1 Introduction

Chapter 1 reviews definitions and classifications of industrial robots and service robots.

1 Introduction: Sources and methods

1.1 COMPLIANCE

The IFR Statistical Department ensures the confidentiality of individual company data. Access to raw data is strictly limited to IFR Statistical Department staff. The IFR Statistical Department will never provide company-level data to third-parties neither outside nor inside the IFR. This means that the IFR Statistical Department publishes only aggregated data by country, by industry, or by application area. The IFR Statistical Department will not reveal the data in a specific category, if the data is reported by fewer than four companies. This is to prevent mathematical retrieval of company-level data. If there are fewer than four reports, the numbers will be added to "all others" or "unspecified". This rule has been applied since 2015.

Please note that this rule may lead to seemingly inconsistent data, because columns or rows may not necessarily add up to the sums reported. In addition, time series data may seem incomplete, especially in small markets, because in some years data can be revealed and in others it cannot.

1.2 COVERAGE, ACCESS TO DATA FOR PREVIOUS YEARS AND CONTACT

The annual publication "World Robotics Industrial Robots: Statistics, Market Analysis, Forecasts, Case Studies and Profitability of Robot Investments" covers **multipurpose industrial robots** as defined in section 1.7. Whenever this study refers to "robots" it means "multipurpose industrial robots".

From 2000 to 2008, World Robotics included statistics on service robots as a separate chapter. Since 2009, the companion publication "World Robotics Service Robots" covers service robots (see section 1.7 for delimitation of industrial robots).

World Robotics Industrial Robots contains data on robot installations by **type, country, industry** and **application**. The data is collected from nearly all industrial robot suppliers worldwide and supplemented with data provided by several national robot associations. Therefore, World Robotics Industrial Robots covers the global industrial robot market. The publication also provides estimates of the operational stock of industrial robots at year-end.

Chapter 1 contains **definitions, classifications** and **general methodological remarks.**

Chapter 2 analyzes the **worldwide spread of industrial robots from 2012 to 2017.** It contains **summary tables** of the world robot stock and the global robot supply by country, by application, or byindustry. For the Republic of China, the United States, Japan, Germany and the Republic of Korea, the **value of the robot market, and the**

average unit prices of robots are calculated and an estimate of the **total world market** value of industrial robot sales is deduced.

The chapter also contains analyses on the development of **industrial robot densities** (number of robots in operation per 10,000 employees) in the manufacturing industry of over 40 countries and in the automotive versus the general industry (manufacturing without automotive) for over 20 countries.

Chapter 3 presents statistical data on industrial robots for some 40 **countries**, using uniform table setups which lend themselves to country comparisons. The market analyses provide a discussion of the present situation and deduce a forecast of future robot installations for major markets.

Chapter 4 contains **forecasts** for the world industrial robot market **2018-2021** as well as major trends in customer industries and main countries.

Finally, **chapter 5** of each issue of World Robotics Industrial robots provides selected case studies of actual robot installations from different countries and industries. These case studies illustrate the effects of robots on costs, production and employment structure. They also provide an indication of the overall profitability of robot investments. Both potential and actual robot users are essentially interested in information on how robots can solve specific manufacturing problems, how such solutions have been obtained and what the implications are.

How to get access

The present issue of World Robotics as well as access to the World Robotics database that contains data of previous years (in some cases dating back to 1993), can be ordered at www.ifr.org.

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1.3 DATA SOURCES, REVISIONS, RELIABILITY AND VALIDITY

Sources

World Robotics Industrial Robots statistics rely on primary and secondary data.

The **primary source** is data on robot installations by country, industry and application that nearly all industrial robot suppliers worldwide report to the IFR Statistical Department directly. If a table or graph does not mention a specific source, it means that it is primary data and the source is "IFR Statistical Department".

Several national robot associations collect data on their national robot markets and provide their results as **secondary data** to the IFR. This data is used to validate the IFR primary data, thus ensuring data quality. It is also used to fill in the missing information. The final statistics provided in this publication and in the online database is therefore the consolidated primary and secondary data.

Since 2015, the Korean Association of Robot Industry (KAR) has been providing data on Korean production, imports and exports. Before 2014, the Korean Machine Tool Manufacturers Association (KOMMA) provided the data on the Korean robot companies' sales in the Republic of Korea.

