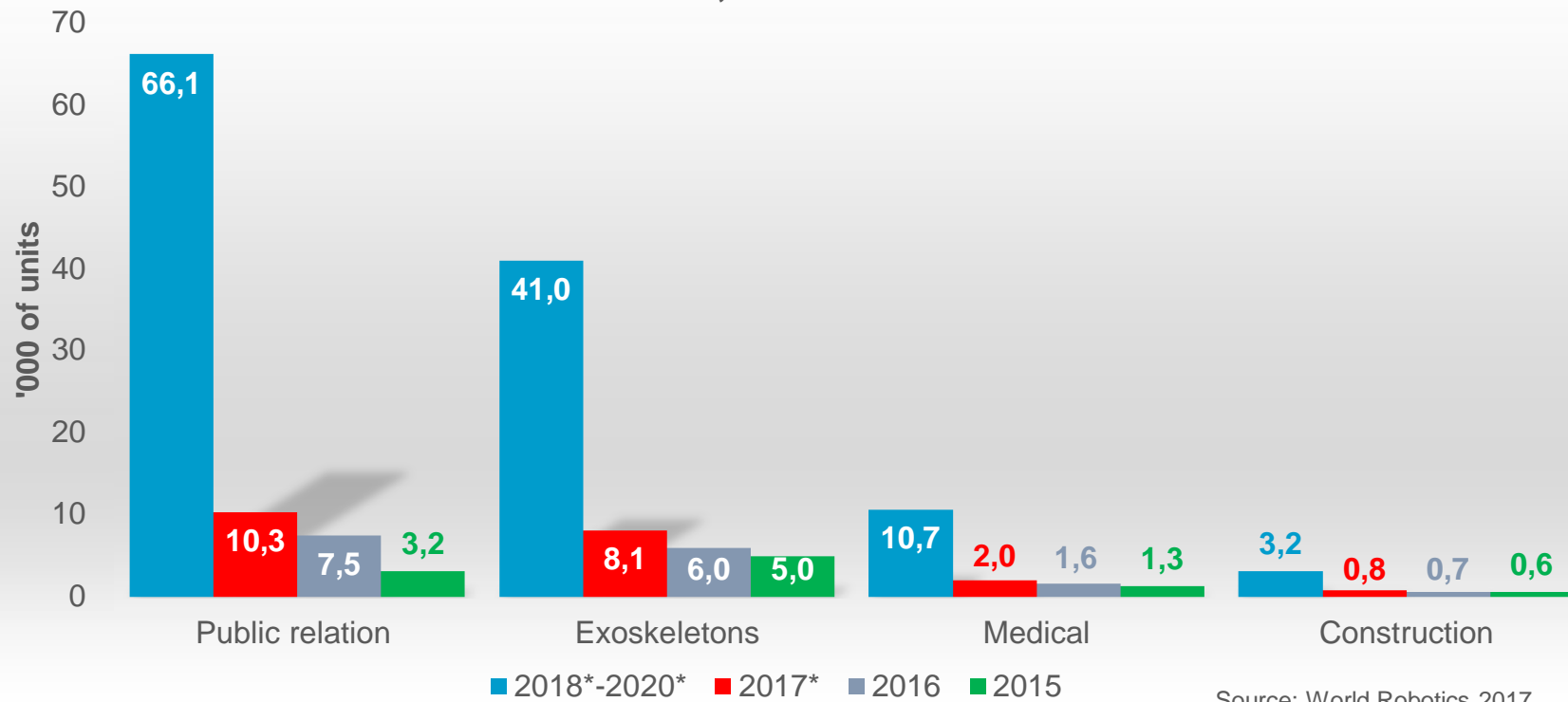
Main drivers: logistic systems

Service robots for professional use. Main applications
Units sales 2015 and 2016, forecast 2017*, 2018*-2020*



Public relation robots and exoskeletons on the rise

Service robots for professional use. All other applications - 1 -
Units sales 2015 and 2016, forecast 2017* and 2018*-2020*

