European Commission

Study on the Electronics Ecosystem

OVERVIEW, DEVELOPMENTS AND EUROPE'S POSITION IN THE WORLD

Annex 1 & 2

A study prepared for the European Commission
DG Communications Networks, Content & Technology
by:

Digital Single Market

This study was carried out for the European Commission by

Decision SARL

This study was written by Olivier Coulon (DECISION), John K. Olliver (DECISION), Guy Dubois (DECISION), Léo Saint-Martin (DECISION) and Marc Vodovar (DECISION).

We would like to thank Colette Maloney, Francisco Ibanez and Nikolaos Kattavenos for their constant availability and for the quality of our exchanges. This was a very precious help for us in achieving the objectives of this important study.

Internal identification

Contract number: LC-00644814

SMART number 2016/0007

DISCLAIMER

By the European Commission, Directorate-General of Communications Networks, Content & Technology.

The information and views set out in this publication are those of the author(s) and do not necessarily reflect the official opinion of the Commission. The Commission does not guarantee the accuracy of the data included in this study. Neither the Commission nor any person acting on the Commission's behalf may be held responsible for the use which may be made of the information contained therein.

ISBN 978-92-76-02934-2
doi: 10.2759/014809

Luxembourg: Publications Office of the European Union, 2020

Annex 1 - Industrial and robotics

Overview - Industrial electronics, a traditional European stronghold

- **The second largest user segment in Europe, and third largest in the world**

Industrial electronics are the second largest end user segment in Europe, and a segment where Europe's position is particularly strong. European production is 20% of the world market, well over the average for all end user segments (14%), and Europe ranks second in the world for the manufacture of industrial electronics, behind China, but before the USA and Japan.

Two European companies are world leaders (Siemens and ABB) in this field, and with Schneider three European companies are among the top five. Inside the EU, Germany is by far the leading country.

The synergy between end user segment and component supply is particularly efficient in this field. The three large European semiconductor manufacturers (Infineon, STM and NXP) are among the top ten suppliers of analog ICs. Analog ICs correspond to a very large share of the industrial market (47%), far above their modest share in the total IC market (15%). The same is true of discrete devices.

- **Strong growth in the past, should continue**

The global market for industrial electronics has grown at 7.8% per year over 2010-2016, and this strong growth should last during the coming years, pulled by innovation (Industry 4.0...) and the strong demand in Asian countries, as well as by the shift to renewable energies (wind and solar power).

This global growth is very unequally distributed by regions. The "historic" regions are losing market shares, and Asia, growing very fast, is gaining.

European production of industrial electronics has grown at 3.7% over 2010-2016, falling back in market share in the world from 25% in 2010 to 20% today. In contrast US production has grown at 6.4% during the same period, whereas Japanese production has shrunk by 4% per year.

- **China becoming leading manufacturing country**

Industrial electronics production has grown very fast over the recent years, at rates close to 20%, until China is now the first country for industrial electronics manufacturing, just before Europe.

China has now about 21% of the world industrial electronics market. This share should be compared with the place of China in the world.

Table – Country / Region comparisons

	China	Europe	The USA	Japan
Share of world Industrial electronics production	24%	20%	19%	12%
Share of world GNP	15%	21%	24%	6%
Share of world population	18%	7%	4%	<2%

Source: DECISION Etudes & Conseil, Eurostat, United Nations, World Bank

This shows how China is fast rising to occupy a rank consistent with its size, and has in fact already developed industrial electronics, an essential instrument of productivity and competitivity, beyond its share in world GNP or population.

This should continue, as the Chinese government has an active policy of further developing industrial electronics, and in particular robotics, in line with the Made in China (MiC205) program. The objective of the Chinese government is to sell a total of 100 000 domestically produced industrial robots by 2020. In 2017, on the Chinese market of 87 000 robots, 27 000 were from Chinese robot suppliers, and 60 000 from foreign robot suppliers. A sign or an effect of this policy is the acquisition in 2016 of KUKA, a leading German robotics company, by the Chinese household appliance and HVAC giant Midea.

- **Strong positions of European companies on the world markets**

The European Siemens is by far the leading global supplier of industrial electronics, with around 10% of the world market, and is present on all the sub-segments. The second is the European ABB, who acquired GE Industrial Solutions in 2018, thus ending the American company's involvement in the segment. Schneider Electric is the third major European player, ranking fourth in the world, after the American Honeywell, and before the Japanese Mitsubishi.

The European Bosch is also a leading player with its Bosch-Rexroth subsidiary specialized in motion control, which ranks ninth among world players.

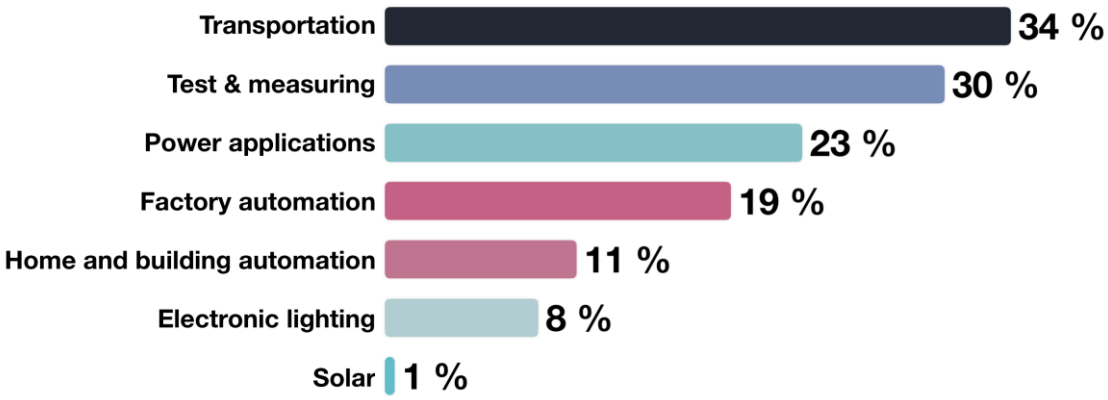
Other significant European players are Danfoss, Legrand, Rohde & Schwartz, Heidenhain.

- **Many differentiated applications, products, systems and value chains**

Measuring and testing is the largest segment in industrial electronics, followed by industrial automation (robots, drives, motion control, numerical control, and other control). This comprises a large variety of products and systems, some of which in new developing fields such as Industry 4.0 or smart metering.

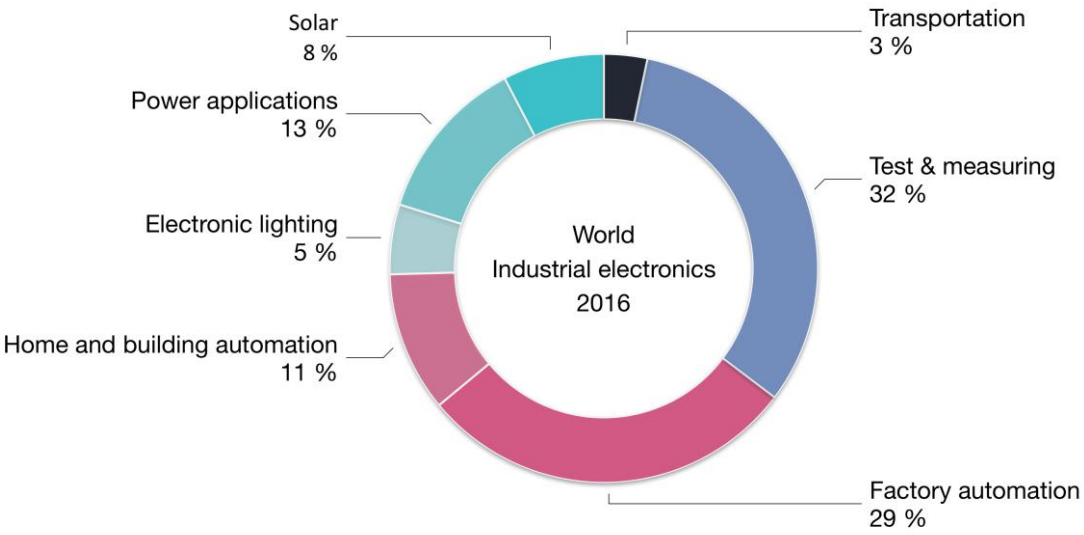
The share of European production is high for the whole segment (20%), but unequal in the sub-segments. In particular home and building automation, which includes a lot of HVAC controls, is less developed in Europe.

Bar chart - European share of the world in industrial electronics segment production



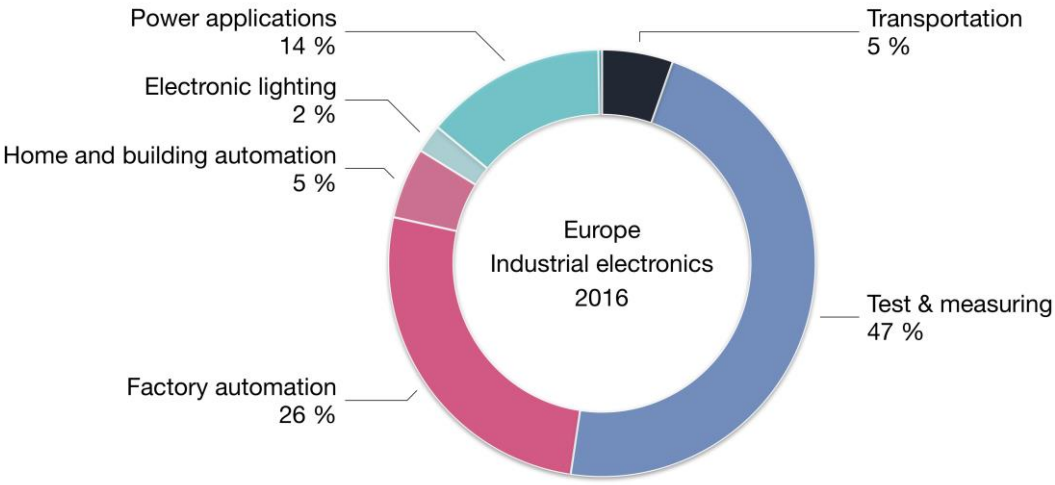
Source: DECISION Etudes & Conseil

Figures - Industrial electronics: segment share in the world 2016



Source: DECISION Etudes & Conseil

Figures - Industrial electronics: segment share in Europe 2016



Source: DECISION Etudes & Conseil

Table - Industrial electronics production by region B €

Region	2010	2016	2010-2016 CAGR
Europe	59.6	74.3	4%
The USA	48.3	69.9	6%
Japan	56.2	44.0	-4%
China	30.9	87.6	19%
Other Asia	20.4	42.9	13%
RoW	14.6	40.7	19%
World total	**229.1**	**359.3**	**8%**

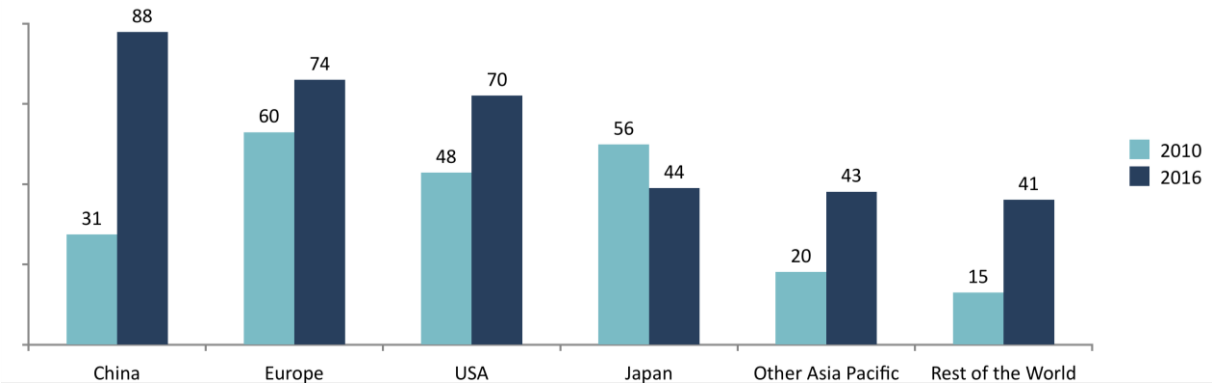
Source: DECISION Etudes & Conseil

Table - Industrial electronics production by segment B € in 2016

	World	Europe	Europe share
Factory automation	103.0	19.4	19%
Of which robots	36.2	3	9%
Home and building automation	38.0	4	11%
Test & measuring	115	34.9	30%
Power applications	45.0	10.2	22%
Solar	27.5	0.2	1%
Electronic lighting	18.9	1.6	9%
Transportation	11.8	4	33%
Total	**359.2**	**74.3**	**20%**

