

Executive Summary World Robotics 2017 Service Robots

The total number of professional service robots sold in 2016 rose considerably by 24% to 59,706 units up from 48,018 in 2015. The sales value increased by 2% to US\$ 4.7bn. The reason for this rather low increase rate is the considerable decrease of high valued defense robots. Since 1998, a total of about 285,000 service robots for professional use have been counted in these statistics. It is not possible to estimate how many of these robots are still in operation due to the diversity of these products resulting in varying utilization times. Some robots (e.g. underwater robots) might be more than 10 years in operation (compared to an average life time of 12 years in industrial robotics). Others like defence robots may only serve for a short time.

The main applications are:

- Logistic systems
- Defense robots
- Field robots (milking robots)
- Public relations robots
- Powered human exoskeletons
- Medical robots

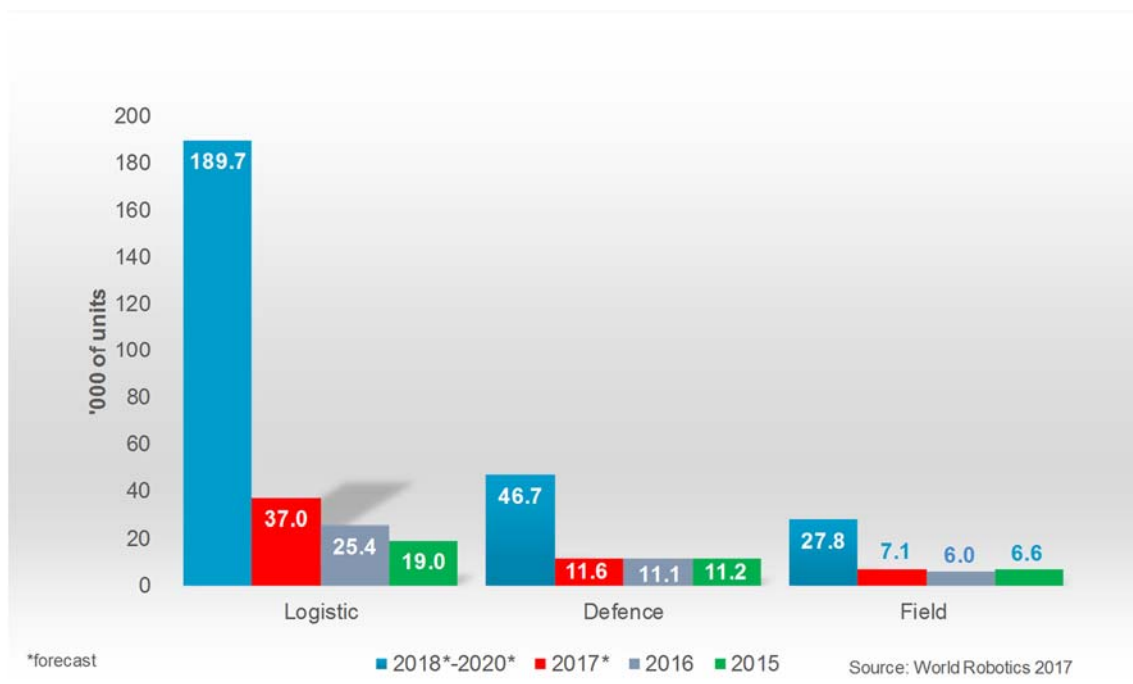
About 25,400 logistic systems were installed in 2016, 34% more than in 2015 (19,000), accounting for 43% of the total units and 21% of the total sales (in value) of professional service robots. These are automated guided vehicles in manufacturing environments and in non-manufacturing environments. It is assumed that the actual number of newly deployed systems is far higher. The value of sales of logistic systems is estimated at about US\$ 992m, and increased by 27% compared with 2015.