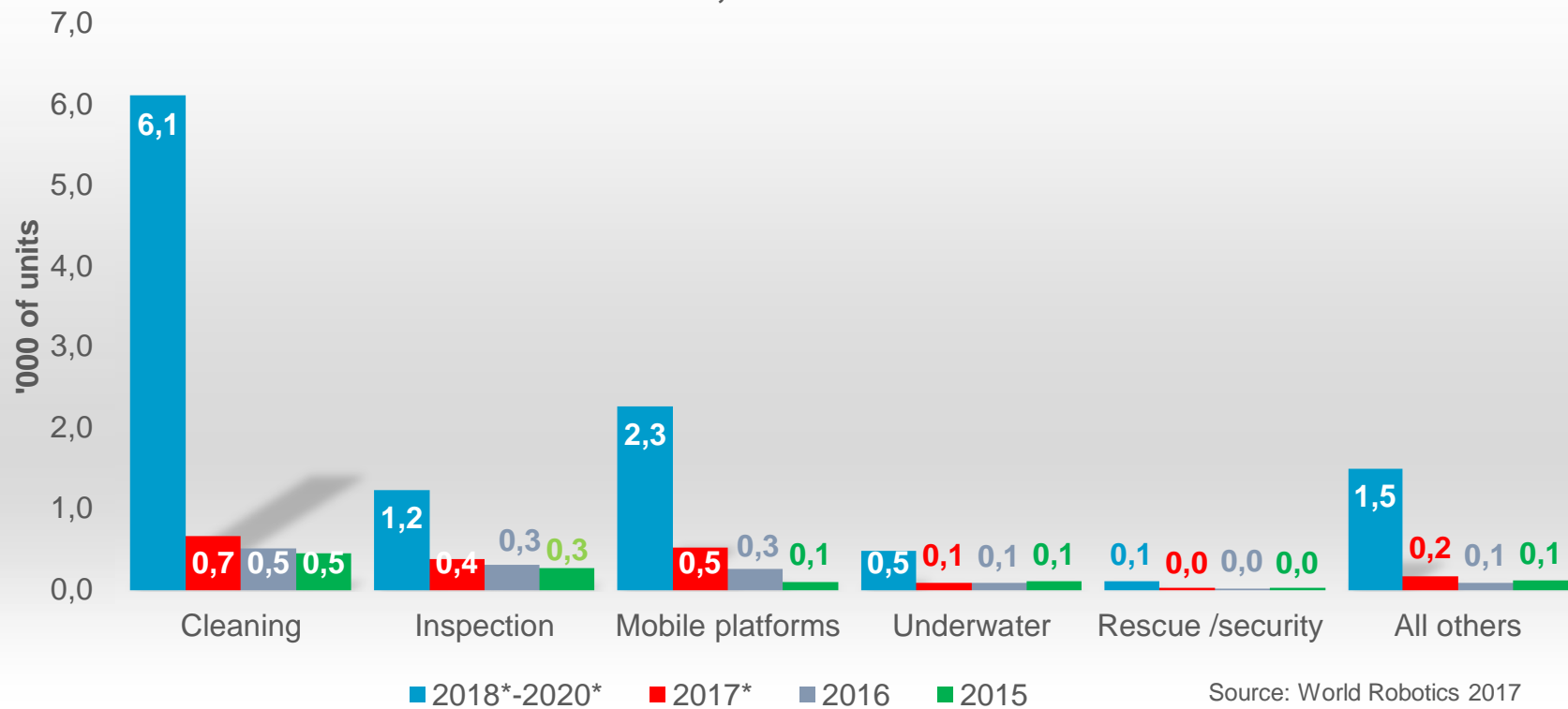


*forecast

Source: World Robotics 2017

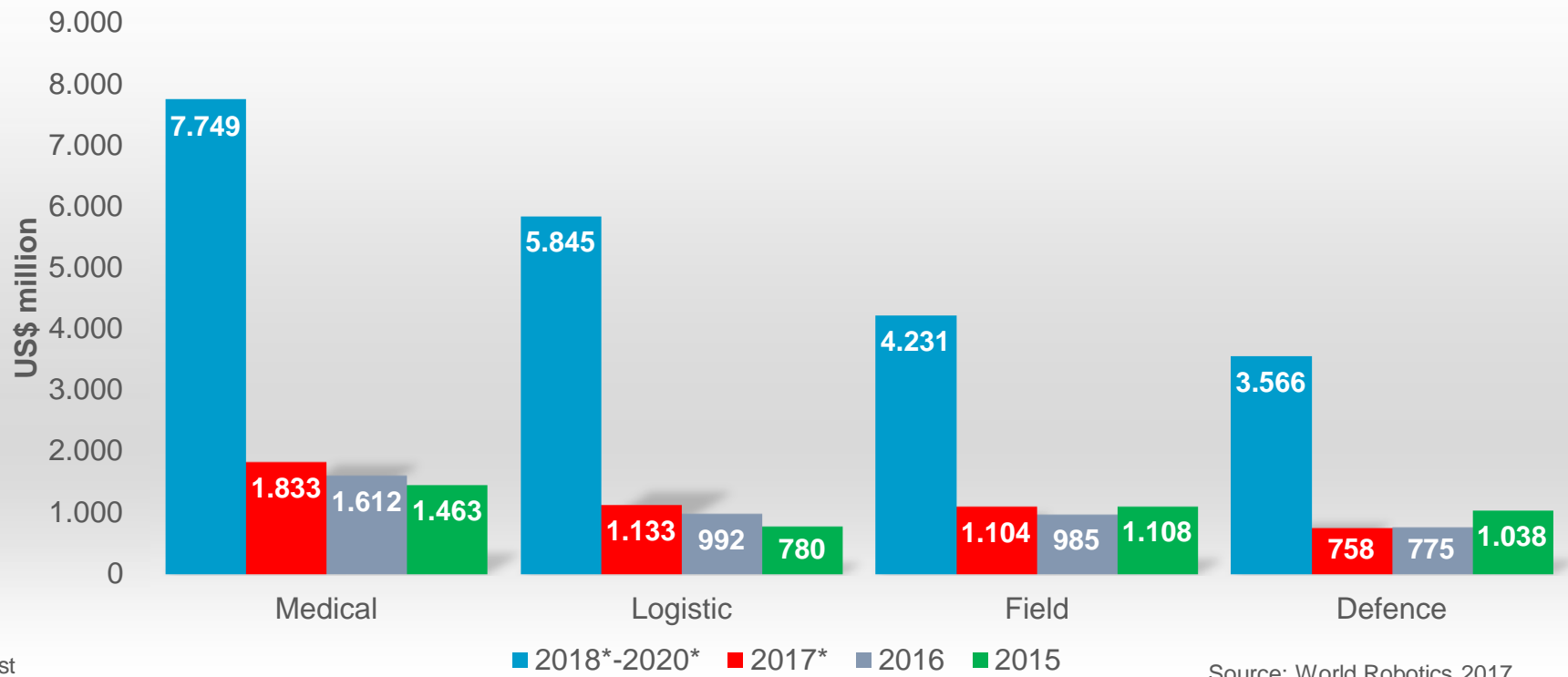
Good prospects for cleaning robots

Service robots for professional use. All other applications - 2 -