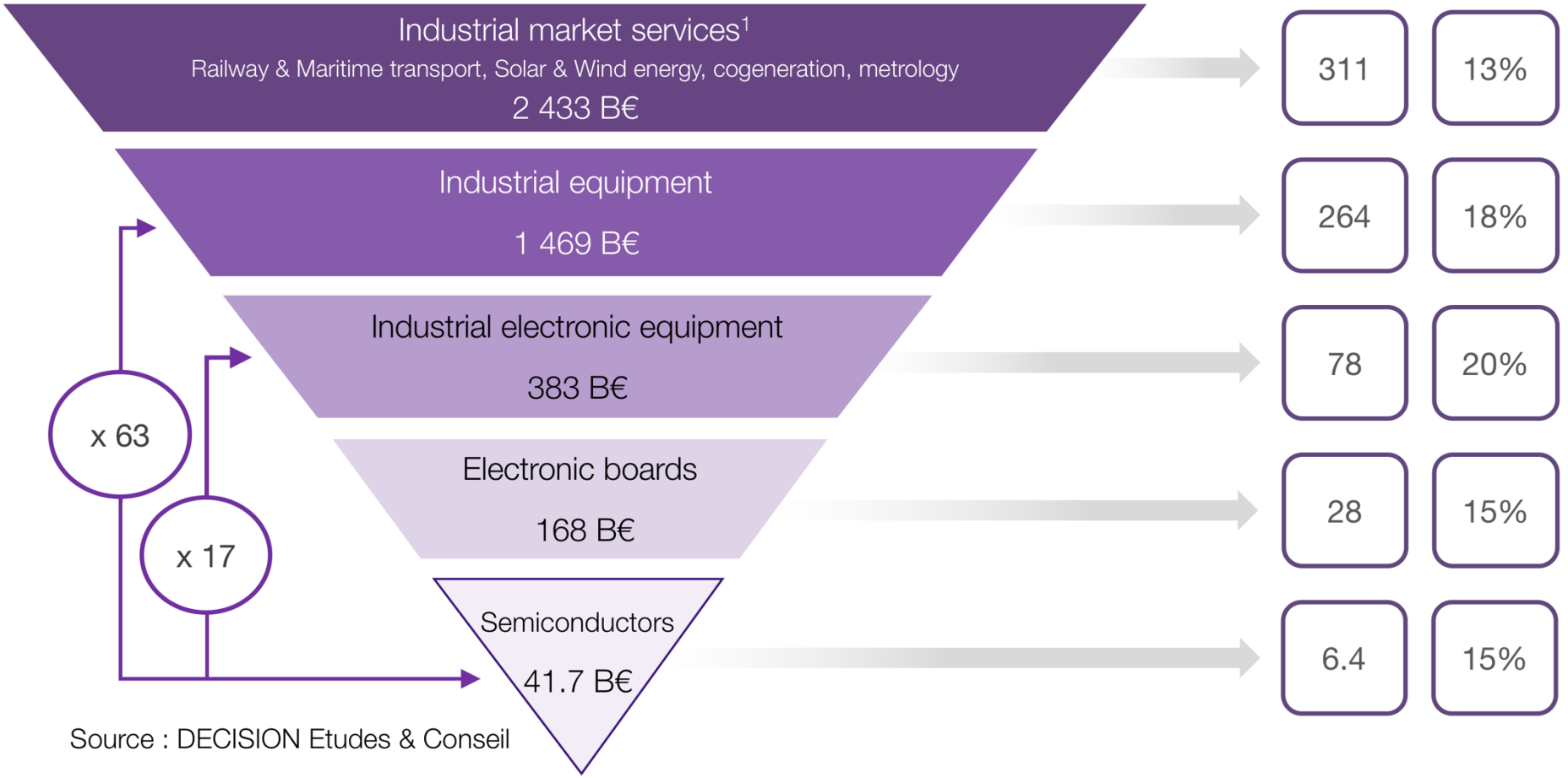
Source: DECISION Etudes & Conseil

Bar chart - Industrial electronics production by regions (B €)



Source: DECISION Etudes & Conseil

Worldwide Industrial electronics value chain in 2017



Source : DECISION Etudes & Conseil

[1] The services measured in this diagram only corresponds to the "market services", that is the services produced for sale on the market at a price intended to cover production costs and to provide a profit for the producer. Yet, industrial equipment provide a majority of "non market services" once they are sold.

1.1.1 The industrial electronics value chains

Table - Sub-segmentation of industrial electronics

Level 1	Level 2	Level 3	Level 4
Automation	**Factory and utilities automation**	Motion control	
		VFD drives	
		PLC	
		DCS	
		NC	Ordinary NC
			Computer controlled (CNC)
		Robotics	Industrial
			Service
			Domestic
		RFID	
	Home and building automation	Home automation	
		Building automation	
		HVAC (electronic content)	
Instrumentation, measurement & test	**Electronic test & measurement**	Automatic Test Equipment	
		General purpose instruments	
		Communication and network test equipment	
		Electronic weighing	Laboratory, commercial, personal weighing
			Industrial weighing
	Smart meters		
Power electronics	**UPS, supplies, inverters, distribution**	Uninterrupted Power supplies	
		Other power supplies, inverters...	
		Battery chargers	
		Solar inverters	
	Solar energy	Solar panels	
		Other	
	Electronic lighting	LED lighting	General lighting
			Intelligent lighting
	Signaling & infrastructure		

Source: DECISION Etudes & Conseil

1.1.2 Industrial electronics in figures

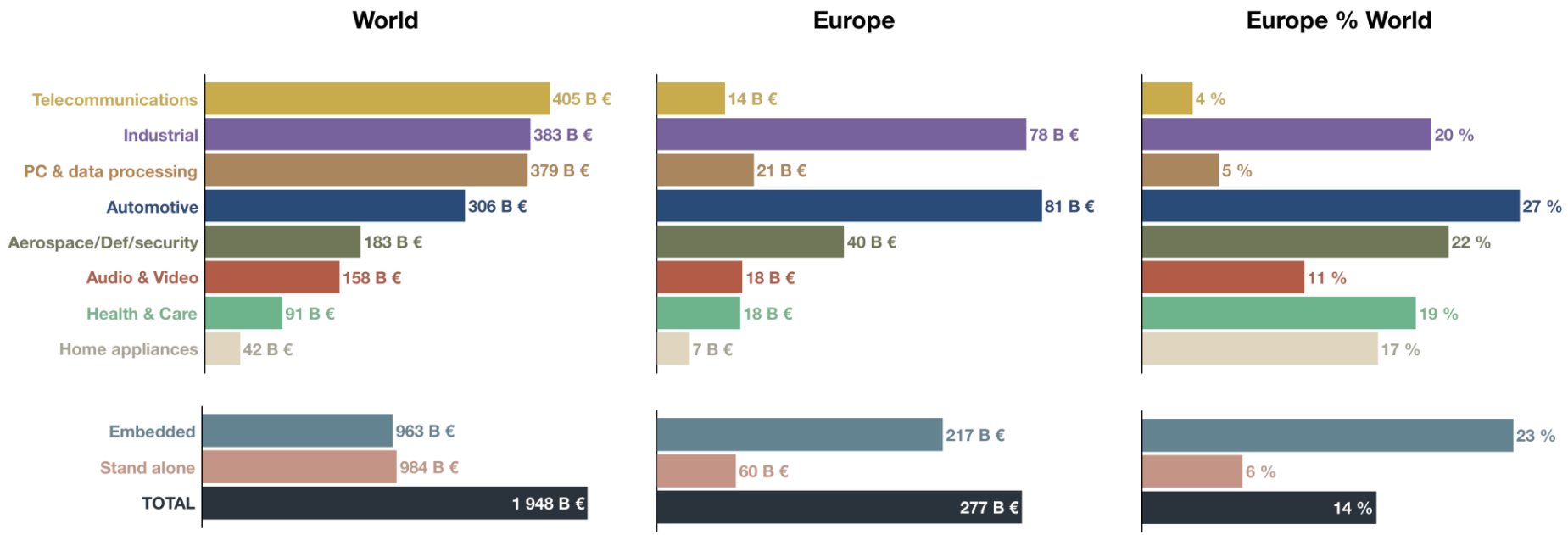
i. Europe's position in the World

Two types of figures are presented in this industrial report:

- The figures of the Prodcom database (Eurostat). According to the Eurostat Prodcom figures the total production of industrial electronics in Europe was 62.5 billion € in 2016, up from 51.8 billion € in 2010.
- The figures of DECISION, that are based on the Prodcom database but with corrections for Prodcom sub-segments that should not be added. For instance, automation figures in Eurostat may be under-estimated because it is possible that not all electronic control modules or cards that are incorporated into end equipment (machines, HVAC...) are counted separately in the statistics. Furthermore, the Prodcom figures do not include transportation, photovoltaics and electronic lighting, as well as some RFID and building and HVAC control equipment, giving re-estimated figures of respectively 74.3 and 59.6 B €.

Industrial electronics is the second largest end-user segment in the European electronics ecosystem (78 B € in 2017), just below automotive electronics (81 B € in 2017) and is one if the fastest growing ones with automotive and healthcare.

Production of electronic equipments by segment in 2017 (M €)



Source: DECISION Etudes & Conseil

We have estimated world production on the basis of the statistical numbers available for Europe, the USA and Japan, and our estimate of the relative size of the China, the rest of Asia, and the rest of the world.

We have been able to collect consistent statistical data for Europe, the USA and Japan only. Figures for China and the rest of the world were estimated, based on qualitative or partial elements.

Table - Total Industrial electronics production by region 2010 - 2016 (in B €)

	2010	2016	CAGR 2010-2016
Europe	59.6	74.3	4%
The USA	48.3	69.9	7%
Japan	56.2	44.0	-4%
China	30.9	87.6	21%
Other Asia-Pacific	20.4	42.9	14%
Rest of the World	14.6	40.7	13%
World total	**229.1**	**359.3**	**8%**

Source: DECISION Etudes & Conseil

Whereas in Europe and the USA production of industrial electronics has steadily grown over the 2010-2016 period, in Japan it has steadily decreased due to competition from China mainly. Industrial electronics has traditionally been a strong point of Japan, particularly in robotics, 52% of the industrial, robots sold in the world in 2016 were manufactured in Japan.

Table - Total Industrial electronics production by segment in 2016 (in B €)

	World	Europe	Europe % World
Factory automation	**103**	**19,4**	**19 %**
Of which robots	36,2	3	9 %
Home and building automation	**38**	**4**	**11 %**
Test & measuring	**115,016**	**34,9**	**30 %**
Power applications	**45**	**10,2**	**22 %**
Solar	**27,5**	**0,2**	**1 %**
Electronic lighting	**18,9**	**1,6**	**9 %**
Transportation	**11,8**	**4**	**33 %**
Total	**359,3**	**74,3**	**20 %**

Source: DECISION Etudes & Conseil

Below is a table that depicts the sub-segments of the automation electronics industry.

Table - Automation segment detailed

Subsegment	Main manufacturers	Comments	Segment market (B €)
Factory and utilities automation			**141**
Factory automation			**102.8**
Motion control	Siemens (Europe), Schneider Electric (Europe), ABB (Europe), and also Parker Hannifin (USA), Yaskawa (Japan), Moog (USA), and Bosch Rexroth (Europe)	The principal players in this field are European	14.0
VFDs	ABB (Europe) and Siemens (Europe), followed by Danfoss-Vacon (Europe) afterwards come Schneider Electric (Europe), Rockwell Automation (USA) and Mitsubishi Electric (Japan).		16.0
PLCs	Siemens (Europe) and Rockwell Automation (USA) control about 50% share between them, followed by Mitsubishi Electric (Japan) and Schneider Electric (Europe).		10.0
DCS	ABB (Europe), Emerson (USA), Honeywell (USA) and Siemens (Europe)		6.3
NCs	Fanuc (Japan), Haas Automation (USA), Heidenhain (Europe), Siemens (Europe), Mitubishi Electric (Japan)		11.5
Robotics	Fanuc (Japan), Yaskawa (Japan), Kawasaki Heavy Industries (Japan), ABB (Europe), KUKA (Midea, China)	The market leaders in this sector are the Japanese	36.0
RFID			9.0
Home & building Automation	Honeywell (USA), Johnson Controls (USA) and Siemens (Europe)		**38**
Home Automation		Smart Homes, domestic robots, smart meters, security...	14
Building Automation			24.0

Source: DECISION Études & Conseil

ii. Europe

The NACE SBS statistics do not have a heading that corresponds to Industrial Electronics. These are partly in 26.51, and partly in 27.12 and 28.99 (robots). This does not enable statistical employment or value-added figures to be shown. However, using the average production per employee value in the whole of the 26.51 heading (measuring, control, navigation, watches), employment in the industrial electronics segment could be about 370 000 people.