The Japanese Robot Association (JARA) provides the data for the Japanese companies' worldwide robot shipments. This data is by country and application, but not by industry (except for the Japanese domestic market), because Japanese suppliers do not have this information. For Europe this part is added by European subsidiaries of these companies reporting the information directly to the IFR Statistical Department. For North America the distribution of imports from Japan by industry is estimated using the results of the RIA order statistics. JARA also reports the operational stock of robots in Japan. Before 2000, Japan consistently reported data that included both multipurpose and dedicated industrial robots (for definitions see section 1.7). This historic data is therefore not directly comparable to that of other countries. From 2001 onwards, definitions and coverage were largely harmonized, so that data on Japan is comparable to that of other countries.

The Robotic Industries Association (RIA) provides data on North America. The statistics report sales/installation data from North American companies in compliance with the IFR industry and application classifications. Primary data not included in the RIA statistics and JARA data on exports to North America supplement this data. The result is more accurate and more detailed data making it possible to provide separate reports for the United States, Canada and Mexico by applications and industries. Before 2011, data was only available only for North America (Canada, Mexico, United States) as a whole. From 2004 to 2010, data on North America was based on the consolidated data of robot suppliers worldwide and JARA. Before 2004, the annual data for North America only comprised what was reported to RIA by its member companies.

Since 2013, robot sales of Chinese robot suppliers provided by the Chinese Robot Industry Alliance (CRIA) have been included. For Asian countries, except for Japan and

the Republic of Korea, the distribution by industries is only partly available. The missing data is estimated using the information provided by other national IFR associations.

Prior 2004, country reports relied exclusively on data of national robot associations. This holds true for Denmark, Finland, France, Germany, Italy, Japan, Rep. of Korea, North America, Norway and Spain. Reports on other countries were based on data provided by a few robot suppliers. In 2005, robot suppliers reported consolidated data classified by country, industry or application for the first time. This facilitated more detailed reports on countries that do not have a national robot association.

For sources of **employment data** and methods of computing robot densities, see chapter (2.5.1)

Quality, reliability and validity

The IFR Statistical Department considers the high-quality data to be valid and reliable.

The IFR Statistical Department provides definitions and delimitations of robot types, industries and applications for all primary and secondary data sources to ensure data reliability.

The objective of World Robotics Industrial Robots is a comprehensive overview of the dissemination of industrial robots globally. The main indicator is the number of robots newly installed per year. For some countries there is also information on sales in monetary units available. The IFR Statistical Department considers these indicators to be a valid measure of robot dissemination.

The data presented in World Robotics Industrial Robots covers the whole population. This is ensured by permanent market observation and cooperation with national robot associations. The availability of primary and secondary data sources enables the IFR Statistical Department to check the data for consistency.

Revisions

Minor revisions: World Robotics Industrial Robots statistical data on robot installations in previous years is updated if new information becomes available. Therefore, some of the numbers in the current issue might differ slightly from numbers published in previous issues. This holds true especially for the robot density data, because the employment data which is used to compute robot densities is only available with a rather large time lag. Thus, employment data is often preliminary or estimated and must be revised later.

In the processing of this vast statistical material, errors are inevitable. The IFR Statistical Department would be most grateful for a notification, if the reader happened to find such an error.

Major revisions: The current issue of World Robotics Industrial Robots does not contain major revisions. The most important major revision of the past was a downwards revision of the robot stock of the former USSR that affected the robot stock before 2007. The data originated from the end of the 1980s and early 1990s before the transition of the economic system. In view of the profound industrial restructuring, it can be suspected

that a large share of those robots had been taken out of operation – some of the reported units probably were never taken into operation. Some 80% of the 1990 robot stock consisted of simple sequence-controlled robots.

1.4 FORECASTS

Forecasts of investments in industrial robots, presented in chapter 4, are derived as the consolidated assessment of:

- economic factors
- technological progress
- expert opinions of some of the leading robot manufacturers, major robot users and national robot associations

1.5 DEFINITION OF "SALES", "SHIPMENTS" AND "SUPPLY"

World Robotics Industrial Robots uses the words sales, shipments and supply of industrial robots synonymously. Thus, all these terms refer to the number of robots installed in a year. The term "domestic sales" also refers to the number of robots installed in a year in a specific country and is used for clarity, if data on production, imports and exports is available. Domestic sales can then be derived as the sum of production and imports minus exports.