With 11,100 units, service robots in defense applications accounted for 19% of the total number of service robots for professional use sold in 2016. Thereof, unmanned aerial vehicles seem to be the application with the highest share and their sales increased by 4% to 9,700 units. A number of almost 1,000 unmanned ground based vehicles which include were sold, 32% less than in 2015. There is a decreasing trend of unmanned ground based vehicles since 2015. The value of defense robots can only roughly be estimated. It was about US\$ 775m, 25% less than in 2015. This number accounts for about 17% of the total sales of professional service robots. However, the true number as well as the value might be significantly higher.

A total of about 5,300 milking robots were sold in 2016 compared to 5,860 units in 2015, representing a 10% decrease. Dairy farmers suffered financially. As a result, investments were moved forward and takeovers were postponed. Also, other robots for livestock

farming such as mobile barn cleaners or robotic fencers for automated grazing control decreased in 2016. The total number of field robots sold in 2016 was about 6,000 units, accounting for a share of 10% of the total unit supply of professional service robots. The sales value of field robots decreased by 11% to US\$ 985m, accounting for about 21% of the total value of professional service robot sales. Agricultural robots are getting grounded in the market.

Sales of medical robots increased by 23% compared to 2015 to 1,600 units in 2016, accounting for a share of 2.7% of the total unit sales of professional service robots. The most important applications are robot assisted surgery or therapy. The total value of sales of medical robots increased to US\$ 1.612m, accounting for 34% of the total sales value of the professional service robots. Medical robots are the most valuable service robots with an average unit price of about US\$ 1.0m, including accessories and services. Therefore, suppliers of medical robots also provide leasing contracts for their robots. Medical robots as well as logistic systems are well established service robots with a considerable growth potential.



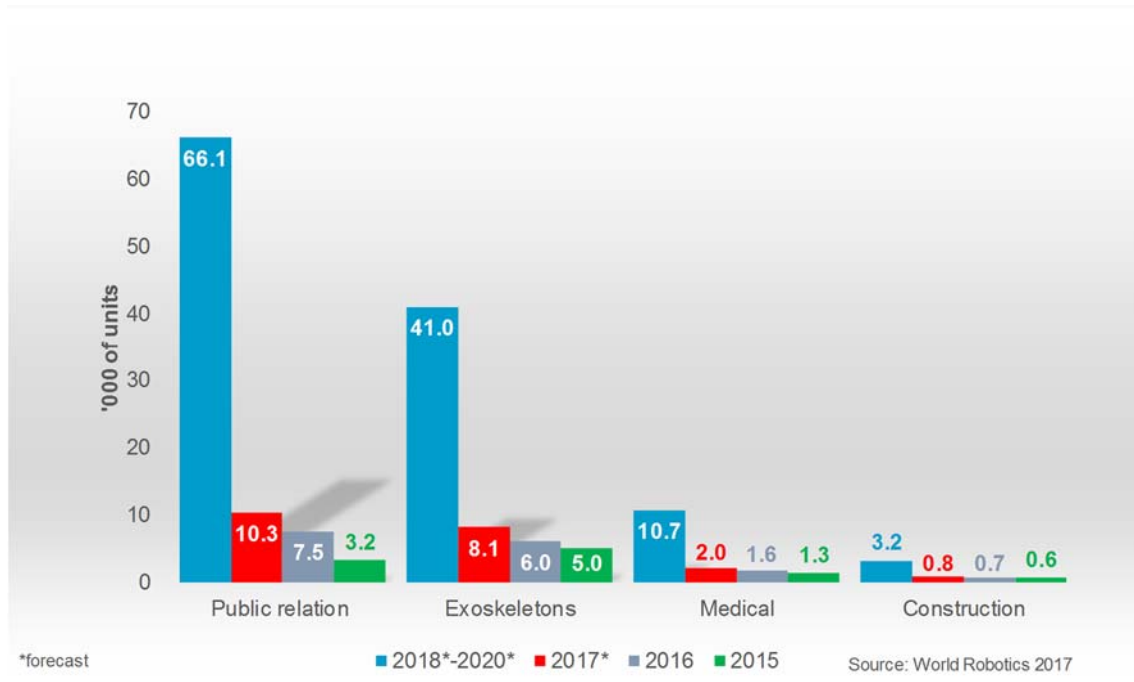
Service robots for professional use in main applications. Unit sales 2015 and 2016, forecast 2017 and 2018-2020.