Production breakdown by country in the Eurostat Prodcom statistics is incomplete due to a lot of confidential figures. However, the available data does show a very great predominance of Germany (with 44% of the total).

These figures do not include transportation, solar, power applications and electronic lighting.

Table - Share of Germany in Industrial electronics production in Europe in 2016

B €	Europe	Germany	Share %
Test & measuring	34.9	14.6	41.8
Factory automation	19.4	8.5	43.8
Of which robots	3.3	1.0	30.3
Signaling equipment	2.8	0.7	25.0
Total measuring and automation	57.1	23.8	41.7

Source: DECISION Études & Conseil, Eurostat Prodcom

The country breakdown of production statistics is not always complete, as it must not enable the identification of figures for single companies. The share of undisclosed country data is relatively important for industrial electronics (between 8 and 16%).

Table – European industrial electronics production in Europe in 2016 – Share of undisclosed

B €	Total	Identified	Undisclosed	Undisclosed share %
Test & measuring	34.9	29.4	5.5	15.8
Factory automation	19.4	18	1.4	7.2
Of which robots	3.3	3.3	0	0
Signaling equipment	2.8	2.4	0.4	14.3
Total measuring and automation	57.1	49.8	7.3	12.8

Source: DECISION Études & Conseil, Eurostat Prodcom

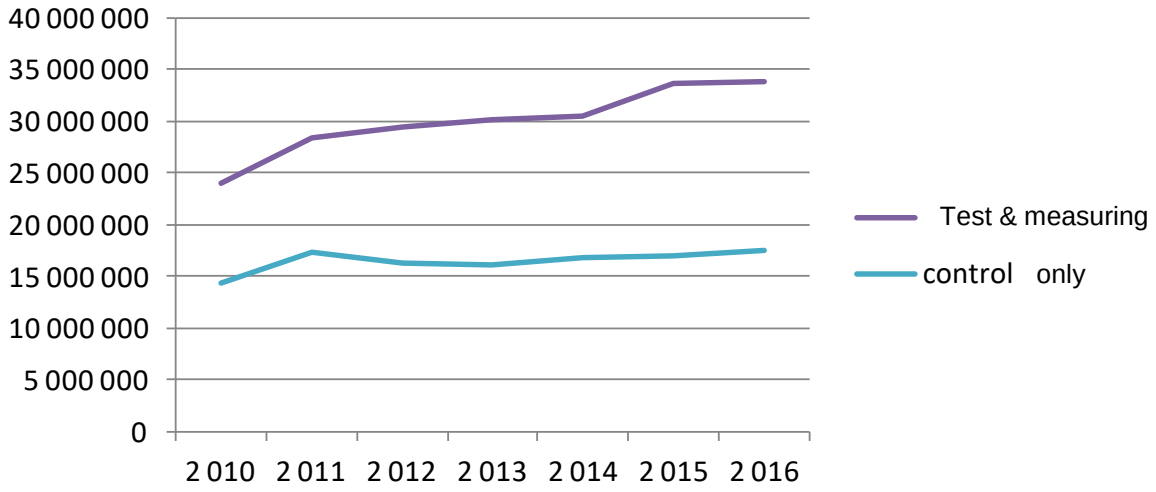
Table - Country breakdown for the main categories of industrial electronics in 2016

Measuring eq	%	Automation eq	%	Of which robots	%
Germany	42.9	Germany	48.6	Germany	30.3
UK	11.5	France	8.0	Italy	27.3
France	7.4	Italy	8.0	France	21.2
Italy	6.2	UK	6.3	Austria	5.1
Denmark	2.7	Austria	5.1	Sweden	3.9
Austria	2.1	Denmark	4.0	The Netherlands	2.2
Finland	1.5	Spain	2.9	UK	1.9
Netherlands	1.5	Sweden	2.8	Spain	1.7
Sweden	1.4	Poland	1.7	Denmark	1.1
Poland	1.2	Netherlands	1.1	Finland	1.0
Others	5.1	Others	3.5	Others	3.4
Undisclosed	16.5	Undisclosed	8.0	Undisclosed	0.9
Total	**100.0**	**Total**	**100.0**	**Total**	**100.0**

Source: DECISION Études & Conseil, Eurostat Prodcom

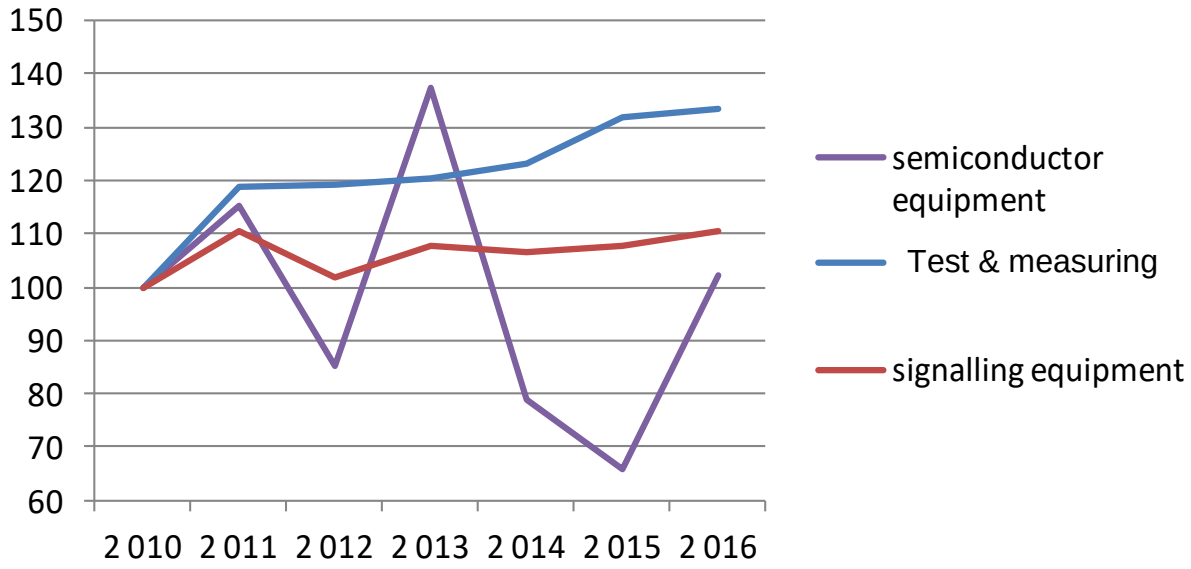
The top ten counties for industrial electronics production in Europe are more or less the same for measuring equipment, automation or robots, their ranking varies, but, among the ten, eight are always present, the other two are according to the field Spain, Poland or Finland. Denmark and Austria are particularly strong in this field.

Graph - European industrial electronics production 2010-2016 (k€)



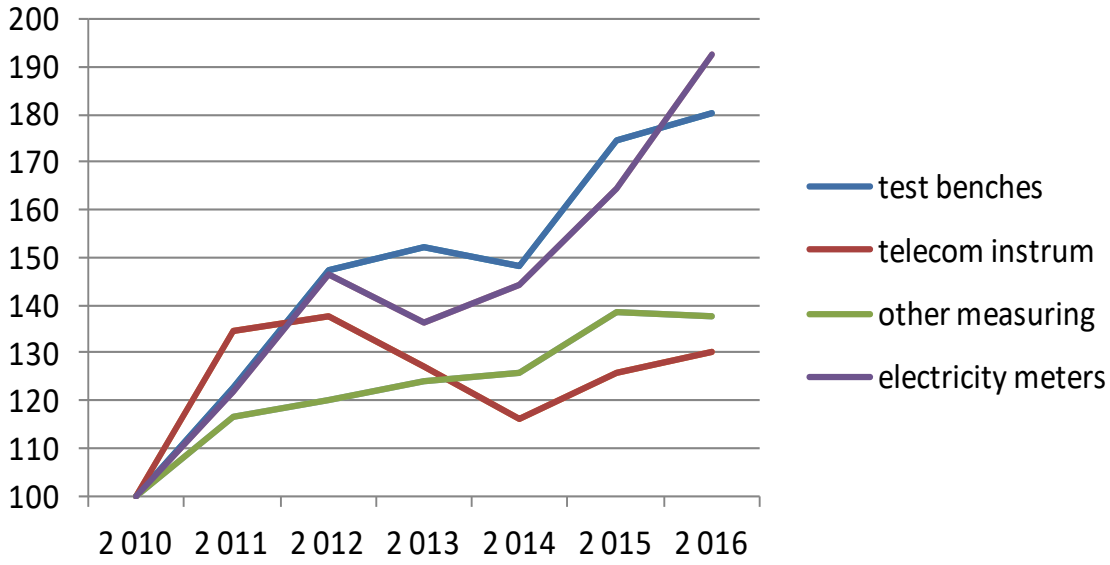
Source: DECISION Études & Conseil

Graph - European industrial electronics production 2010-2016 (index 2010 = 100)



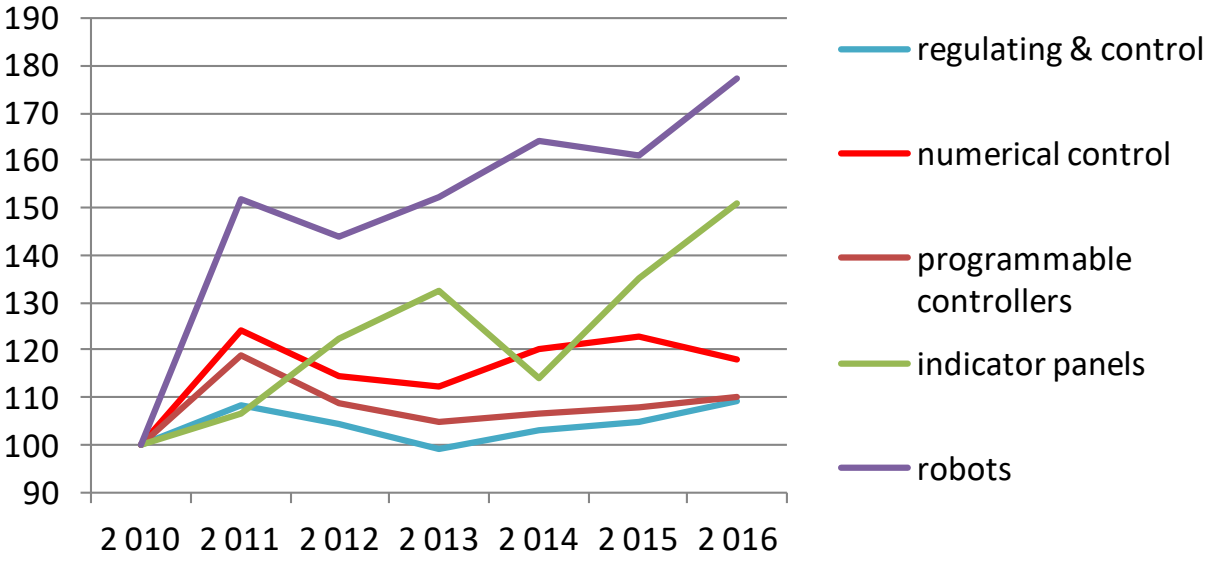
Source: DECISION Études & Conseil

Graph - European measuring equipment production 2010-2016 (index 2010=100)



Source: DECISION Études & Conseil

Graph - European control equipment production 2010-2016 (index 2010=100)



Source: DECISION Études & Conseil

1.1.3 Industrial electronics company positioning

This segment includes a wide number of suppliers. Nine large global companies with varied activities dominate the segment, followed by many more specialized players...

The European Siemens is by far the largest player, followed by the American Honeywell and the Europeans ABB and Schneider Electric. Four European companies are among the top ten, along with four American, one Japanese and one Chinese.

Table - Top 10 Automation manufacturers and world sales in 2016 (B€)

Company	Country	Industrial electronics world sales 2016	Total sales 2016
Siemens	Europe	39.1	83.0
Honeywell	USA	13.8	35.5
ABB	Europe	13.0	30.3
Schneider Electric	Europe	9.4	24.7
Mitsubishi Electric	Japan	9.0	34.7
Emerson	USA	8.8	13.1
UTC	USA	7.7	51.6
MIdea (2017)	China	6.0	31.6
Bosch (2017)	Europe	5.5	78.0
Rockwell Automation (2017)	USA	5.3	53

Source: DECISION Etudes & Conseil

Some of the major industrial players are present both in industrial automation and in home and building automation (Siemens, Schneider Electric, Honeywell) whereas others are more specialized (ABB, Rockwell Automation, Johnson Controls, Mitsubishi Electric).