1.6 DEFINITION OF "OPERATIONAL STOCK" AND "ACCUMULATED SALES"

The operational stock of robots measures the number of robots currently deployed. JARA determines this number in a survey and provides it to the IFR Statistical Department. For other countries, the IFR Statistical Departments estimates the operational stock **assuming an average service life of 12 years with an immediate withdrawal from service afterwards.** This assumption was investigated in an UNECE/IFR pilot study, carried out in 2000 among some major robot companies (see annex B in **World Robotics 2001**).[3] This investigation suggested that an assumption of 12 years of average life span might be too conservative and that the average life/ service life was closer to 15 years. On the other hand, German tax authorities suggest in their standard depreciation schedules an average service life of 5 years for robots in the automotive industry and 6 years for robots in the mechanical engineering industry. Similarly, useful life of class 80.0C "Robotics" is 5 years in the American tax law. Of course, robots may be refurbished and appreciated, so the standard depreciation schedule rather underestimates the service life. Nevertheless, the differences (5, 12 or 15 years) are substantial and need further investigation. Presumably, there are substantial differences

[3] For several years IFR and the United Nations Economic Commission for Europe UNECE have cooperated closely in the compilation, processing and analysis of worldwide statistics on industrial robots. In 2005, the full responsibility for World Robotics was transferred to the IFR Statistical Department.

depending on industry, application and type of robot. In the meantime, the operational stock is calculated as the sum of robot installations of the last 12 years.

1.7 DEFINITIONS AND CLASSIFICATIONS

1.7.1 INDUSTRIAL ROBOTS DEFINITION (ISO 8373:2012) AND DELIMITATION

World Robotics Industrial Robots presents statistics on the production, imports, exports and domestic installations/shipments of industrial robots (at least three or more axes) as described in ISO 8372:2012:

INDUSTRIAL ROBOT AS DEFINED BY ISO 8373:2012:

AN AUTOMATICALLY CONTROLLED, REPROGRAMMABLE,

MULTIPURPOSE MANIPULATOR

PROGRAMMABLE IN THREE OR MORE AXES,

WHICH CAN BE EITHER FIXED IN PLACE

OR MOBILE FOR USE IN INDUSTRIAL AUTOMATION APPLICATIONS

The terms used in the definition above mean:

- Reprogrammable: designed so that the programmed motions or auxiliary functions can be changed without physical alteration;
- Multipurpose: capable of being adapted to a different application with physical alteration;
- Physical alteration: alteration of the mechanical system (the mechanical system does not include storage media, ROMs, etc.)
- Axis: direction used to specify the robot motion in a linear or rotary mode

Figures 1.1 shows examples of robot types which are covered by this definition and hence included in the surveys.

A robot which has its own control system and is not controlled by the machine should be included in the statistics, although it may be dedicated for a special machine. Other dedicated industrial robots should not be included in the statistics.

- Wafer handlers have their own control system and should be included in the statistics of industrial robots. Wafers handlers can be articulated, cartesian,

cylindrical or SCARA robots. Irrespective of the type of robots they are reported in the application “cleanroom for semiconductors”.

- Flat panel handlers should also be included. They are mainly articulated robots. Irrespective of the type of robots they are reported in the application “cleanroom for FPD”.

Examples of dedicated industrial robots that should not be included in the international survey are:

- Equipment dedicated for loading/unloading of machine tools (see figure 1.3).
- Dedicated assembly equipment, e.g. for assembly on printed circuit boards (see figure 1.3).
- Integrated Circuit Handlers (pick and place)
- Automated storage and retrieval systems
- Automated guided vehicles (AGVs) (see “World Robotics Service Robots”)

The submission of statistics on industrial robots is mandatory for IFR member associations. In some countries, however, data is also collected on all types of manipulating industrial robots, that is, both multipurpose and dedicated manipulating industrial robots. Optionally, national robot associations may also submit statistics on all types of manipulating industrial robots, which will be included in the publication World Robotics under the respective country chapter.

1.7.2 DEFINITIONS OF ROBOT TYPES

In agreement with the robot suppliers, robots should be classified only by mechanical structure as of 2004.

Classification by mechanical structure:

- Linear robots (including cartesian and gantry robots)
- SCARA robots
- Articulated robots
- Parallel/delta robots
- Cylindrical robots
- Others
- Not classified

Figures 1.1 illustrates the mechanical configuration of these types of robots.

The number of axes should be understood as the basic feature supplied by the producer and not axes added later by the user.

Robots broken down by mechanical structure are based on the following definitions:

Cartesian robot: robot whose arm has three prismatic joints and whose axes are correlated with a cartesian coordinate system

SCARA robot: a robot, which has two parallel rotary joints to provide compliance in a plane

Articulated robot: a robot whose arm has at least three rotary joints

Parallel/Delta robot: a robot whose arms have concurrent prismatic or rotary joints