Sales of powered human exoskeletons were up from 4,970 units in 2015 to 6,018 units in 2016. These robots are successfully used for rehabilitation and ergonomic support for reducing loads and have a high growth potential.

Another strong growing sector is public relation robots. Almost 7,500 units were sold in 2016, 133% more than in 2015. Most of these robots were telepresence robots, robots for mobile guidance and information with a sales volume of 7,200 units in 2016 up from

3,100 units in 2015. The total value of public relation robots increased by 126% to US\$ 119bn.

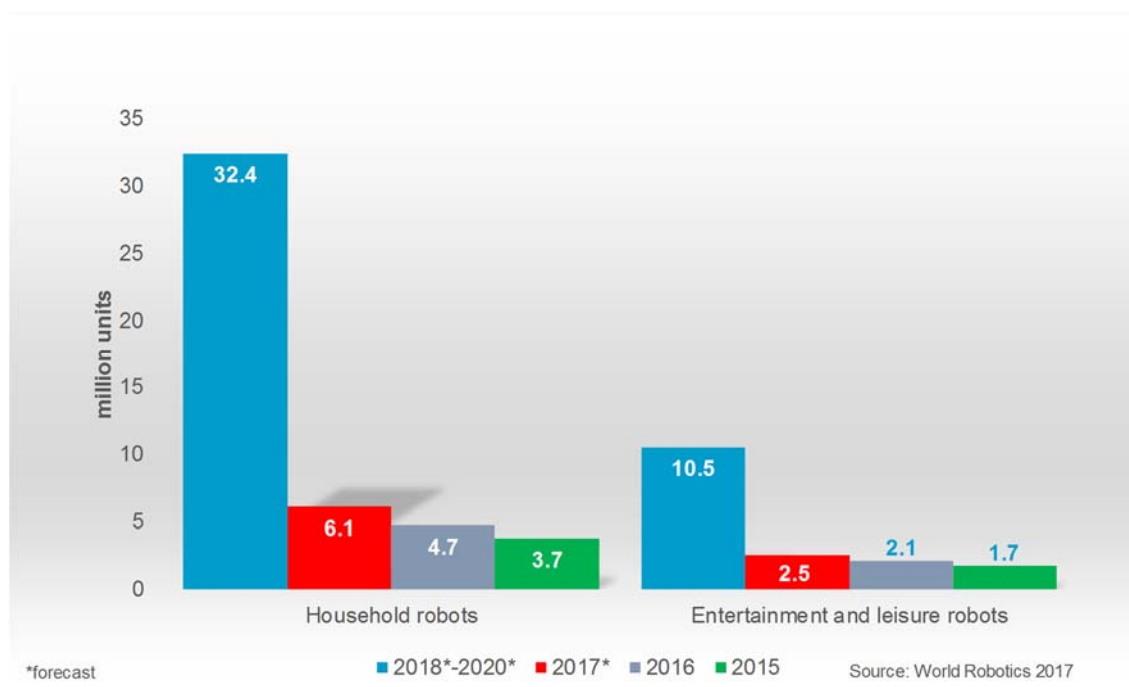
Annual sales units of all other categories of professional service robots are below 1,000 units: professional cleaning, demolition and construction robots, inspection and maintenance systems, rescue and security applications, underwater systems and mobile platforms in general use.



Service robots for professional use in more applications, unit sales 2015 and 2016, forecast 2017* and 2018*- 2020*

The total number of service robots for personal and domestic use increased by 24% to about 6.7 million units in 2016. The value was up by 15% to US\$ 2.6bn.

Service robots for personal and domestic use are recorded separately, as their unit value is generally only a fraction of that of many types of service robots for professional use. They are also produced for a mass market with completely different pricing and marketing channels. So far, service robots for personal and domestic use are mainly in the areas of domestic (household) robots, which include vacuum and floor cleaning, lawn-mowing robots, and entertainment and leisure robots, including toy robots, hobby systems, education and research.