Below is a table that depicts the sub-segments of the automation electronics industry.

Table - Automation segment detailed

Subsegment	Main manufacturers	Comments	Segment market (B €)
Factory and utilities automation			**141**
Factory automation			**102.8**
Motion control	Siemens (Europe), Schneider Electric (Europe), ABB (Europe), and also Parker Hannifin (USA), Yaskawa (Japan), Moog (USA), and Bosch Rexroth (Europe)	The principal players in this field are European	14.0
VFDs	ABB (Europe) and Siemens (Europe), followed by Danfoss-Vacon (Europe) afterwards come Schneider Electric (Europe), Rockwell Automation (USA) and Mitsubishi Electric (Japan).		16.0
PLCs	Siemens (Europe) and Rockwell Automation (USA) control about 50% share between them, followed by Mitsubishi Electric (Japan) and Schneider Electric (Europe).		10.0
DCS	ABB (Europe), Emerson (USA), Honeywell (USA) and Siemens (Europe)		6.3
NCs	Fanuc (Japan), Haas Automation (USA), Heidenhain (Europe), Siemens (Europe), Mitubishi Electric (Japan)		11.5
Robotics	Fanuc (Japan), Yaskawa (Japan), Kawasaki Heavy Industries (Japan), ABB (Europe), KUKA (Midea, China)	The market leaders in this sector are the Japanese	36.0
RFID			9.0
Home & building Automation	Honeywell (USA), Johnson Controls (USA) and Siemens (Europe)		**38**
Home Automation		Smart Homes, domestic robots, smart meters, security...	14
Building Automation			24.0

Source: DECISION Études & Conseil

1.1.4 Industrial electronics technology and market developments

Technological developments in industrial electronics will largely be driven by "Industry 40" and IoT.

The market will be driven first of all by the growth of demand in Asia and other regions of the world where automation is still a lot behind its penetration in Europe or the USA. Industry 4.0 and the IoT will fuel this growth by a constant renewal demand…

Among the technological innovations that will have a profound impact on the industrial automation market is the development of "IoT" (Internet of Things) within the machinery world which is expected to lead to significant increases in productivity. Likewise, the appearance of 3D printing additive manufacturing processes will also transform the means of producing prototypes and parts for maintenance, but also other products that need to be customized, e.g. hearing aids...

Industrial robots still have strong growth prospects, as the world average is 74 robots per 10 000 employees, whereas it is about five times that number in Germany and Japan, and nearly ten times in South Korea. The spreading of robots into the service and personal markets is a new factor of growth. However, Europe still ranks low in the development of robot density with a5% growth rate compared with 7% for the Americas and 9% for Asia.

An example of the rising domain of service robots is "public relations" robots in the hospitality sector (hospitals, hotels, restaurants...). One of the primary drivers for this market is the rising need to improve productivity and efficiency. Public relation robots are more productive than humans, are not subject to social legislation, and are adaptable and competent in several applications, such as delivery of goods, monitoring, supervision, and guiding to the guest.

This often implies advanced applications of artificial intelligence (AI). The growing implementation of humanoids has compelled the robotics companies to integrate advanced AI in robots to make them more familiar while interacting with humans. For instance, Pepper (the humanoid robot from SoftBank Robotics) is one of the most human-like robots in the world which can interact with humans and read emotions. AI helps robots to understand the language, read faces, understand emotions, and even imitate human emotions. To fulfil the tasks of assisted living, several companies are using AI technology to develop such humanoids. The Japanese company SoftBank owns operations in broadband; fixed-line telecommunications; e-commerce; internet; technology services; finance; media and marketing; semiconductor design; and other businesses.

Field robots include a growing number of autonomous robots in applications like agriculture, mining, exploration... Such autonomous robots are also beginning to be used in domestic applications (vacuum cleaners, lawn mowers...).

A large number of functions in professional or collective residential buildings are converging into the "intelligent building". The primary functions typically addressed are: control of electrical energy, lighting, HVAC systems, and security functions such as access control to the premises, lifts, alarm systems and fire prevention. Cloud computing and sophisticated software are increasingly used, for example in the "software as a service" (SAAS) mode.

An important trend is the development of increasingly integrated technologies and related applications such as communicating meters and HVAC equipment. Applications that provide a high level of service quality (building security and alarms, etc.) used to rely on cable connections, but wireless technologies are gradually taking a greater market share, in particular in applications such as lighting.

The primary goal of developed countries for the air conditioning and ventilation segment is the overall reduction of electrical energy consumption, which presently represents 25% of household energy use against 16% for lighting and 16% for refrigerators. Air conditioning units with a variable frequency drive (VFD), a sensor and a microcontroller that manage the compressor in function of the ambient temperature are a growing market.

The perspectives of market growth in emerging countries are significant as the use of air conditioners in the world is no more than 10%.

1.1.5 Industrial electronics MNE interaction

The industrial segment uses a lot of power semiconductors, and photovoltaic SCs and LEDs. It also uses a very large share of analog ICs. Nearly half (49.8%) of the ICs used in industrial electronics are analog, whereas that share is only 14.8% of0 the total IC market.

The IC content is 5.7% in industrial electronics as shown i our figures, and with the other discrete semiconductors this rises to 8%.

The regional distribution of IC markets in the industrial segment should reflect the relative shares if the regions in industrial electronics production. However, that is not the case for Japan, whose share seems high compared to production in Japan. That is probably due to the fact that large global companies like Mitsubishi, Fanuc, Yaskawa, Yokogawa who manufacture elsewhere in Asia, order their components from Japan.

Table - IC market in industrial electronics 2016 B€

	Industrial electronics production	IC markets	Other SC markets	Total SC markets
Europe	74.3	8.0	6.4	14.4
USA	69.9	3.9	3.0	6.9
Japan	44.0	3.1	6.4	9.5
China	87.6	2.9	2.0	4.9
Other Asia Pacific	42.9	2.4	3.0	5.4
RoW	40.7	0.3	0.3	0.6
World total	**359.3**	**20.6**	**21.1**	**41.7**

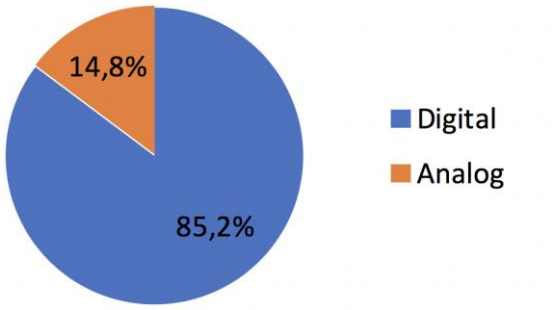
Source: DECISION Etudes & Conseil, IC Insights

Table - Analog ICs in Industrial electronics (B$)

	2015	2016	2017	2021	% share 2017
Total ICs	286 900	296 100	369 400	467 300	100
Total analog	47 010	49 436	54 536	74 985	14.8
Of which general purpose	19 055	19 794	22 145	28 054	
Of which specific	27 955	29 642	32 390	46 931	
Total Industrial	19 491	20 061	23 203	31 737	100
Analog industrial	9 543	9 986	10 907	13 947	49.8
Of which general purpose	7 349	7 474	8 206	9 818	
Of which industrial specific	2 194	2 512	2 701	4 129	

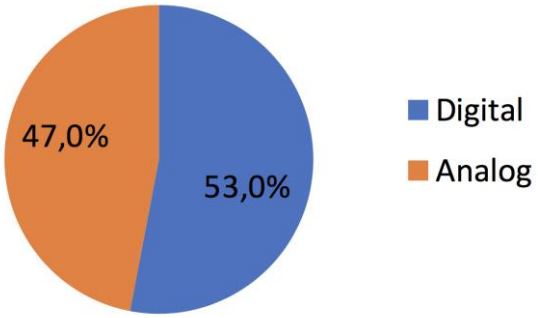
Source: DECISION Etudes & Conseil, IC Insights

Pie chart - Global ICs analog share 2017



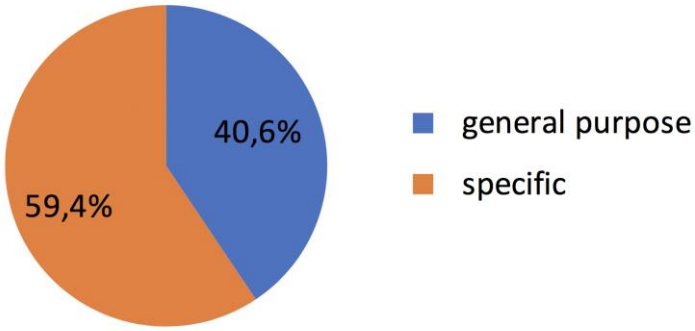
Source: DECISION Études & Conseil

Pie chart - Industrial ICs analog share 2017



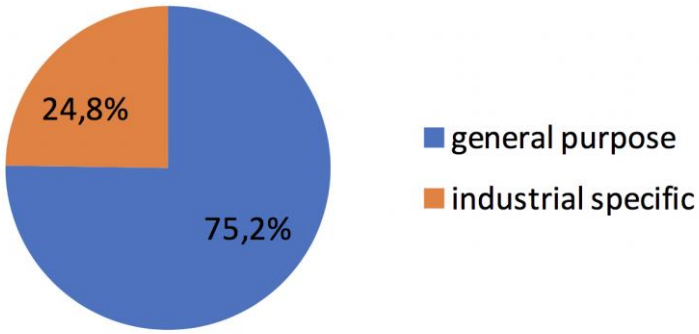
Source: DECISION Études & Conseil

Pie chart - Global analog ICs



Source: DECISION Études & Conseil

Pie chart - Industrial analog ICs



Source: DECISION Études & Conseil

Table - Leading Analog IC Suppliers ($M)

2017 Rank	Company	2016	2017	% Change	% Market share
1	Texas Instruments	8,536	9,900	16%	18%
2	Analog Devices*	3,790	4,310	14%	8%
3	Skyworks Solutions	3,205	3,710	16%	7%
4	Infineon	3,030	3,355	11%	6%
5	ST	2,519	2,930	16%	5%
6	NXP	2,430	2,415	-1%	4%
7	Maxim	1,900	2,025	7%	4%
8	ON Semi*	1,335	1,800	35%	3%
9	Microchip*	819	940	15%	2%
10	Renesas*	810	915	13%	2%

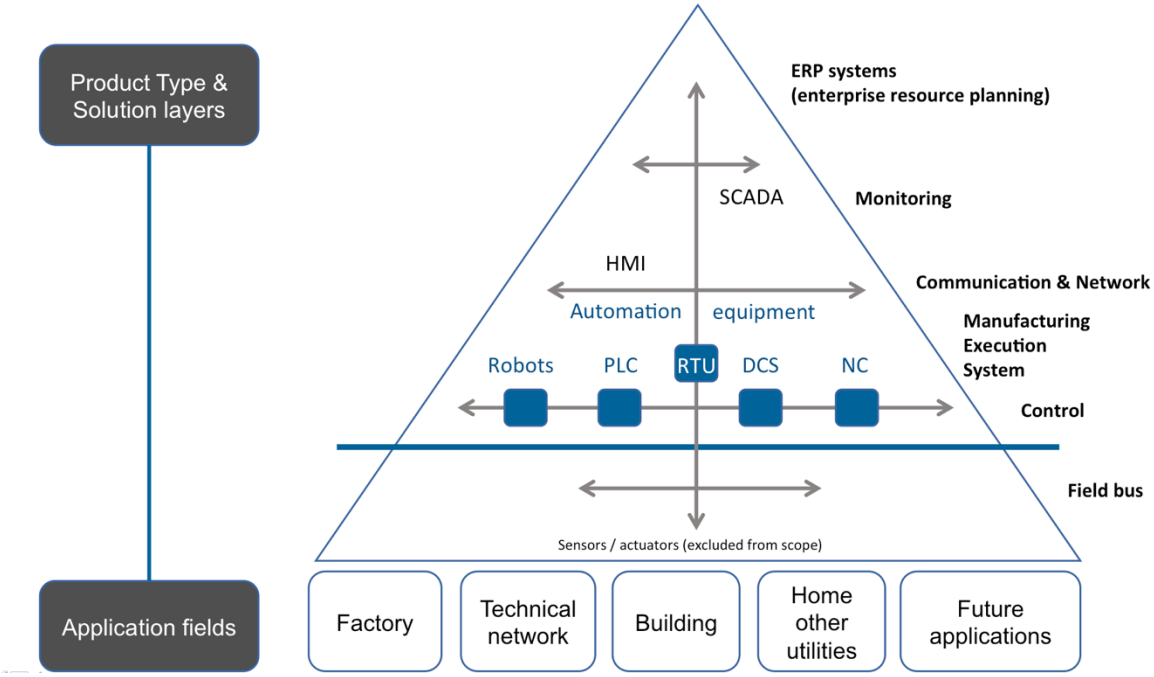
Source: IC Insights

1.1.6 Appendix I: Industrial electronics segment analysis

i. Automation

Automation is defined as an element of the general functional structure of factory and residential entities and the market for automation equipment is situated somewhere between sensors and actuators on the one hand and supervision (SCADA Supervisory Control and Data Acquisition) and management (ERP Enterprise Resource Planning), on the other.