Cylindrical robot: a robot whose axes form a cylindrical coordinate system

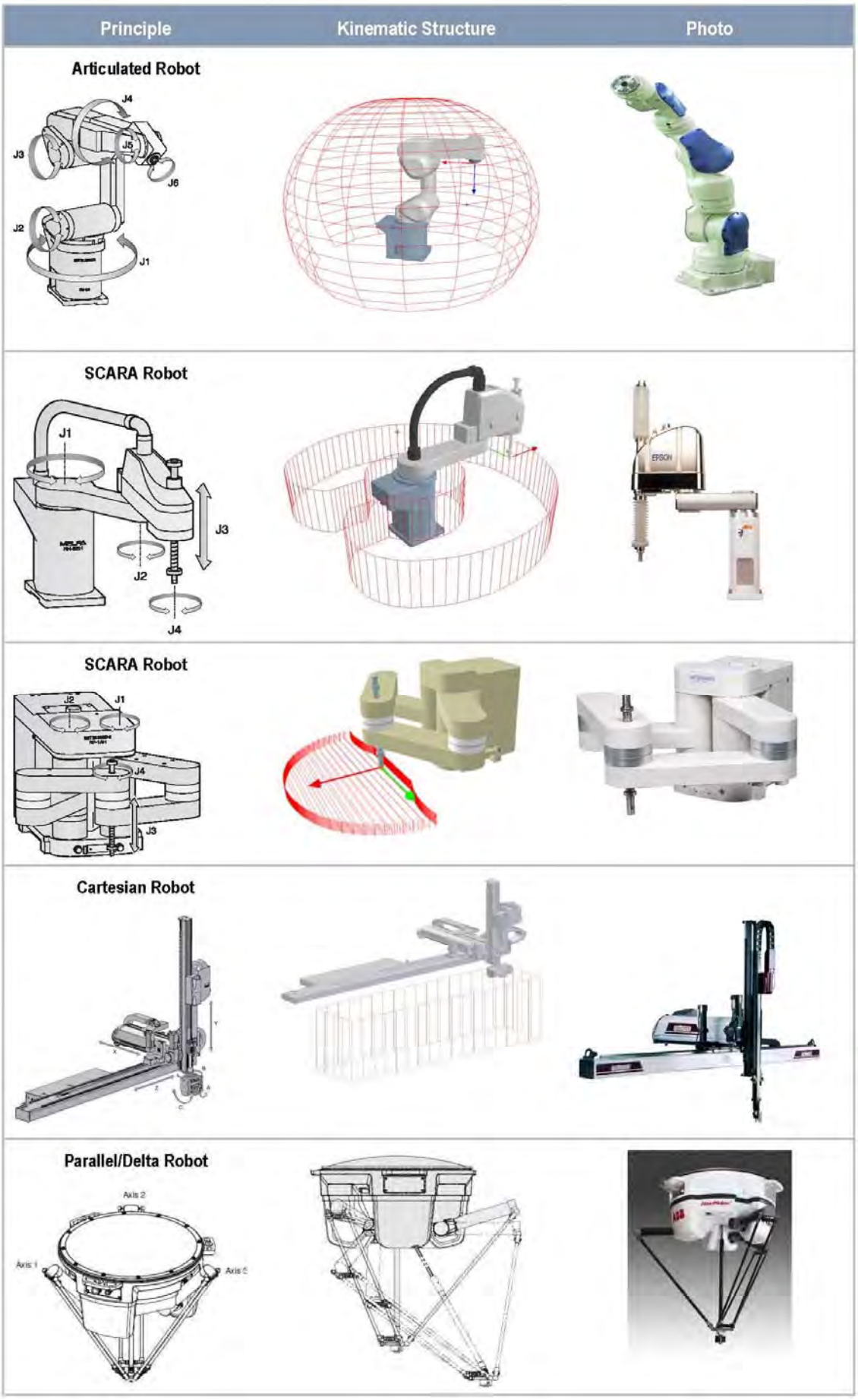


Figure 1.1: Classification of industrial robots by mechanical structure

Examples of articulated robots:

©NACHI

©FANUC

Flexible mounting possibilities – optimized working range

©ABB

©EPSON

Welding Robot

©DAIHEN

©KUKA

Examples of articulated robots:

©Dürr

The Swingarm is an articulated robot combined with SCARA elements

Different dualarm robots

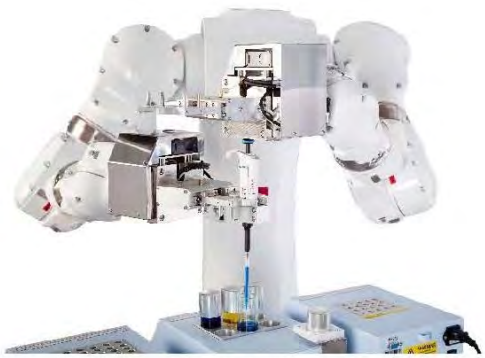
©Universal Robots

©EPSON

©Comau

©ABB

©Schunk



©YASKAWA

Examples of applications of articulated robots:

Handling for metal casting

©Comau

Packaging

©Kawasaki

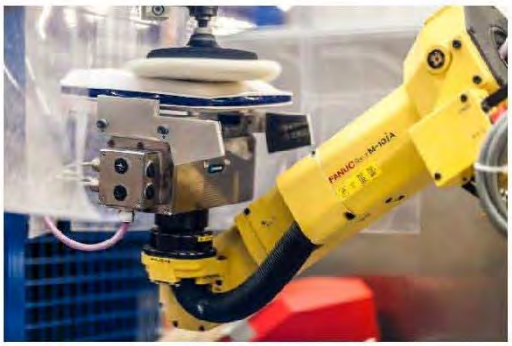
Welding

©Valk Welding

Painting

©DÜRR

Polishing



©FANUC

Machine Feeding

©Schunk

Sealing

©DÜRR

Grinding

©OnRobot

Material Handling

©KUKA

Examples of applications of articulated robots:

FDP handling

Wafer handler

Examples of SCARA robots and their applications:

©FANUC

©EPSON

©Omron

Assembly

©EPSON

Examples of linear/Cartesian/gantry robots:

Linear robot

©Wittmann

Gantry robot

©GÜDEL

Examples of applications of cartesian robots:

Material Handling

©GÜDEL

Material Handling

©GÜDEL

Machine feeding

©Wittmann

Handling for plastic moulding

©Wittmann

Examples of parallel robots:

©Omron

©FANUC

Examples of applications of parallel robots:

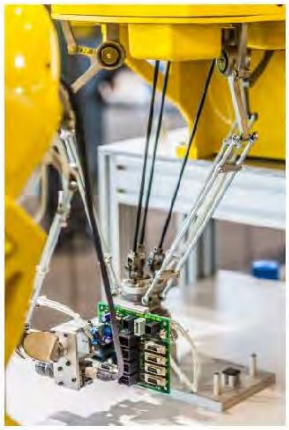
Picking and Placing

©Omron

Assembly

©ABB

Handling



©FANUC

Picking and Placing

©FANUC

1.7.3 CLASSIFICATION OF INDUSTRIES

Starting from the 2010 issue, data broken down by industrial branches is reported based on the International Standard Industrial Classification of All Economic Activities (ISIC) revision 4. The categories do not correspond exactly to the ISIC rev4. In previous issues, data was presented according to ISIC revision 2 or 3. In conjunction with the change of classification system, the number of branches to be surveyed by the IFR questionnaire was extended somewhat, reflecting the need for deeper analysis of the distribution of robots. (see table 1.1). All earlier data was transferred into this classification.

Table 1.1

IFR class	Categories, divisions and classes of economic activities, ISIC, rev. 4	Definitions
A-B	Agriculture, hunting and forestry; fishing	Crop and animal production, hunting and related service activities, forestry and logging, fishing and aquaculture
C	Mining and quarrying	Mining of coal and lignite, extraction of crude petroleum and natural gas, mining of metal ores, mining support service
D	Manufacturing	
10-12	Food products and beverages; Tobacco products	
13-15	Textiles, leather, wearing apparel	Textiles; Wearing apparel; dressing & dyeing of fur; Luggage, handbags, saddlery, harness and footwear
16	Wood and wood products (incl. furniture)	Manufacture of wood, products of wood (incl. wood furniture) and products of cork
17-18	Paper and paper products, publishing & printing	Manufacture of pulp, paper and converted paper production, printing of products, such as newspapers, books, periodicals, business forms, greeting cards, and other materials, and associated support activities, such as bookbinding, plate- making services, and data imaging; reproduction of recorded media, such as compact discs, video recordings, software on discs or tapes, records etc.
19-22	Plastic and chemical products	
19	Chemical products, pharmaceuticals, cosmetics	Manufacture of basic pharmaceutical products and pharmaceutical preparations. This includes also the manufacture of medicinal chemical and botanical products
20-21	Unspecified chemical, petrolium products	Transformation of crude petroleum and coal into usable products, transformation of organic and inorganic raw materials by a chemical process and the formation of products
22	Rubber and plastic products without automotive parts*	(e.g. rubber tires, plastic plates, foils, pipes, bags, boxes, doors, etc.) rubber and plastic parts for motor vehicles should be reported in 29.3.2
23	Glass, ceramics, stone, mineral products n.e.c. (without automotive parts*)	Manufacture of intermediate and final products from mined or quarried non-metallic minerals, such as sand, gravel, stone or clay, manufacture of glass, flat glass ceramic and glass products, clinkers, plasters, etc.
24-28	Metal	
24	Basic metals (iron, steel, aluminium, copper, chrome)	e.g. iron, steel, aluminium, copper, chrome etc.
25	Metal products (without automotive parts*), except machinery and equipment	e.g. metal furniture, tanks, metal doors, forging, pressing, stamping and roll forming of metal, nails, pins, hand tools, etc.
28	Industrial machinery	e.g. machinery for food processing and packaging, machine tools, industrial equipment, rubber and plastic machinery, industrial cleaning machines, agricultural and forestry machinery, construction machinery etc.