Service robots for personal/domestic use. Unit sales 2015 and 2016, forecast 2017* and 2018*- 2020*

In 2016, it is estimated that more than 4.6 million robots for domestic tasks, including vacuum cleaning, lawn-mowing, window cleaning and other types, were sold, an impressive 25% more than in 2015. The actual number might, however, be significantly higher, as the IFR survey is far from having full coverage in this domain. The value was about US\$ 1.6bn. Compared to 2015, this represents an increase of 26%.

As for entertainment robots, about 2.1 million units were counted in 2016, 22% more than in 2015. Numerous companies, especially Asian ones, offer low-priced “toy robots”. But among those mass products, there are increasingly more sophisticated products for the home entertainment market. For many years now, the LEGO® Mindstorms® programme has belonged to the more high quality products offering software environments which reach well into high-tech robotics.

The total value of the 2016 sales of entertainment robots amounted to US\$ 0.98bn.

Handicap assistance robots have taken off to the anticipated degree in the past few years. In 2016, a total of 5,305 robots were sold, up from 4,713 in 2015 – an increase of 13%. Numerous national research projects in many countries concentrate on this huge future market for service robots. In contrast to the household and entertainment robots, these robots are high-tech products.

Projections 2017 and 2018-2020 professional service robots

In 2017, total unit sales of professional service robots are estimated to increase by 17% to almost 79,000 units with a value of about US\$ 3.2bn. Between 2018 and 2020, almost 397,000 units will be sold.

This represents an average annual increase between 20% and 25%. The value will also increase between 20% and 25% on average per year in the same period, reaching a total of almost US\$19bn between 2018 and 2020.

Sales of logistic systems will increase considerably in 2017, by 46% to about 37,000 units valued about US\$ 1.1bn. Between 2018 and 2020 another 190,000 units will be sold, an average annual increase between 25% and 30%. AGVs in the factory are important tools for flexible manufacturing, industry4.0. There is a huge potential for AGVs in non--manufacturing areas, e.g automation of e-commerce and automation of logistics in hospitals.

It is estimated that robots for defense applications will only moderately increase in 2017, by 4% to about 11,600 units. However, between 2018 and 2020 an average annual increase of about 15% is likely, about 47,000 units in total in this period.

They are followed by field robots with about 7,100 units in 2017 and 29,000 units in the period between 2018 and 2020, representing an increase between 10% and 15% on average per year. Investments in this sector depend highly on the financial situation of the farmers.

Another strong growing sector will be professional cleaning robots. About 6,100 units are estimated to be sold in the period between 2018 and 2020, mainly floor cleaning systems.

A continued increase of medical robots is expected. In 2017, about 2,000 units will be sold, 23% more than in 2016. About 10,700 units are estimated to be sold in the period between 2018 and 2020.

Exoskeletons will establish in the market. More than 8,000 units will be sold in 2017, 35% more than in 2016. About 41,000 units are estimated to be sold between 2018 and 2020, representing an average annual increase of about 25%.

A strongly growing sector is public relation robots which will increase by 37% to about 10,300 units in 2017 and to about 66,100 units between 2018 and 2020. These robots are increasingly used in supermarkets, at exhibitions, in museums etc. as guides or information providers. A lower number of robots for inspection and maintenance will be needed in the period between 2018 and 2020: 1,240 units.

Another growing application group is construction and demolition. More than 3,100 units are estimated to be sold in the period between 2018 and 2020. This is also a rather conservative forecast. Construction and demolition robots are increasingly used in areas which are dangerous or unhealthy for humans.

These forecasts are, as mentioned earlier, based mainly on individual sales projections by companies and professional organizations. It is the opinion of the IFR Statistical Department that the forecasts should be seen as trends concerning market direction rather than actual and precise sales forecasts.