Diagram - Automation Product Segmentation



Source: DECISION Etudes & Conseil

Business growth in the automation segment is closely dependent on industrial investment and economic activity. Global growth in this segment has averaged 5% since 2010. Automation, as defined, contributes significantly to the world's critical societal needs and particularly to energy efficiency. The growing impact of connected objects will accelerate growth of this market in coming years.

Table - World Automation electronic equipment production by product segment 2016-2022 (in billion euros)

Segment	World 2016	World CAGR 2016-22	Europe 2016	Europe CAGR 2016-22
Automation	**157.0**	**5.1%**	**24.7**	**3.2%**
Factory automation	103.0	4.5%	19.4	3.4%
Home & Building	38.0	6.0%	4.0	2.0%
HVAC	16.0	6.5%	1.3	1.9%

Source: DECISION Etudes & Conseil

A. Factory & Utilities Automation

Industries that use automation equipment are usually split into two categories: “Discrete” or “Assembly” industries and “Process” industries. The production mode of discrete industries is the machining and assembly of parts and sub-assemblies into a finished product that requires more or less complex assembly operations. This is the case of the aviation, automotive, electrical, electronic and machine industries, amongst others. “Process” industries transform a variety of products such as oil and chemicals, for example, using continuous flow processes such as in refining to obtain the final product. These processes are employed in chemical and petrochemical industries, cement, glass, food processing, beverages, gas, pharmaceuticals, cosmetics, paper, textile, mine products and energy production. Traditionally, industrial automation companies specialized in either discrete or process industries, however this is changing as witnessed by the acquisition by Schneider Electric in 2014 of Invensys, a supplier of equipment, software and services for process industries (oil, chemicals and pharmaceuticals.).

Among the technological innovations that will have a profound impact on the industrial automation market is the development of “IoT” (Internet of Things) within the machinery world which is expected to lead to significant increases in productivity. Likewise, the appearance of 3D printing additive manufacturing processes will also transform the means of producing prototypes and parts for maintenance.

a. Motion control & drives (excluding transportation)

Motion Control

Motion control systems Factory provide permanent control over a servomotor or a stepper motor assembled on to a machine. In the case of a servomotor, the system includes, besides the motor itself, a servo-drive that ensures that the performance of the motor (speed or other parameter) remains compatible with the program, correcting the motor’s operation if need be. It is this method of permanent feedback that is the basic advantage of servomotors over classic AC or DC motors. In the case of a stepper motor, there is no servo system; it is simply the number of steps carried out by the motor that puts it in its programmed position.

The world motion control market is expected to grow from 14 Billion € in 2016 to 16 Billion € by 2022, at a CAGR of 3.5% during the coming period.

The principal players in this field are European: Siemens (Europe), Schneider Electric (Europe), ABB (Europe), but also Parker Hannifin (USA), Yaskawa (Japan), Moog (USA), and Bosch Rexroth (Europe).

Variable Frequency Drives

Global industrial activity consumes 42% of the world’s electricity, of which 2/3 is used by electric motors (according to IHS). Of these motors 80% are low voltage AC motors. Speed regulators, known as VFDs (“Variable Frequency Drives”), can increase energy efficiency of these motors measured by the comparison of energy produced over energy supplied. This is all the more necessary since regulations in place in an increasing number of countries impose efficiency levels that are more and more stringent. The widest application of this type of equipment is to be found in compressors, elevators, ventilators and pumps.

The world market for VFDs reached about 20 million units sold and will grow from an estimated 16 Billion € in 2016 to 20 Billion € by 2022 with a CAGR of 3.6%. Market growth is slowing somewhat in comparison to prior years as a result of the progressive modernization of machines currently in use.

The major VFD manufacturers are ABB (Europe) and Siemens (Europe), followed by Danfoss (Europe) subsequent to their acquisition of Vacon (Europe) in 2014. Afterwards come Schneider Electric (Europe), Rockwell Automation (USA) and Mitsubishi Electric (Japan).

b. PLCs, DCS, NC

PLCs

"Programmable Logic Controllers" are electronic devices used to automate industrial equipment such as machines, conveyors and assembly lines. A PLC is composed of a central processor unit (CPU), input/output boards, communication modules and a power supply. It communicates via industrial networks (Industrial Ethernet, Profibus, LonWorks, etc.). The main technological evolution is the transition to PACs (Programmable Automation Controllers) which are a PLC combined with a PC. PLCs were at first used with "discreet" industries. As the distinction between "discreet" and "process" industries becomes less distinct the generalization of their use in process industries is their principal vector of growth.

The world market for PLCs has been stable since 2012 and can be estimated at 10 billion € in 2016. The market will remain stable notably as a consequence of reduced investment in the Oil and Gas sectors.

Market leaders are Siemens (Europe) and Rockwell Automation (USA) who control about 50% share between them, followed by Mitsubishi Electric (Japan) and Schneider Electric (Europe).

DCS

Distributed Control Systems are also industrial process control systems which have the important feature of being equipped with a Man/Machine interface that enables supervision and control. They were initially developed to provide control for production units in "process" industries. Progress in microelectronics and therefore in microprocessors in recent years has done much to bring PLCs and DCS closer together. Certain industries that are both "process" and "discrete" require a process control system with the capability of both PLCs and DCS. This is common in pharmaceutical and food & beverage industries...

The global market for DCS is estimated at 6.3 B € in 2016. Growth through 2022 is expected to average 2.0%. The principal manufacturers of DCS are ABB, Emerson, Honeywell and Siemens.

NC

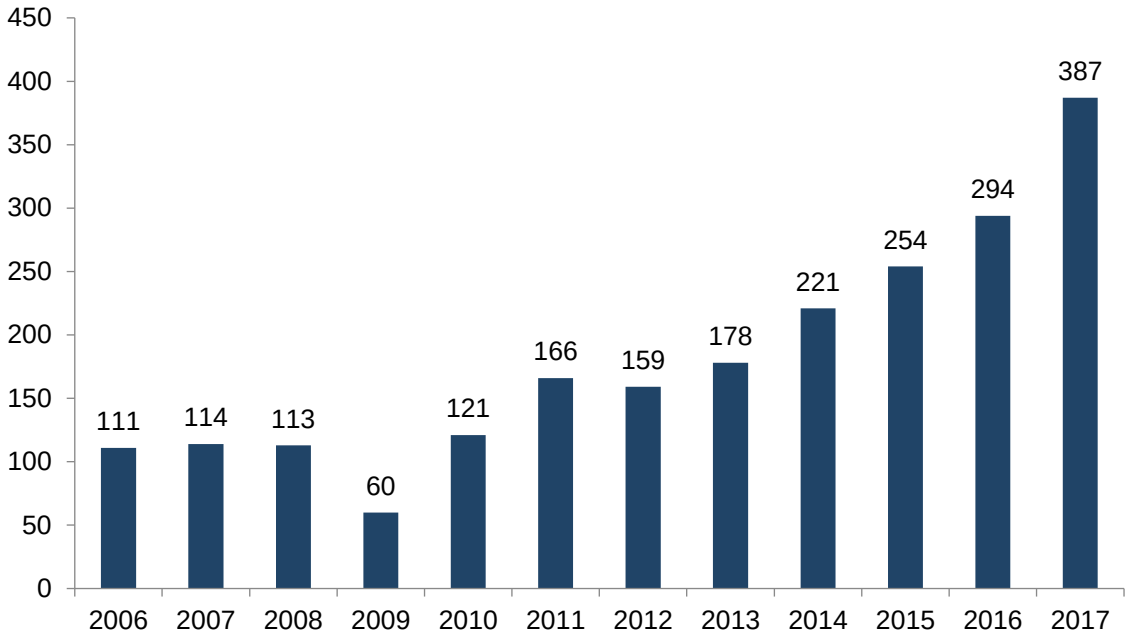
A "Numerical Control" is a machine tool-based apparatus which provides to the tool the machining program either from a memory or from a computer. The majority of Numerical Control devices, today, integrate a computer, referred to as CNC or Computerized Numerical Control. CNCs are extensively used in drilling, turning, grinding, electro-erosion, and in machining-centers.

The market for CNCs in 2016 was 7 billion €, and the whole Numerical Control market was 11.5 B € in 2016. Growth through 2022 is anticipated to be at an annual average rate of 2.2%. The principal manufacturers of Numerical Controls are Fanuc (Japan), Haas Automation (USA), Heidenhain (Europe), Siemens (Europe) and Mitubishi Electric (Japan).

c. Robotics

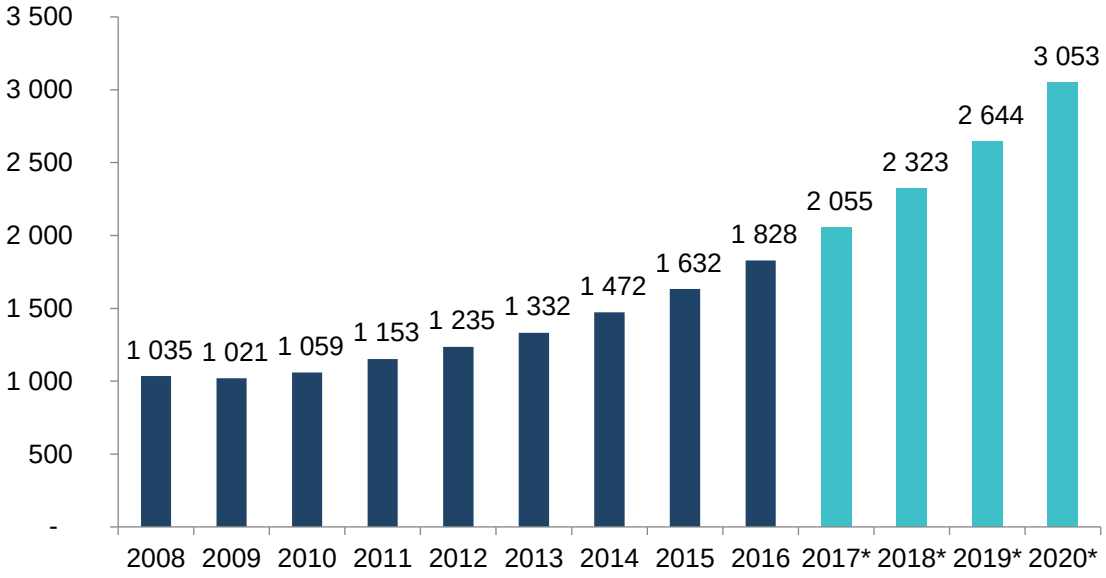
In 2016 Asia represented 61% of global demand, Europe 19% and North America 13.5%. China in recent years has become the largest global market, before Europe.