Sources: IFR

Table 1.1 (continued)

IFR class	Categories, divisions and classes of economic activities, ISIC, rev. 4	Definitions
26-27	Electrical/electronics	
275	Household/ domestic appliances	(e.g. refrigerators, vacuum cleaners, lawn mowers, lamps, ovens, shavers, vacuum cleaners, etc.)
271	Electrical machinery and apparatus n.e.c. (without automotive parts*)	Manufacture of power, distribution and specialty transformers; electric motors, generators and motor generator sets; switchgear and switchboard apparatus; relays and industrial controls, batteries and accumulators; manufacture of current-carrying wiring devices and non current- carrying wiring devices for wiring electrical circuits regardless of material, fiber optic cables and insulating of wires; manufacture of electric light bulbs and tubes and parts and components thereof (except glass blanks for electric light bulbs), electric lighting fixtures and lighting fixture components (except current-carrying wiring devices)
260	Electronic components/devices	Manufacture of electronic capacitors and resistors, microprocessors, bare printed circuit boards, electron tubes, electronic connectors, integrated circuits (analog, digital or hybrid), diodes, transistors and related discrete devices, inductors (e.g. chokes, coils, transformers), electronic component type, electronic crystals and crystal assemblies, solenoids, switches and transducers for electronic applications, interface cards (e.g. sound, video, controllers, network, modems), printer cables, monitor cables, USB cables, connectors etc.
261	Semiconductors, LCD, LED (incl solar cells and solar thermal collectors)	Manufacture of dice or wafers, semiconductor, finished or semi- finished and of display components (plasma, polymer, LCD), light emitting diods (LED), including solar cells and solar thermal collectors
262	Computers and peripheral equipment	Manufacture of desktop, laptop, main frame computers and hand-held computers (e.g. PDA), magnetic disk drives, flash drives and other storage devices,optical (e.g. CD-RW, CD- ROM, DVD-ROM, DVD-RW) disk drives, printers, monitors, keyboards, all types of mice, joysticks, and trackball accessories, dedicated computer terminals, computer servers, scanners, including bar code scanners, smart card readers, virtual reality helmets, computer projectors (video beamers), computer terminals, like automatic teller machines (ATM's), point-of-sale (POS) terminals, not mechanically operated, of multi-function office equipment, such as fax-scanner-copier combinations
263	Info communication equipment domestic and professional (TV, radio, CD, DVD-Players, pagers, mobile phones, VTR etc.) without automotive parts*	Manufacture of video cassette recorders and duplicating equipment, televisions, television monitors and displays,audio recording and duplicating systems, stereo equipment, radio receivers, speaker systems household-type video cameras, jukeboxes, amplifiers for musical instruments and public address systems, microphones, CD and DVD players, karaoke machines, headphones (e.g. radio, stereo, computer), video game consoles Manufacture of pagers, cellular phones, mobile communication equipment, telephone and facsimile equipment, incl. telephone answering machines, data communications equipment, such as bridges, routers, and gateways, transmitting and receiving antenna, cable television equipment, radio and television studio and broadcasting equipment, including television cameras, modems, carrier equipment, burglar and fire alarm systems, sending signals to a control station, radio and television transmitters, infrared devices (e.g. remote controls)
265	Medical, precision and optical instruments	Manufacture of measuring, testing, navigating and control equipment for various industrial and non-industrial purposes, including time-based measuring devices such as watches and clocks and related devices; manufacture of irradiation, electromedical and electrotherapeutic equipment, manufacture of optical instruments and photographic equipment
29	Automotive	
291	Motor vehicles, motor vehicle engines and bodies	Manufacture of cars, trucks, buses and their engines, manufacture of bodies (coachwork) for motor vehicles, manufacture of trailers and semitrailers
293	Parts and accessories for motor vehicles:	
2931	Metal products	metal parts of motor vehicles (e.g. brakes, gearboxes, axles, road wheels, suspension shock absorbers, radiators, silencers, exhaust pipes, catalytic converters, clutches, steering wheels, steering columns and steering boxes)
2932	Rubber and plastic	tyres, plastic parts of motor vehicles (e.g. bumpers)
2933	Electrical/electronics	electrical/electronic parts of motor vehicles (e.g. generators, alternators, spark plugs, ignition wiring harnesses, power window and door systems, assembly of purchased gauges into instrument panels, voltage regulators, navigation systems, communication equipment, electric motors; switchboard apparatus; relays, batteries and accumulators;airbags
2934	Glass	auto glass
2939	Other	car seats, safety belts, airbags
30	Other transport equipment	e.g. ships, locomotives, aeroplanes, spacecraft vehicles
91	All other manufacturing branches	
E	Electricity, gas and water supply	
F	Construction	General construction and specialized construction activities for buildings and civil engineering works. It includes new work, repair, additions and alterations, the erection of prefabricated buildings or structures on the site and also construction of a temporary nature
P	Education, research and development	
90	All other non-manufacturing branches	
99	Unspecified	