Units sales 2015 and 2016, forecast 2017* and 2018*-2020*



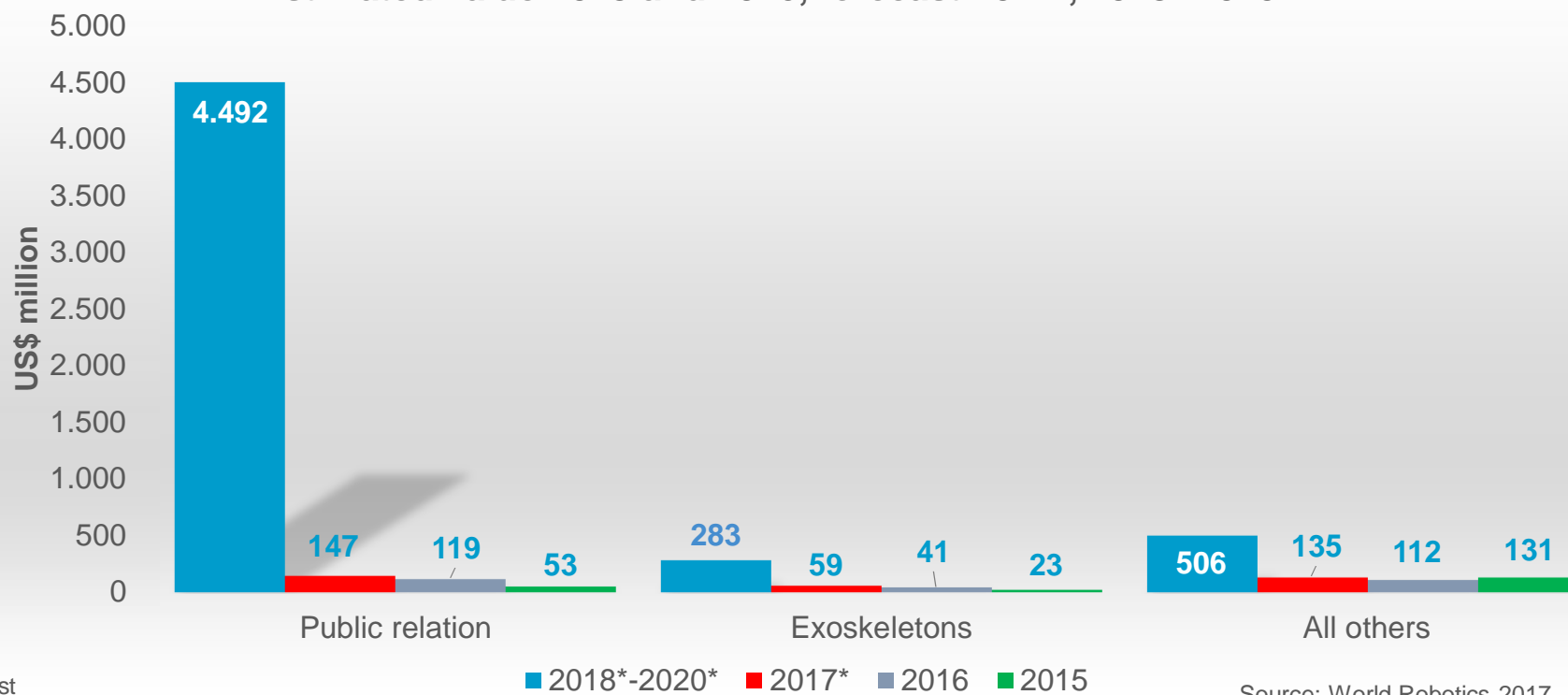
Medical robots: most valuable

Service robots for professional use in main applications. Estimated values 2015 and 2016, forecast 2017*, 2018*-2020*