Bar chart - Estimated worldwide annual supply of industrial robots 2006-2017 (000 units)



Source: World Robotics 2018

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



Source: World Robotics 2018

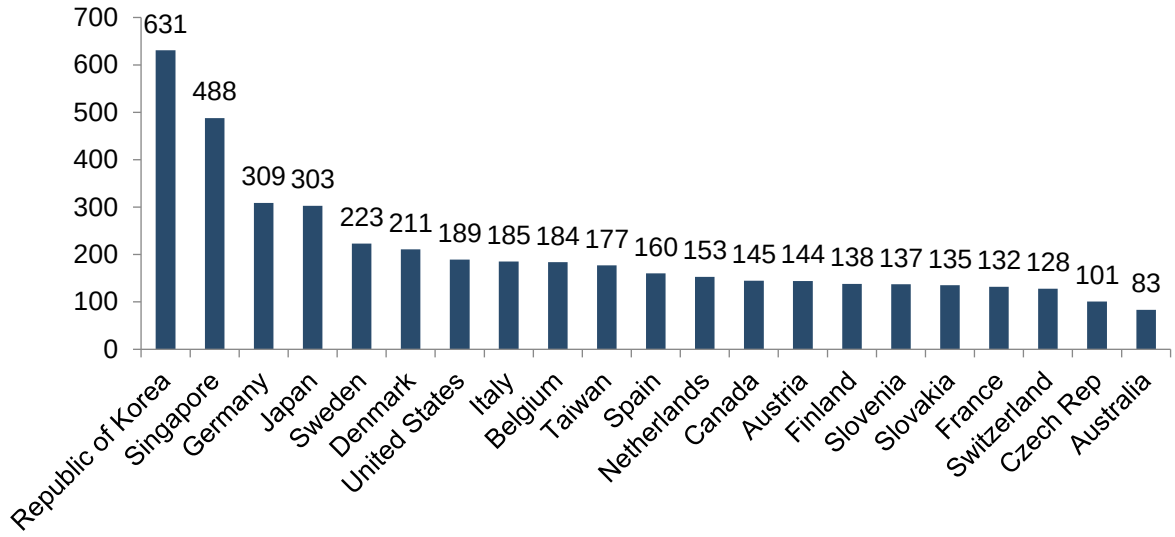
Table – Industrial robots: Europe second world market after China (thousand units)

Region	2015	2016	2017
China	69	87	138
Europe	50	56	67
Japan	35	39	46
S Korea	38	41	40
USA	38	31	33
Rest of Asia & Pacific	19	24	38
Others	5	16	25
Total	**254**	**294**	**387**

Source World Robotics IFR

China alone accounted for 36% of the world market for industrial robots in 2017, and China and Europe together account for more than half (53%) of the world market. Together with the three following markets (Japan, S Korea and the USA), the five largest markets represent 84% of the world total.

Bar chart - Number of installed industrial robots per 10,000 employees in the manufacturing industry 2016



Source: World Robotics 2017

In 2016, the average ratio of robots used in manufacturing to employees was 74 per 10,000 (66 in 2015). Europe has the largest robot density (99) compared to 84 in the Americas and 63 in Asia. However, as a result of the high volume of robot installations in Asia in recent years, the region has the highest growth rate. Between 2010 and 2016, the average annual growth rate of robot density in Asia was 9 percent, in the Americas 7 percent and in Europe 5 percent.

The development of robot density in China was the fastest in the world, with a density rate rising from 25 units in 2013 to 68 units in 2016 (against a world average of 74), and 150 targeted for 2020.

The search for ever increasing industrial efficiency, as well as (in Japan and in Germany) the need to compensate for insufficient national demographics helps to explain this phenomenon.

Japan is the leader of the global robotics industry. 52% of all industrial robots sold globally in 2016 were manufactured in Japan, even though the Japanese share is steadily declining to the benefit of China and to a lesser

extent, South Korea. However, the aim of the Chinese government is to sell a total of 100,000 domestically produced industrial robots by 2020 (2017: 27,000 units from Chinese robot suppliers, 60,000 from foreign robot suppliers).

Professional service robots and personal and domestic robots have escaped this Asian domination, America makes 55% and 44% of professional service robots and personal-domestic robots respectively, and Europe 27% and 41% respectively.

The automotive industry with 35% and the electrical-electronics industry with 31% account for two thirds of the global market for industrial robots.

Table - Industrial robots: Global annual market by industries (K units)

	2015	2016	2017
Automotive industry	94	98	103
Electrical electronics industry	46	65	91
Metal	21	29	29
Chemical rubber plastics	17	20	20
Food	7	7	8
Others	11	15	19
Unspecified	24	20	24
Total	**220**	**254**	**294**

Source: IFR

The global market in 2016 was, according to IFR, 40 B $ (36 B €), of which professional service robots were 4.2 B €. Industrial robots' shipments increased between 2010 and 2016 at 16% per annum. This fast growth should continue over the next years, at 14% in value, with service robots growing faster still, at 20%.

These figures do not include personal robots.

The main manufacturers are Fanuc (Japan), Yaskawa (Japan), Kawasaki Heavy Industries (Japan), ABB (Europe)

Table - Global Professional service robots: Units and Million € by applications in 2016

Segment	Units	B €
Medical	1 600	1 458
Logistics	25 400	936
Field	6 000	891
Defence	11 100	701
Public relation	7 500	108
Exoskeleton	6 000	37
All others	2 000	101
Total	**59 600**	**4 232**

Source: IFR

An example of the rising domain of service robots is "public relations" robots in the hospitality sector (hospitals, hotels, restaurants...). One of the primary drivers for this market is the rising need to improve productivity and efficiency. Public relation robots are more productive than humans, are not subject to social legislation, and are adaptable and competent in several applications, such as delivery of goods, monitoring, supervision, and guiding to the guest.

This often implies advanced applications of artificial intelligence (AI). The growing implementation of humanoids has compelled the robotics companies to integrate advanced AI in robots to make them more familiar while interacting with humans. For instance, Pepper is one of the most human-like robots in the world which can interact with humans and read emotions. AI helps robots to understand the language, read faces, understand emotions,

and even imitate human emotions. To fulfill the tasks of assisted living, several companies are using AI technology to develop such humanoids.

Field robots include a growing number of autonomous robots in applications like agriculture, mining, exploration...

B. Home & Building Automation

Automation systems are deployed in residential and commercial buildings so as to provide comfort, energy efficiency and security to occupants. These systems are designed, as is the case for industrial automation, to allow communication between sensors, actuators, controllers and man/machine interfaces via bus-type networks. They allow management of lighting, and control over smoke and fire alarms, building access and other security systems. A new fast developing market is that of domestic robots (vacuum cleaners, lawn mowers, security and a growing number of other applications).

The market for Home & Building Automation has for a long time been driven by a search for increased comfort. Today, the principal drivers are energy efficiency and security, and the new “smart building” and “smart home” paradigms.

The market for “Home Automation” consists of equipment and services enabling optimized remote management of energy use, comfort and security of residential properties (houses or flats). This market had been stagnating for many years, but today it is boosted by the development of cheaper wireless-based security systems, the Internet of Things, connected objects and smartphones. A clear sign of this new interest in the market is the turmoil created by the leaders in digital and connected objects, most notably by the acquisition of Nest Labs by Google in 2014.

“Building Automation” groups equipment and services enabling the management of a large number of functions in professional or collective residential buildings. The convergence of these functions leads to the “intelligent building”. The primary functions typically addressed are: control of electrical energy, lighting, HVAC systems, and security functions such as access control to the premises, lifts, alarm systems and fire prevention. Cloud computing and sophisticated software are increasingly used, for example in the “software as a service” (SAAS) mode.

An important trend is the development of increasingly integrated technologies and related applications such as communicating meters and HVAC equipment. Applications that provide a high level of service quality (building security and alarms, etc.) used to rely on cable connections, but wireless technologies are gradually taking a greater market share, in particular in applications such as lighting.

The “Building Automation” market brings together a variety of end users: professional offices and sites, residential, institutional and administrative buildings (education, hospitals, government offices, etc.) as well as niche markets like theatres, entertainment and sports installations. The market size in 2016 was €38 billion and a rapid growth of 7% annually is anticipated through 2022.

The major players in Home & Building Automation are Honeywell (USA), Johnson Controls (USA) and Siemens (Europe).

Table - Top Home & Building suppliers 2016

Company	Country	Home Automation	Building Automation
Honeywell	USA	⊘	●
Johnson Controls	USA	●	●
Siemens	Europe	⊘	●
Legrand	Europe	●	⊘
Panasonic	Japan	●	⊘
Schneider Electric	Europe	●	●

Source: DECISION Etudes & Conseil

C. Heating, ventilating and air conditioning

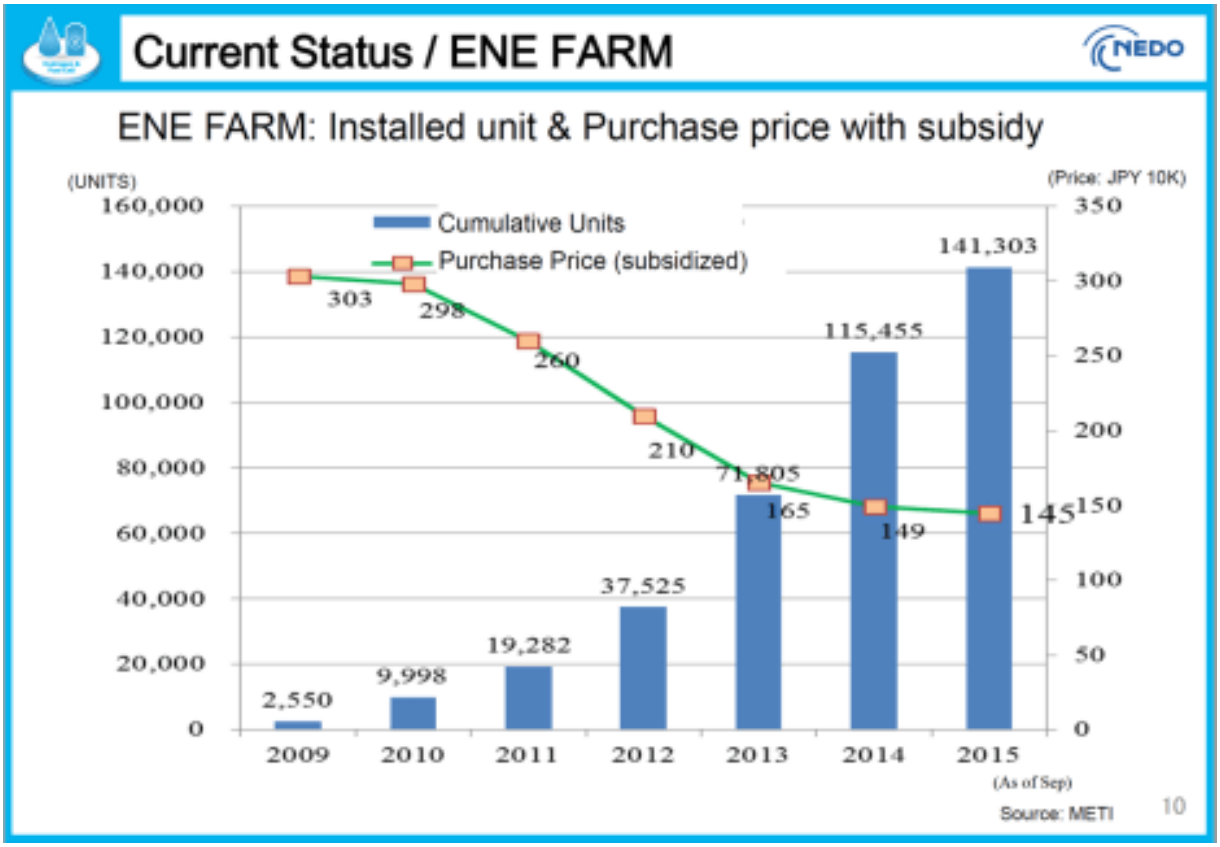
Another segment of systems for residential and commercial buildings is climatic control, heating, ventilation and air conditioning (HVAC). The increase in electronic content here enables improvement of energy efficiency, as well as lower operating noise and increased ease of control and maintenance

The market for heating ventilation and air conditioning (HVAC) equipment has been growing fast. The principal vectors of development associate the continuing expansion of urban living, the goal of reduced energy consumption, the necessary reduction of CO2 emissions following the application of increasingly severe environmental regulations, and the integration of efficient electronic systems.

The use of heat pumps is rapidly expanding in the USA, while their principal market in growth and volume is China.

In Europe, the market for condensing central heaters is widespread, representing 80% of all installations sold, compared to 15% in other regions of the world. Heating by thermal solar methods are little used in the USA or Japan but more so in Europe and notably in Turkey, the No. 1 world market for this technology.

Japan has taken the lead in the fuel cell heating market with 200 000 “ene farm” installations in 2017, driven by ambitious government goals and incentives (governmental goal of 1.4 million installations by 2020, drastically reduced from the 10 million objectives announced in 2009, and 5.3 million by 2030). However, even with Prime Minister Abe’s backing, hydrogen isn’t expected to play a dominant role as a source of energy in Japan any time soon. The nation’s 2030 power mix, an outlook published by the trade ministry in 2015, makes no mention of hydrogen.



One catalyst is the Tokyo Olympic Games in 2020, a major showcase for Japan's technological prowess. The capital has announced plans to spend ¥45.2 billion ($400 million) on fuel cell vehicle subsidies and hydrogen stations by the time of the games. Toyota envisions more than 100 fuel cell buses crisscrossing the nation's capital by then.

Panasonic has half of the home fuel cell systems. Toshiba has 40%, but has stopped this activity in 2017, leaving Aisin Seiko as the only other supplier beside Panasonic. Kyocera Corp is entering the market for commercial fuel cell systems for use in restaurants and factories.