Sources: IFR

1.7.4 CLASSIFICATION OF APPLICATIONS

From 2004, the applications have been revised in agreement with the robot suppliers. All earlier data was transferred into the revised classification. The table 1.2 below shows the type of classification, by application areas.

Table 1.2

IFR Class	Application area	Definitions
110	Handling operations/ Machine tending	Assistant processes for the primary operation (the robot doesn't process the main operation directly)
111	Handling operations for metal casting	including die-casting
112	Handling operations for plastic moulding	also inserting operations for injection moulding
113	Handling operations for stamping/forging/ bending	
114	Handling operations at machine tools	
115	Machine tending for other processes	e.g. handling during assembly, handling operations during glas or ceramics production or food production Robots that handle workpieces at an external welding TCP (i.e. MIG/MAG torch or spot gun) need to be reported in the appropriate welding classification (i.e. 161 for arc welding or 162 for spot welding) and shall not be counted to the classification of handling operations.
116	Handling operations for measurement, inspection, testing	triage, quality inspection, calibrating
117	Handling operations for palletizing	all sectors, all kinds and sizes of pallets
118	Handling operations for packaging, picking and placing	e.g. operations during primary and secondary packaging
119	Material Handling n.e.c.	e.g. transposing, handling during sandcasting
160	Welding and soldering (all materials)	
161	Arc welding	
162	Spot welding	
163	Laser welding	
164	other welding	e.g. ultrasonic welding, gas welding, plasma welding
165	Soldering	
170	Dispensing	
171	Painting and enamelling	area-measured application of lacquer (surface coat)
172	Application of adhesive, sealing material or similar material	spot-wise and line-wise
179	Dispensing others/ Spraying others	e.g. powder coating, application of mould release agent, area-measured application of adhesive, spraying of wax to conserve)
190	Processing	enduring changing, the robot leads the workpiece or the tool, material removal
191	Laser cutting	
192	Water jet cutting	
193	Mechanical cutting/grinding/ deburring/ milling/polishing	
198	Other processing	e.g. gas/plasma cutting, drilling, bending, punching, shearing
200	Assembling and disassembling	enduring positioning of elements
201	Fixing, press-fitting	screw/nut-driving, clinching, reveting, bonding
202	Assembling/ mounting/ inserting	also temporarily positioning to facilitate the assembling process
203	Disassembling	recycling, removal of cover after processing
208	Other assembling	not mentioned before
900	Others	
901	Cleanroom for FPD	
902	Cleanroom for semiconductors	
903	Cleanroom for others	
905	Others	not mentioned before
999	Unspecified	the application is unknown

Sources: IFR

1.7.5 DEFINITION OF SERVICE ROBOTS

In a joint effort that started in 1995 the United Nations Economic Commission for Europe (UNECE) and IFR engaged in working out a preliminary service robot definition and classification scheme, which has been absorbed by the current ISO Technical Committee 184/Subcommittee 2. This resulted in a novel ISO-Standard 8373, which became effective in 2012[4]. A preliminary extract of the relevant definitions is given here:

- A robot is an actuated mechanism programmable in two or more axes with a degree of autonomy, moving within its environment, to perform intended tasks. Autonomy in this context means the ability to perform intended tasks based on current state and sensing, without human intervention.
- 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.
- A robot system is a system comprising →robot(s), end-effector(s) and any machinery, equipment, devices, or sensors supporting the robot performing its task.

Please note: According to the definition, “a degree of autonomy” is required for service robots ranging from partial autonomy (including human robot interaction) to full autonomy (without active human intervention). Therefore, in addition to fully autonomous systems service robot statistics include systems, which may also be based on some degree of human robot interaction or even full tele-operation. In this context human robot-interaction means information and action exchanges between human and robot to perform a task by means of a user interface.