Projections 2017 and 2018-2020 personal/domestic service robots

It is projected that sales of all types of robots for domestic tasks (vacuum cleaning, lawn-mowing, window cleaning and other types) could reach almost 6.7 million units (valued US\$ 2bn in 2017) and 32.4 million units in the period 2018-2020, with an estimated value of US\$ 11.3bn. The size of the market for toy robots and hobby systems is forecast at about 2.3 million units in 2017 and 9.5 million units between 2018 and 2020, most of which for obvious reasons are very low-priced. About 218,000 robots for education and research are expected to be sold in 2017 and another 994,000 in the period 2018-2020.

Sales of all types of entertainment and leisure robots are projected at about 2.5 million in 2017 (valued US\$ 1.1bn and 10.5 million units between 2018 and 2020, with a value of about US\$ 7.5bn.

Sales of robots for elderly and handicap assistance will be about 32,900 units in the period of 2018-2020. This market is expected to increase substantially within the next 20 years.

Overview:

Professional service robots:

- 2016: 59,700 units, +24%
- 2017: 78,700 units, +17%
- 2018-2020: 397,000 units, 20% - 25% per year on average

Service robots for domestic/household tasks:

- 2016: 4.7 million units, +25%
- 2017: 6.1 million units, +30%
- 2018-2020: 32.4 million units, between 30%-35% per year on average

Service robots for entertainment:

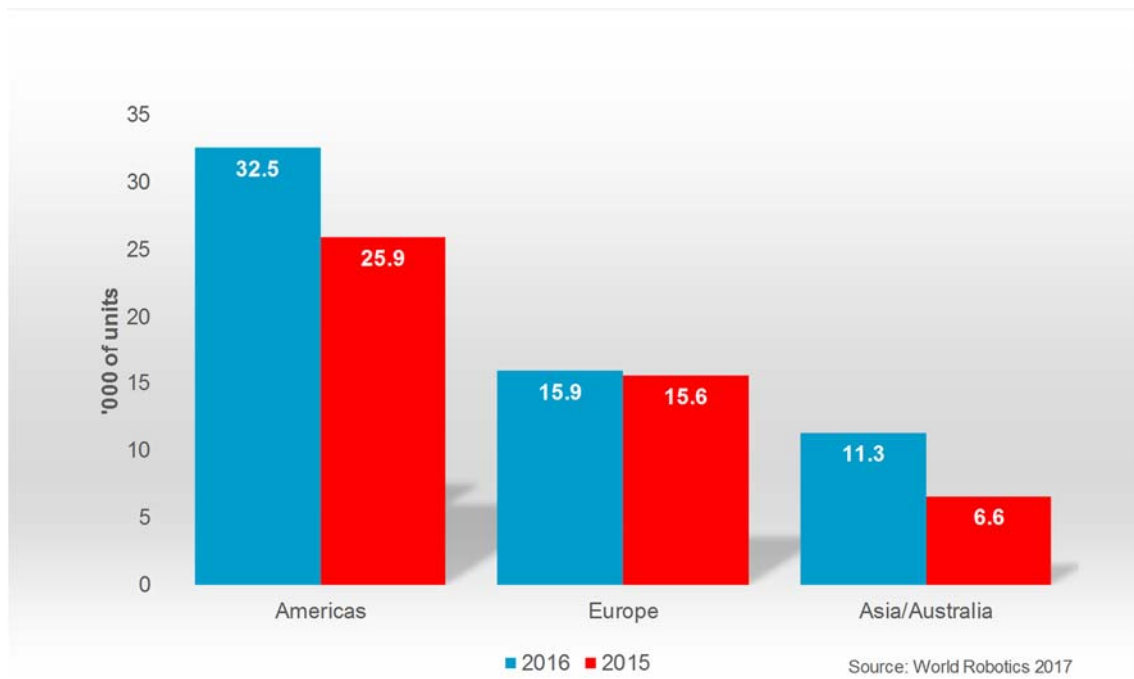
- 2016: 2.1 million units, +22%
- 2017: 2.6 million units, +22%
- 2018-2020: 10.5 million units, between 20%-25% per year on average