The primary goal of developed countries for the air conditioning and ventilation segment is the overall reduction of electrical energy consumption, which presently represents 25% of household energy use against 16% for lighting and 16% for refrigerators. Air conditioning units with a variable frequency drive (VFD), a sensor and a microcontroller that manage the compressor in function of the ambient temperature are a growing market.

The perspectives of market growth in emerging countries are significant as the use of air conditioners in the world is no more than 10%.

In total the worldwide market for HVAC equipment was approximately € 90 billion with an expected average growth rate of 5.0% annually through 2022. Estimates of the global HVAC market vary between 70 and 100 billion € in 2016. Vehicle systems, not included here, are another 16 billion €.

The electronic content is variable according to the type of equipment, and averages at 20%, giving a market of 18 billion € in 2016 This should grow at a faster rate (6.5%) than HVAC equipment on the whole, because the more modern equipment, gaining market shares, uses more electronics.

Major US-based companies include Goodman Global, Lennox, Nortek, Trane, and the climate control divisions of Johnson Controls and United Technologies; other leading companies include BBT Thermotechnik (Europe), Daikin Industries and Yazaki (both of Japan), Danfoss (Europe), and Gree (China).

Table - Top Heating & Air Conditioning suppliers, 2016 sales (in billion euros)

Company	Country	World sales 2016
Daikin	Japan	17.0
UTC	USA	12.7
Johnson Controls *	USA	10.7
Midea	China	10.0
Gree	China	8.7
Ingersoll Rand	USA	7.4

Source: DECISION Etudes & Conseil

ii. Instrumentation, Measurement & Test

This heading comprises measuring instruments and meters (particularly electricity meters.

Table - World Instrumentation, Measuring & Test production by product segment 2016-2022 (in billion euros)

Segment	World 2016	World CAGR 2016-22	Europe 2016	Europe CAGR 2016-22
Instrumentation	115.0	3.3%	33.6	3.0%
Measuring & Test				
Electronic Test & Measurement	100.1	3.0%	32.6	3.0%
Meters	14.9	6.0%	1.0	5.0%

Source: DECISION Etudes & Conseil

A. Electronic Test and Measurement

The Electronic Test and Measurement equipment segment includes a wide range of devices, from automatic test benches in particular for semiconductor wafer automatic test equipment to general-purpose stand-alone oscilloscopes or modular instrumentation. End-user demand comes from various industries such as semiconductors, aerospace and defense, telecommunications, or transportation.

In national statistics a number of products are sometimes, according to countries, attributed to “control equipment” and sometimes to “measuring instruments”, which makes detailed comparisons difficult. Moreover, the distinction between electronic and non-electronic instruments is losing significance as most instruments are becoming electronic.

We distinguish four different sub-segments (ATE, General purpose, Communications & networks, Weighing) in this industry, where economic cycles and growth factors are heterogeneous and depend on the application considered.

Globally, the Electronic Test and Measurement market reached 100 billion € in 2016. Over the period 2016-2022, this market will grow by 3.1% on average per year.

Table - Electronic Test & Measurement Leaders' Sales and Segments. 2016 in billion euros

Rank	Company	Country	Sales 2016	ATE	General Purpose	Comm & network
1	Danaher	USA	5.3	⊘	●	●
2	Yokogawa	Japan	3.1	●	⊘	⊘
3	Keysight Technologies	USA	2.2	●	●	●
4	Mettler Toledo	Europe	1.9	⊘	●	⊘
5	JDSU	USA	1.3	⊘	⊘	●
6	Teradyne	USA	1.3	●	⊘	⊘
7	Advantest	Japan	1.3	●	⊘	⊘
8	Anritsu	Japan	0.9	⊘	⊘	●
9	Rohde & Schwarz	Europe	0.8	⊘	●	⊘
10	National Instruments	USA	0.8	●	●	●

Source: DECISION Etudes & Conseil, HIS

a. Automated Test Equipment (ATE)

ATE tests can be simple or complex depending on the equipment tested. ATE testing is used in wireless communication and radar as well as electronic component manufacturing. There is also specialized semiconductor ATE for testing semiconductor devices. ATE is also used in the electronics, aerospace and automotive industries, particularly in maintenance.

The global market for ATE was 8 B € in 2016, of which semiconductor ATE was 3.7 B €.

Increasing adoption of System-on chip and high demand for electronic components in the automotive sector and penetration of smartphones is expected to drive the market over the forecast period. Miniaturization of devices has spurred ATE demand across application areas. Additionally, considerable technological advancements coupled with design complexity and the need for effective testing is expected to impact the global industry positively. Developments in the manufacturing processes of semiconductors and expansion of wireless networks in developing nations are expected to provide significant growth for the global market over the coming years.

In the electronic components industry segment of ATE, the semiconductor industry accounts for over 80% of demand, and this is for over 70% located in Asia as is global semiconductor production.

The semiconductor ATE market reached 3.7 billion euros in 2016. This market is extremely concentrated, in fact a duopoly between Teradyne and Advantest, followed by smaller actors such as Xcerra (the new name of LTX-Credence). On the demand side, the market is also concentrated with a limited number of significant customers. The main driver of the ATE market is the need to keep pace with innovation that is permanently driving the semiconductors industry. Over the period 2016-2022, the semiconductor ATE market is expected to grow by an average 2% per year.

b. General purpose electronic T&M instruments

The market for General Purpose T&M instruments reached 90 billion € in 2016. The main instruments listed into this market include oscilloscopes, spectrum analyzers, signal generators, multimeters, VXI/PXI based instruments, and network analyzers. Modular instrumentation is one of the key technology drivers of the market. Another driver is the growth of the service business demand, supplied by specialists like Trescal. Public and private laboratories, discrete and process industry manufacturing sites, and also educational technical class-rooms are using these types of instruments. But globally, the sector is a mature and mostly renewal market, directly related to the general level of investment. From 2016 to 2022, this very diverse market segment will grow worldwide at a rate of 2.5% on average per year.

c. Communication & network test equipment

Communication & network test equipment is a 5 billion euros market dedicated to all communication networks (Optical, Wireless, Broadcast, and others). During the recent years, the business environment has seen dramatic changes with the explosion of the smartphone market. Broadband and 4G mobile networks are today the most dynamic segments of the market. New technologies such as MIMO (multiple input multiple output) and beamforming (or spatial filtering) need better test performances.

Geographically, the BRICS are still dynamic, even if China, the largest smartphone market and manufacture today, is now (relatively) slowing down. Over the coming years, it is expected that this market segment will grow at the same pace as global telecommunication carriers' capital expenditure. From 2016 to 2022, this sector is forecast to have a 3% average growth rate per year.

d. Electronic Weighing Systems

Used in laboratories and industrial sites, the electronic weighing devices and systems market reached 2.4 billion € worldwide in 2016. From 2016 to 2022, a growth of 5.4% in average per year is anticipated. The market comprises two segments:

The Laboratory Electronic Balance market: 1.0 billion € in 2016. Market leaders are A&D (Japan), Mettler-Toledo (Eur), Sartorius (Eur), and Thermo Fisher Scientific (USA). Over the period 2016-2022, this segment will grow by 4.5% on average per year.

- The Industrial Weighing Equipment market: 1.7 billion € in 2016. Market leaders are A&D (Japan), Avery Weigh-Tronix (USA), Bilwinco (Eur), Mettler-Toledo (Eur), CI Precision (Eur). For this segment, the key driver for growth is the transition from mechanical scales to high performance digital ones. Various other electronic devices are progressively introduced in factories and utilities. This segment will grow by 5.9% on average per year.

B. Smart Meters

Smart Metering is a rapidly growing market involving both professional and domestic buildings. In the broadest sense. AMR (automatic meter reading) just enables remote reading, whereas AMI (advanced metering infrastructure) transmits at least hourly data to a central collection point.

The meter market can be subdivided according to two criteria:

- Based on the flow being measured: there are gas, electricity and water meters;
- Based on technology: besides the older “basic” meters, there are communicating, or “smart meters” that provide either one way, (sometimes referred to as “advanced metering”) or two-way metering. In this report we will deal with the smart meters only.

In 2016, there were 140 million Smart Meters shipped in the world, compared to 25 million units in 2011, representing a market of €14.9 billion. Growth over 2016-2022 should be 4% annually. The Asian market at present represents two thirds of the global market and 70% of all meters are, and will continue to be, produced in China, the largest world market for these products.

The new wave of IoT technologies, namely LoRa, Sigfox and NBIoT, are all advertising similar performance specifications to existing solutions but at much lower cost. Utility customers are currently waiting to see if these new technologies offer the needed reliability, longevity and performance that is expected; and once proven, there will be a global acceleration of smart metering from 2019 onwards, according to IHS.

According to the Emerging Markets Smart Grid Outlook 2015, electricity worth approximately 75.7 billion € is stolen each year worldwide. This is a strong incentive for power companies to encourage the installation of smart meters which are more fool-proof.

The total installed base of electricity meters worldwide was estimated at 1.8 billion units at the end of 2016. Of these around 32% (580 million) are smart communicating meters. It is estimated that by 2020 there could be as many as 800 million “Smart Electricity Meters” installed worldwide, of which 437 million in China, 200 million in Europe, 132 million in the USA and 59 million in Japan. In 2016 still about 85% of all smart meters were electricity meters.

Of the 500 million gas meters in use throughout the world in 2016, 20% are “Smart Gas Meters”. The number of “Smart Gas Meters” produced is expected to double between 2016 and 2022, rising from 6 to 12 million units annually.

Finally, in 2016, less than 10% of the 1.2 billion water meters in use in the world were “Smart Water Meters”, a much lower penetration than that seen for electricity or gas meters. Production growth rates in the 2016-2022 period for “Smart Water Meters” will be substantially identical to those of “Smart Gas Meters”. An important incentive is to restrain waste and irregular consumption. The International Energy Agency estimates that more than 34% of pumped water is lost as non-revenue water because of tampering, theft, meter errors, and faulty distribution networks Whereas standard water meter shipments will remain about constant, shipments of smart water meters will double between 2016 to 2013, from about 2 BN € to about 4 B €.

The leading Western manufacturers Itron (USA). Elster (Europe, acquired in 2015 by Honeywell from the British industrial group Melrose). and Landis+Gyr (Europe, acquired in 2011 by Toshiba) are rapidly losing market shares on the world market to newcomers from China: Wasion Group Holdings, Jiangsu Linyang Electronics, Ningbo Sanxing Electric, Hexing Electrical, and Holley Metering are the top 5 of this group.

Electronic “Smart Meters” come up against a number of technical constraints, some of which are the result of their communication characteristics:

Precision and reliability are crucial for the energy supplier. If there are defects, these must be able to be dealt with before the customer is invoiced.

Security: Integrity and confidentiality must be guaranteed in the communications between the Smart Meter, the energy supplier and the customer. In a broader context, this is a critical parameter in the construction and management of “Smart Grid” infrastructures of which the “Smart Meter” is a key component.

Just like any other piece of RF communication equipment, “Smart Meters” must first satisfy EMC (electromagnetic compatibility) standards and be tested for electromagnetic radiation that will be transmitted into their environment.

The technological development of « Smart Meters » over the next several years will be in part marked by the replacement of 8-bit microcontrollers by higher performance 32-bit controllers. The trend is to reduce the number of semiconductors, even to replace them completely by the integration of all functions onto a single chip (SoC, System on a Chip), thereby offering greater performance in a smaller size package.

iii. Power Electronics

Table - Power Electronics equipment production 2016-2022 (in billion euros)

Segment	World 2016	World CAGR 2016-22	Europe 2016	Europe CAGR 2016-22
Power Electronics total	**91.4**	**5.7%**	**12.0**	**3.0%**
UPS. power supplies. distribution	45.0	4.9%	10.2	1.9%
Solar Energy	27.5	4.2%	0.2	4.8%
Electronic Lighting	18.9	9.1%	1.6	6.5%

Source: DECISION Etudes & Conseil

A. Power conversion

Power conversion equipment includes UPS, Power Supplies, Solar Inverters and power distribution modules. The Solar inverters are not counted here, but are included in Solar energy, below.

Taken together, these three segments dealing with medium and low voltage and the conversion of electrical energy represent an electronic equipment market valued at €45 billion in 2016. In the period from 2016 to 2022, driven by the demand for energy efficiency, together with the development of intelligent electrical grids and renewable energy, a consistent average annual growth of 4.9% per year is anticipated.