Public relation robots: significant increase of turnover

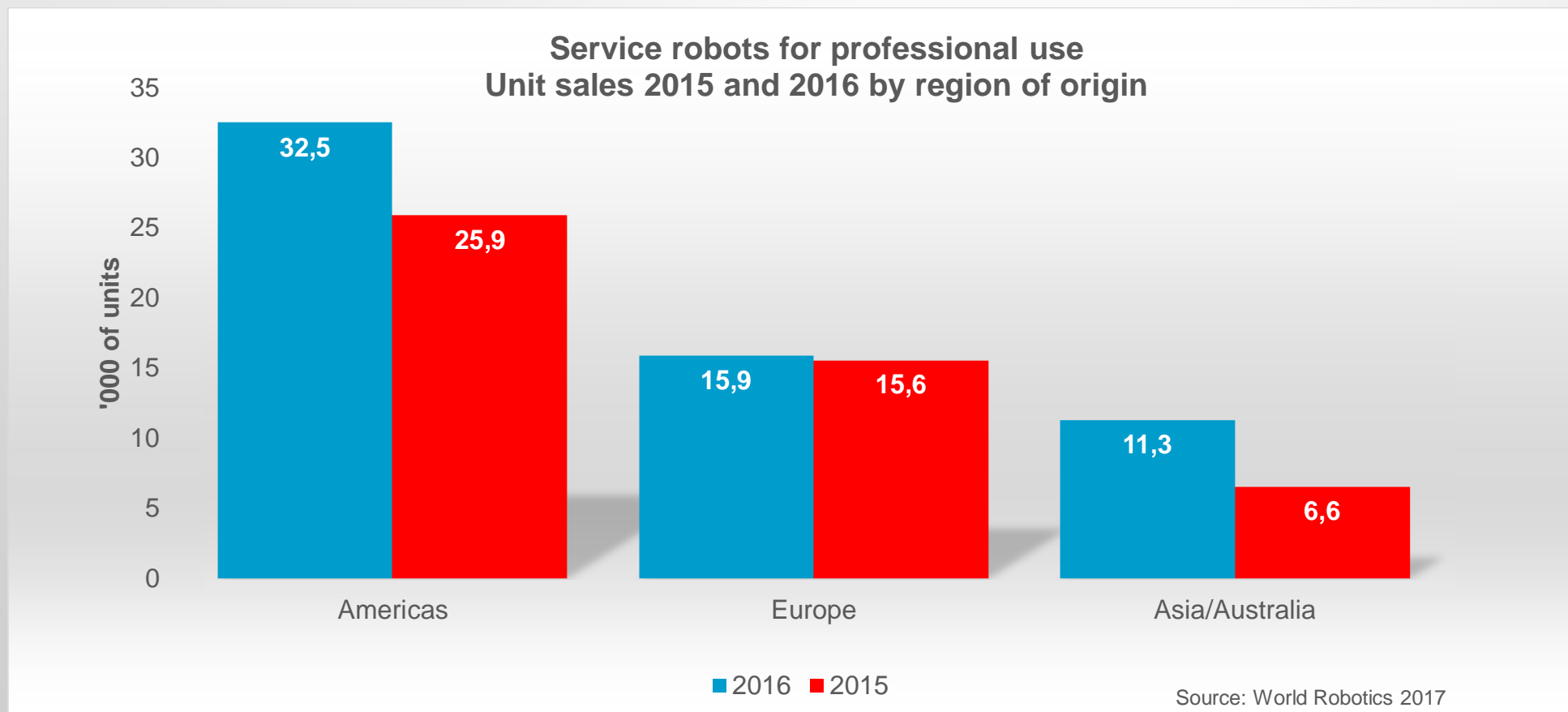
Service robots for professional use. All others
Estimated value 2015 and 2016, forecast 2017*, 2018*-2020*



*forecast

Source: World Robotics 2017

Professional service robots: more than 50% from the Americas



Personal Service Robots

Main categories:

Vacuum and floor cleaning

Lawn-mowing robots

Entertainment and leisure robots

Robots for elderly and handicap assistance

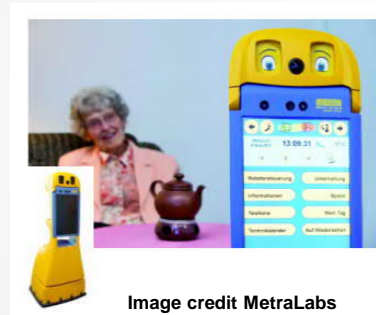


Image credit MetraLabs



Source: Kärcher (Vacuum cleaning)



Image credit Kawada



Image credit Vgo Communications



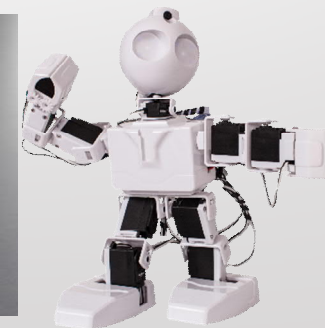
Image credit BlueBotics



Source: Aisoy Robotics S.L



Source: Vorwerk (Vacuum cleaning)