Service robots by region of origin

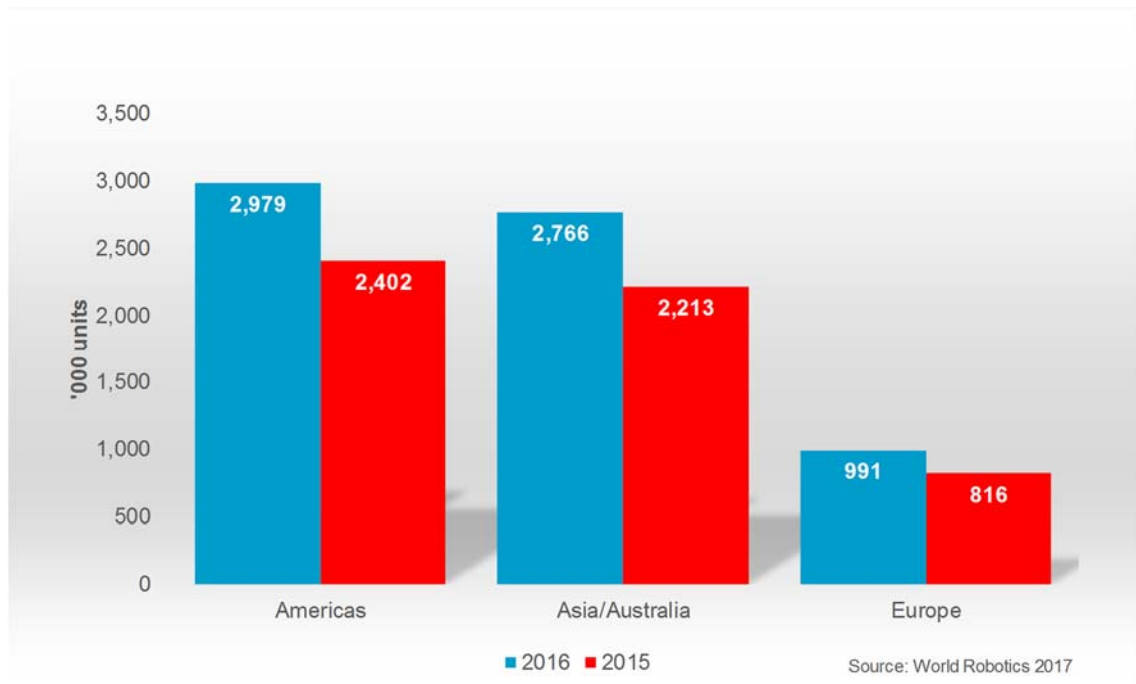
It should be considered that not all service robot suppliers in the world are included in the survey.

In total, 54% of all units of professional service robots came from America, 27% from Europe and a minor part (19%) of professional service robots is produced in Asia. 81% of all logistic systems are produced in America (9% in Europe and 10% in Asia). Most field robots are produced in Europe (about 91% of the global supply in 2016), as well as most construction and demolition robots (90%), most defense applications (53%) and most underwater systems (67%). In the field of medical robotics, Europe (with 52%) and America (with 46%) are almost equal. Sales of professional service robots from Europe increased by 2%, and from the Americas by 25%. Asian sales increased by 72% compared to 2015.

The distribution of personal/domestic robots by region of origin is more different. In 2016 American companies had an overwhelming share of domestic service robots (e.g. vacuum and floor cleaners, lawn mowers). Sales increased by 24% compared to 2015. The total number of domestic service robots reported by Asian/Australian companies increased by 22%, accounting for a share 32% of total sales in 2016. Only 4% of personal/domestic robots came from Europe but increased considerably, by 29%. The major share of 60% of all reported entertainment robots are supplied by Asian/Australian companies, some 39% came from Europe. Nearly all elderly and handicap assistance systems (94%) were sold by Asian and Australian companies.



Service robots for professional use. Unit sales 2015 and 2016 by region of origin.



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