With this definition, manipulating industrial robots (which can be either fixed in place or mobile) could also be regarded as service robots, provided they are installed in non-manufacturing operations. Service robots may or may not be equipped with an arm structure as is the case with some industrial robots. Often, but not always, service robots are mobile.

[4] ISO 8373:2012 Robots and robotic devices - Vocabulary; http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=55890 .

In some cases, service robots consist of a mobile platform on which one or several arms are attached and controlled in the same mode as the arms of an industrial robot. Furthermore, contrary to their industrial counterparts, service robots do not have to be fully automatic or autonomous. In many cases these machines may even assist a human user or be tele-operated.

Due to their multitude of forms and structures as well as application areas, service robots are not easy to define.

1.7.6 CLASSIFICATION OF SERVICE ROBOTS BY APPLICATION AREAS

Since the mid-90s, UNECE and IFR have adopted a preliminary system for classifying service robots by categories and types of interaction which has converged over the years into the current classification scheme. For both personal/domestic robots and professional service robots, the classification of service robot according to application areas and types is shown in table 1.3.

As from 1997, IFR started regularly to collect statistics on service robots, including data on manipulating industrial robots used in service robot applications, according to the current versions of the classification scheme. Recognizing the difficulties in collecting primary statistics from suppliers of service robots, it is not surprising that aggregated statistics from individual countries are very scarce.

Since very few national organizations have any comprehensive statistics on service robots at all, UNECE and IFR decided to collect statistics directly from the manufacturers of service robots. This process has been maintained since 1997, although all statistics related activities have been transferred to the IFR Statistical Department since the year 2005. Manufacturers are asked to report data broken down by application areas as shown in table 1.3 for professional and personal/domestic applications.

The results of the statistics, as well as the analysis, are published in World Robotics – Service Robots 2018.

Table 1.3

Classification of service robots by application areas and types of robots;
service robots for personal/domestic use.

	Types of robots
I	Personal/Domestic Robots
1-7	Robots for domestic tasks
1	- Robot companions / assistants / humanoids
2	- Vacuuming, floor cleaning
3	- Lawn mowing
4	- Pool cleaning
5	- Window cleaning
6	- Home security & surveillance
7	- Others
8-11	Entertainment robots
8	Toy/hobby robots
9	Multimedia robots
10	Education and research
11	Others
12-14	Elderly and handicap assistance
12	- Robotized wheelchairs
13	- Personal aids and assistive devices
14	- Other assistance functions
15	Other personal/domestic robots

Source: IFR

Table 1.3 (Continued)

Classification of service robots by application areas and types of robots; service robots for professional use

Types of robots	
II	Professional service robots
16-21	Field robotics
16	- Agriculture (broad acre, greenhouse, fruit-growing, vineyard)
17	- Milking robots
18	- other robots for livestock farming
19	- Mining robots
20	- Space robots
21	- Others
22-26	Professional cleaning
22	-Floor cleaning
23	-Window and wall cleaning (including wall climbing robots)
24	-Tank, tube and pipe cleaning
25	- Hull cleaning (aircraft, vehicles, etc.)
26	-other cleaning tasks
27-29	Inspection and maintenance systems
27	- Facilities, plants
28	- Tank, tubes, pipes and sewers
29	- Other inspection and maintenance systems
30-33	Construction and demolition
30	- Nuclear demolition & dismantling
31	- Building construction
32	- Robots for heavy/civil construction
33	- Other construction and demolition systems
34-38	Logistic systems
34	- Autonomous guided (AGV) vehicles in manufacturing environments
35	- AGVs in non-manufacturing environments (indoor)
36	- Cargo handling, outdoor logistics
37	- Personal transportation (AGV for persons)
38	- Other logistics
39-42	Medical robotics
39	- Diagnostic systems
40	- Robot assisted surgery or therapy
41	- Rehabilitation systems
42	- Other medical robots
43-45	Rescue und security applications
43	- Fire and disaster fighting robots
44	- Surveillance/security robots without UAV
45	- Other rescue and security robots
46-50	Defense applications
46	- Demining robots
47	- Unmanned aerial vehicles
48	- Unmanned ground based vehicles (e.g. bomb fighting)
49	- Unmanned underwater vehicles
50	- Other defense applications
51	Underwater systems (civil/general use)
52	Powered Human Exoskeletons*
53	Unmanned aerial vehicles (general use)
54	Mobile Platforms (general use)
55-59	Public relation robots and joy rides
55	Hotel and restaurant robots
56	Mobile guidance, information, telepresence robots
57	Robots in marketing
58	Robot joy rides
59	other public relation
60	Other professional service robots not specified above

Source: IFR