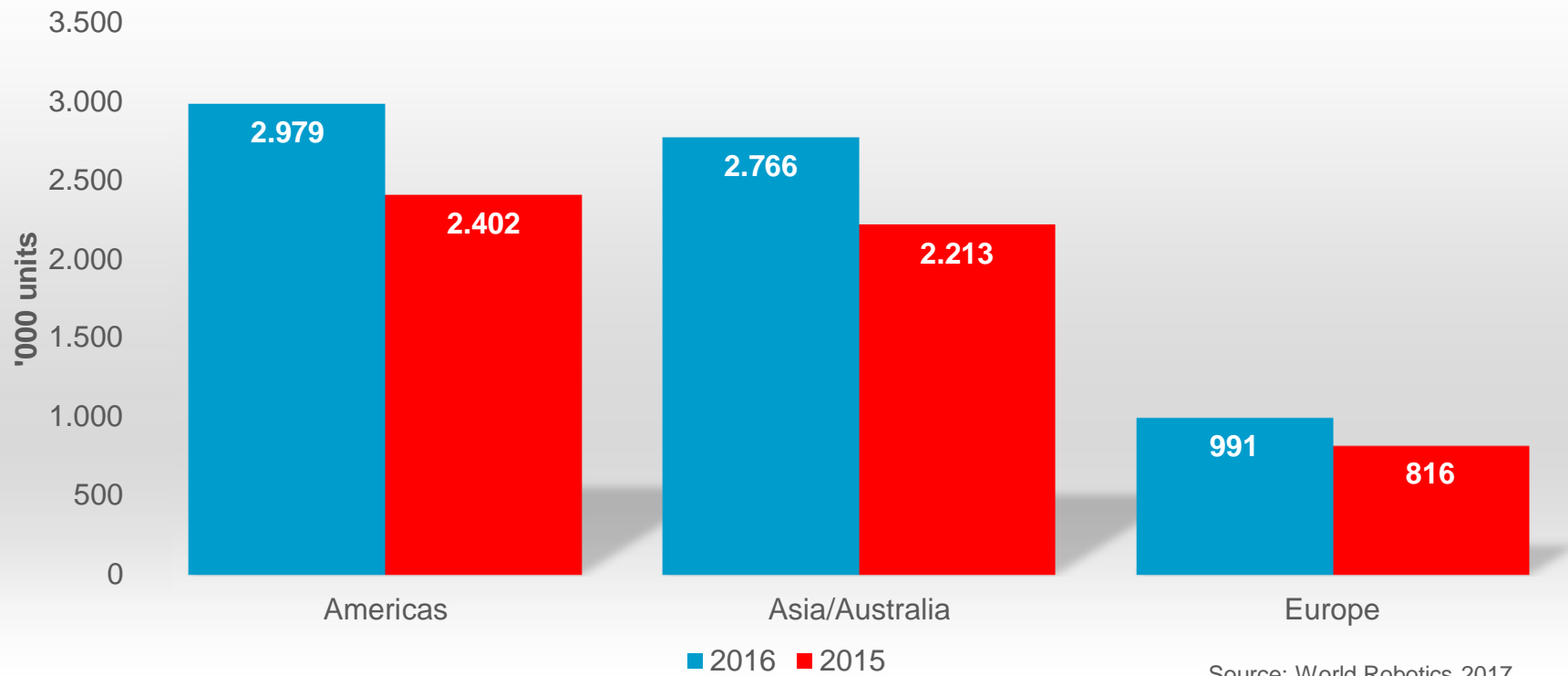
Source: Ezrobot



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Personal/domestic robots on the rise

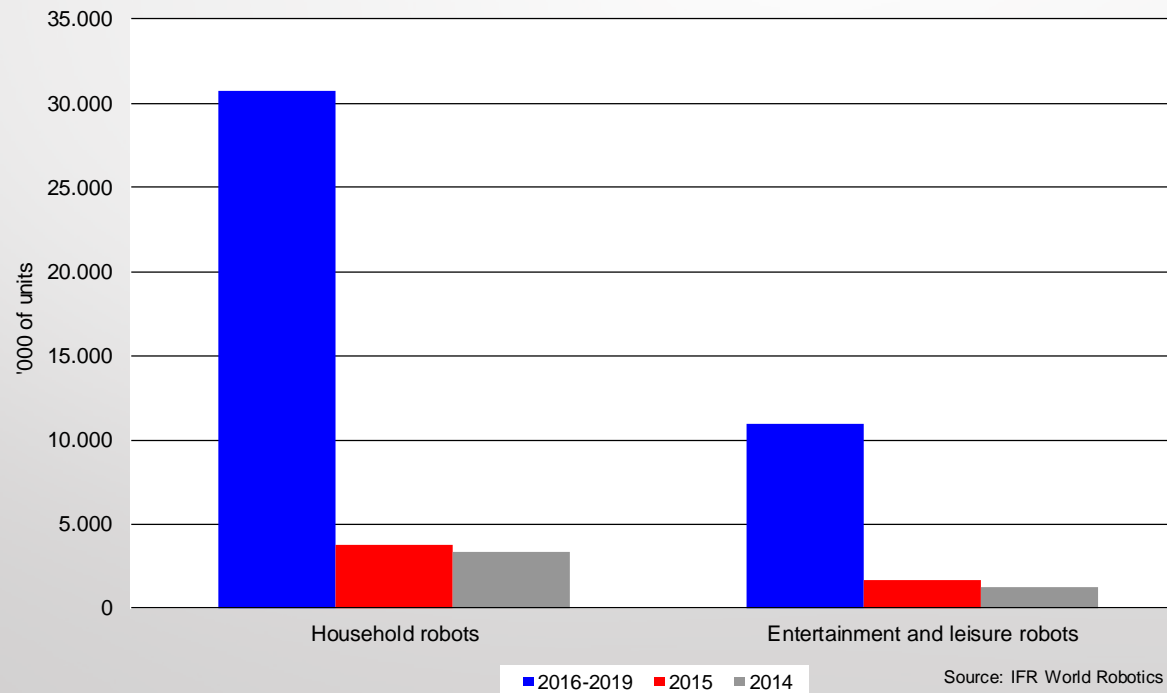
Service robots for personal/domestic use. Unit sales 2015 and 2016 by region of origin.



2016 - 2019: 42 million new service robots for personal and domestic use

Total value of forecast :
Household robots: about US\$ 13 billion
Entertainment robots: about US\$ 9 billion

Figure 2.4 Service robots for personal/domestic use.
Units sales 2014 and 2015, and forecast 2016-2019



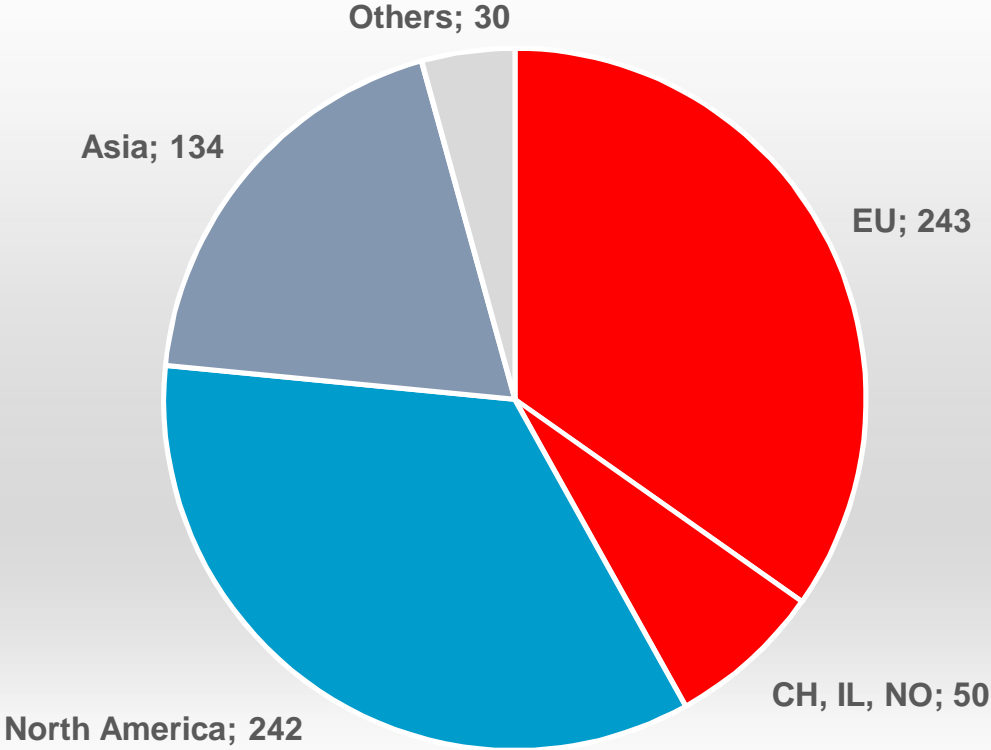


(N)

- **Dynamics of the service robotics industry**
- **Technological enablers**

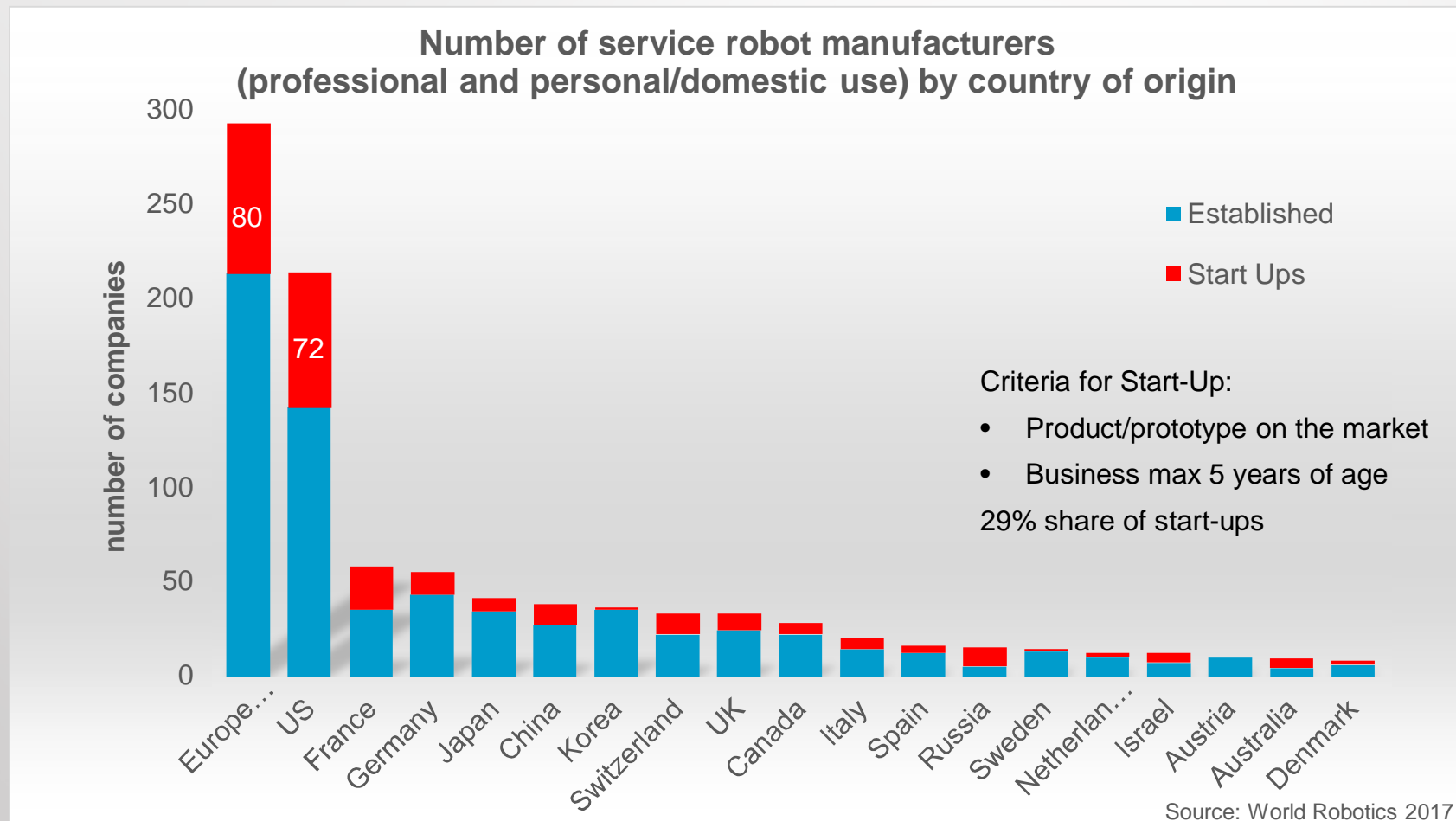
Number of service robot manufacturers of all types by region of origin (N=699)

Number of service robot manufacturers of all types (professional and personal/domestic use) by region of origin

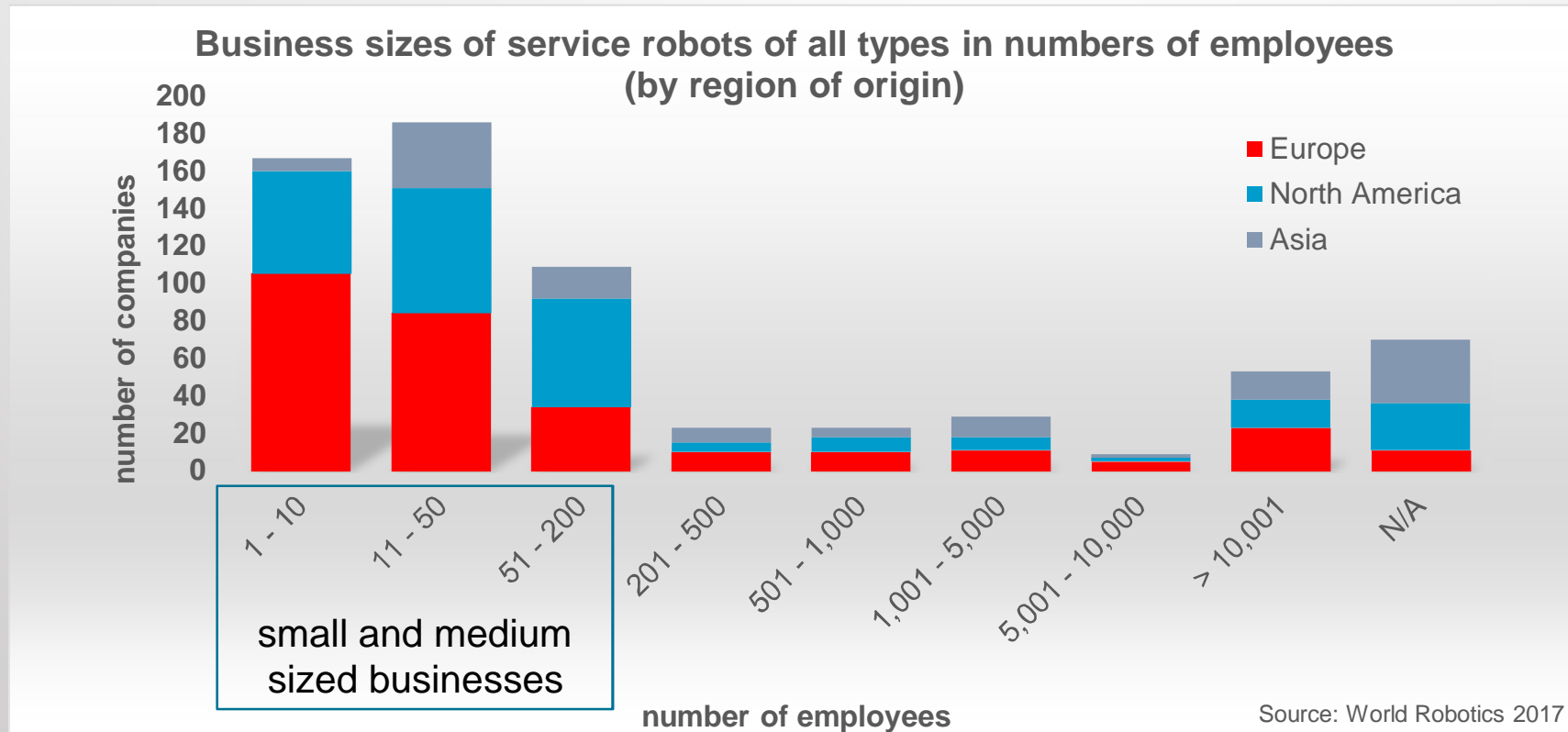


Source: World Robotics 2017

Europe fares well in service robot start-up creation



75% of European service robot suppliers are SMEs



Start-up examples (I): Service robotics in agriculture

Fresh fruit picking robot Platform for vineyard maintenance



FF Robotics (Israel)

WALL-YE (France)

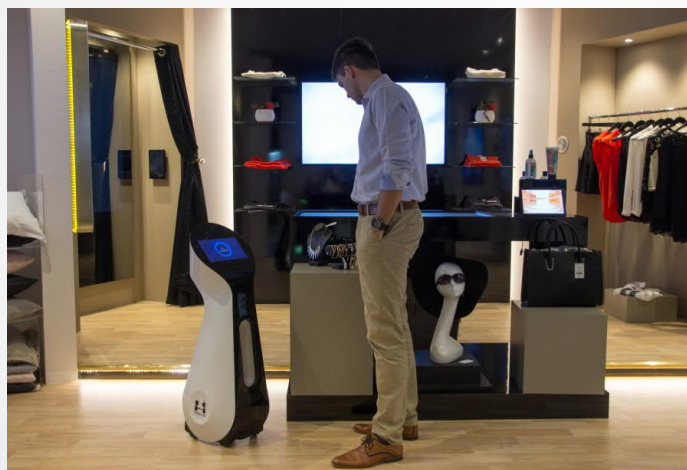
Naïo Technologies (France)

Source: FF Robotics, WALL-YE, Naïo Technologies

Start-up examples (II): Service robots in public-relations



Unity Robotics (D)



Bots and us (UK)



Promobot (RU)

Source: Unity Robotics, Bots and us, Promobot

Start-up examples (III): Service robots in logistics



Mobile Industrial Robots MiR (DK)



Fetch Robotics (USA)



Robotnik (ES)

Source: MiR, Fetch Robotics, Robotnik

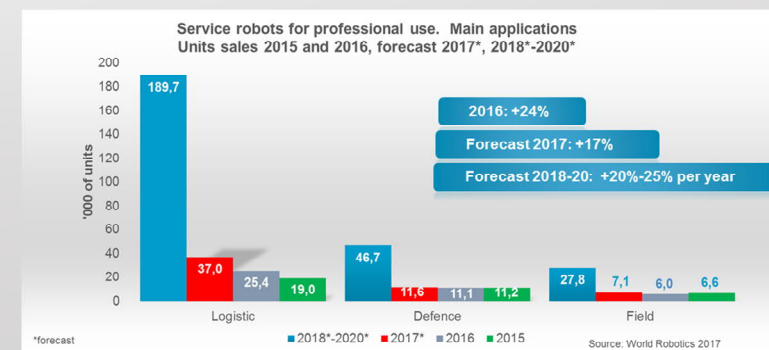
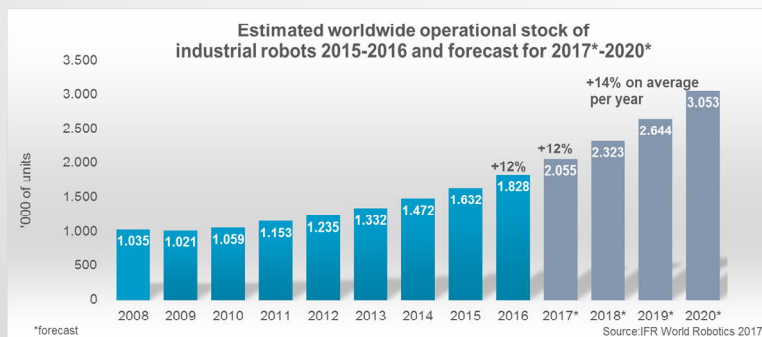
Creating a European Eco-System in robotics

- **Robotic key-technologies:** perception, human-machine-interaction, mechatronics, safety, ...
- **Software:** Major cost-/performance factor in service robotics, 30+% cost share
- **Supply industry** for robotics key-components, software (computer vision, motion control, mobile navigation etc.) emerges
- **Open Source Software** systems hugely popular; e.g. >2/3 of all service robot suppliers use Robot Operating System ROS (and other OSS)
- With **€700M in funding from EU 2014 – 2020**, **SPARC** is the largest civilian-funded robotics innovation initiative in the world.



Conclusions

- Both Industrial and Service Robotics are expected to grow in the forthcoming years at double digit rate.
- Industrial Robots shows an impressive growth in particular in Asian markets. Simplification, digitalization and collaboration are the key developments.
- Service robots are expected to grow in all segments both professional and personal. Most robot producers represented by SME and start ups.



Thanks!

Arturo Baroncelli