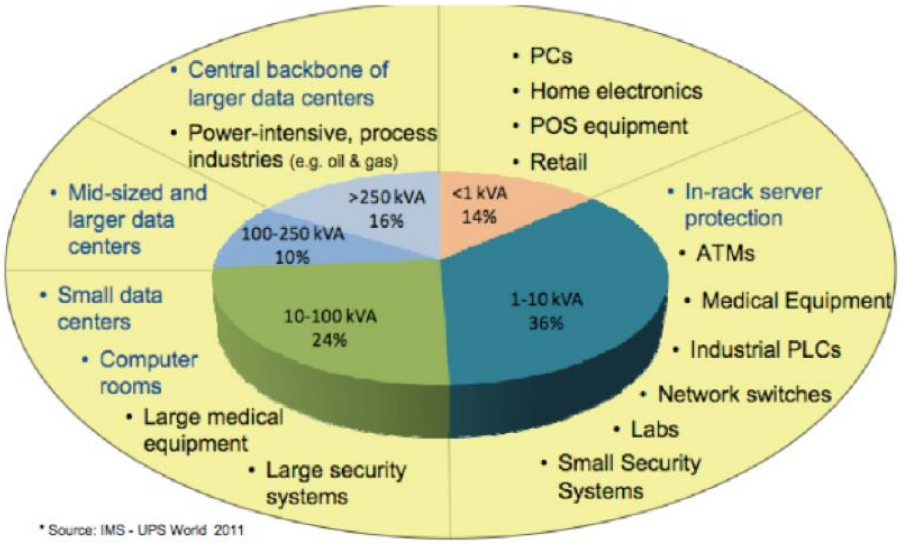
a. UPS

Over the course of the past two years the world market for UPS (Uninterruptable Power Supplies) has grown by an average of 3% annually, reaching a total of €8.0 billion in 2016. The rate of growth is expected to be 5.5% annually over the next five years. The principal driver of this increased growth is the growing use of on-line services by businesses who are moving in increasing numbers towards cloud computing which in turn is driving a growing need for storage and for security.

The market leaders remain Schneider Electric with 25% market share, Emerson Network Power (16%) and Eaton Corp. (10%). Numerous other players are active including ABB, Belkin, Eltek, Piller, Riello, Socomec and Toshiba. Chinese companies are starting to take a sizeable share of their internal market, notably Kehua Group and Kstar as well as telecommunication companies like Huawei and ZTE.

The UPS market is traditionally segmented by power level and by application.

Graph - Global UPS Market and Typical Applications



b. Power supplies (laboratory & industrial), battery chargers

In 2016 the total available market (global TAM excludes captive markets) for power supplies reached €17 B of which 85% were AC/DC and 15% DC/DC. Almost 45% of this market was dedicated to serving the consumer goods industry: telephones, smartphones and tablets. The balance, globally around €9 billion, supplied the demand from industrial applications and laboratory equipment. Within this category, computers and communication networks remain the major users of power supplies. Today, one of the most rapidly growing user segments is LED lighting.

This market anticipates an average annual growth of 5% over the period of 2016-2022. The principal market leaders are Delta Electronics (Taiwan), Emerson (USA) and Lite-On Technology (Taiwan).

c. Power distribution

Power distribution networks are today oriented towards energy efficiency required by all their end-user markets. The main manufacturers are offering complete solutions including controls and services in addition to their classical product, and the privatized power companies now realize that more electronics actually increases their profitability. Good examples are the need for communication equipment required by smart metering (concentrators) and by the smart power grid (in relation with renewable energy sources entering the power grid), and also the need for new monitoring and control functions on the power grid. The three big players in this market are European firms ABB, Schneider Electric and Siemens. Other manufacturers include Eaton (USA), General Electric (USA), Mitsubishi Electric (Japan).

Table - Power distribution, leading world suppliers

Rank	Medium Voltage	Low Voltage
1	Schneider Electric	Schneider Electric
2	ABB	ABB
3	Siemens	Siemens

Source: Company reports

B. Solar energy

Solar energy is the most abundant energy resource on earth. About 885 million TeraWatt hours (TWh) reaching the surface of the planet every year, i.e. 6 200 times the commercial primary energy consumed by mankind in 2008, and 3.500 times the energy that mankind will consume in 2050.

Europe pioneered the installation of solar panels, until capacity ceased growing much after 2012, when capacity started developing in Asia and to a lesser extent in America. Nevertheless, the industry has now practically become an Asian, and most of all Chinese, monopoly.

a. Solar panels

The basic component of a solar panel today is still a group of solar cells, most of the time made of crystalline silicon (c-Si) and manufactured from wafers through a complex and expensive process. Another technology is using thin-film panels (8% of the total market in 2012). Dedicated to produce electricity (unlike solar heating systems), a complete PV (photovoltaic) system comprises solar cells assembled in large numbers to make solar panels, themselves connected together.

In this section, we address only the solar panel market that represents, on average, 50 to 60% of a complete PV system. The rest of the system includes: solar inverter, battery and charge controller if required, junction box and meter, and installation cost. “On-grid” PV systems are connected to the local electricity grid, they account for 90% of the market. “Off-grid” systems are connected to a battery and are used where no main electricity network is available, for example in remote locations.

The solar panel market is defined through the total power installed and the average factory unit price-per-watt of a panel. According to Solar Power Europe (the European photovoltaic industry association), a total of 99.1 GW of grid-connected solar was installed in 2017. It is almost a 30% year-on-year growth over the 76.6 GW added in 2016. In 2017, almost as much solar was installed in one year as the world had installed in total capacity in 2012 (100.9

GW). This led to a total global solar power capacity of over 400 GW in 2017, after solar exceeded the 300 GW mark in 2016 and the 200 GW level in 2015.

Global solar market demand in 2017 was driven by China. For the first time in 2017, China installed more than half of the world's solar capacity in one year (53.3%).

In June 2018, the Chinese government announced its decision to cut down subsidies on renewable energy, with the ultimate motive to instill sustainable development in the nation's solar industry. With China being the largest consumer of solar energy in the world, subsidy depletion from government's side should not hamper the industry's growth

Europe has left its several-year long downward trend in 2017, adding 9.2 GW, a 30% increase compared to the 7 GW installed the year before. The European growth is primarily a result of Turkey's gigantic growth. When looking at the 28 members of the European Union, there was hardly any growth at all: the EU-28 added 5.91 GW in 2017, compared to 5.89 GW in 2016. This result still stems from the UK's 'solar exit' in 2016 with a 65% reduction in government incentives paid to householders, which halved new installations in 2017. Even though 21 of the 28 EU markets added more solar than the year before, the overall market performance was still sluggish.

Under optimal conditions, the world's solar generation plant capacity could reach up to 1,270.5 GW by the end of 2022, but Solar Power Europe considers 1,026.2 GW more likely. Still, that means solar would reach the terawatt production capacity level in 2022.

The global top 10 solar panel manufacturers are all Chinese, except for Canadian Solar whose factories are in China, and Hanwha, a Korean who manufactures in China and Malaysia.

Table - Top Solar panel manufacturers

Rank 2017	Company	Country, factories	Employees 2017	Production 2017	Revenue 2017 (M €)
1	Jinko Solar	China	12 700	9.81 GW	3 670
2	Trina Solar	China	14 000		
3	Canadian Solar	Canada, factories in China	12 130	6.89 GW	3 000
4	JA Solar	China	20 000		
5	Hanwha Q Cells	Korea, factories in China, Malaysia	8 000 (China 5 200, Malaysia 2 200)		2 193 (2016)
6	GCL SI	China, factories in China, Vietnam	30 000		
7	LonGi Solar	China, factories in China, Malaysia, India			1510 (2016)
8	Risen Energy	China	4 300		
9	Shunfeng Suntech	China			
10	Yingli	China	14 500 (2015)		

Source: PV Tech & Solar Media, company reports

The major challenge for photovoltaic cell manufacturers is to increase the rate of the transformation of light into electricity. Solar cell efficiencies vary from 6% for amorphous silicon-based solar cells to 44.0% with multiple-junction production cells and 44.4% with multiple dies assembled into a hybrid package. Solar cell energy conversion efficiencies for commercially available multicrystalline Si solar cells are around 14-19% The highest efficiency cells have not always been the most economical, for example a 30% efficient multijunction cell based on exotic materials such as gallium arsenide or indium selenide produced at low volume might well cost one hundred times as much as an 8% efficient amorphous silicon cell in mass production, while delivering only about four times the output.

Presently, the highest efficiency achieved so far using silicon is 25%. Research and development carried out in Europe in a partnership between France (CEA-Leti, Soitec) and Germany (Fraunhofer ISE) has resulted in 2015 in a cell with a transformation rate of 46%. The PV industry believes that this rate of energy transformation will double in the course of the next 15 years. New technologies are in research and development phases, notably organic and perovskite based solar cells. The technologies employed to attain this goal are constantly evolving. After the appearance of monocrystalline silicon (good efficiency. but expensive), and polycrystalline silicon (lower efficiency. but cheaper), a new technology based on thin film has appeared, providing lower efficiency, but enabling much larger surfaces, opening many new applications.

At the core of the photovoltaic equipment, the solar panel constitutes the principal market of the photovoltaic industry for electronic components and equipment. The value of the solar panel market was € 27 billion in 2016 and could reach (according to Zion Research) € 52 billion by 2022.

b. Solar inverters

The market for solar inverters is growing rapidly following the increase in solar installations in Asia and particularly in China, compared to modest growth in Europe. Prices are also falling rapidly, more rapidly in fact than the volume growth of sales of inverters. In 2016, the market for inverters reached € 5 billion, corresponding to 40 GW of new solar installations. By 2022, the photovoltaic (PV) industry anticipates that the annual installation of new solar power installations will reach 70GW a growth rate of 11% annually. In terms of value, however, growth will only reach 4.5% annually, due to price erosion.

Table - Top Ten Solar inverter manufacturers

Manufacturer	Country	Market share % 2017
Huawei	China	26.4
Sungrow	China	16.7
SMA	Europe	8.7
ABB (Power One)	Europe	5.6
Sineng	India	4.6
TBEA Sun Oasis	China	3.9
Power Electronics	Europe	2.9
TMEIC (Toshiba-Mitsubishi)	Japan	2.8
Schneider Electric	Europe	2.6
Solar Edge	Israel	2.5

Source: GTM Research, Company reports

The development of this market over the last four years has seriously reshuffled the global ranking of manufacturers, although four Europeans are among the top ten, the historic leader SMA's share has dropped from 26% in 2012 to 8.6% in 2016. Only one Japanese company is left in the top ten, against three Chinese, one Indian and one Israeli.

Unlike solar panels, where the leading manufacturers are specialists, leading inverter manufacturers are typically not solar energy specialists, but companies from telecommunications or power electronics.

c. Concentrated Solar Power (CSP)

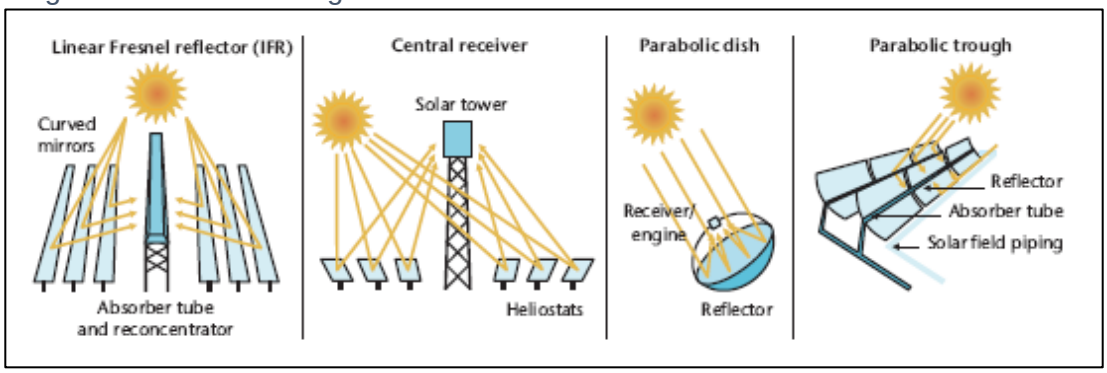
CSP is a technology that concentrates the sun's rays to heat water or special compounds so as to create steam that will turn an electricity producing turbine. Two major technologies are presently in use:

Solar trough, where the silvered interior of a linear trough focuses the sun's rays on a liquid carrying pipe that is thereby superheated to produce steam.

Power tower, where a large number of mirrors track the sun's apparent movement to continually focus the reflected sun's rays onto a tower that contains a network of liquid carrying pipes that are used to create steam.

Both technologies are in use today, in Europe, North America, North Africa and India. Linear Fresnel reflectors and parabolic dishes are also in use, albeit to a lesser extent. Parabolic dishes are attractive for small installations.

Diagram - CSP Technologies

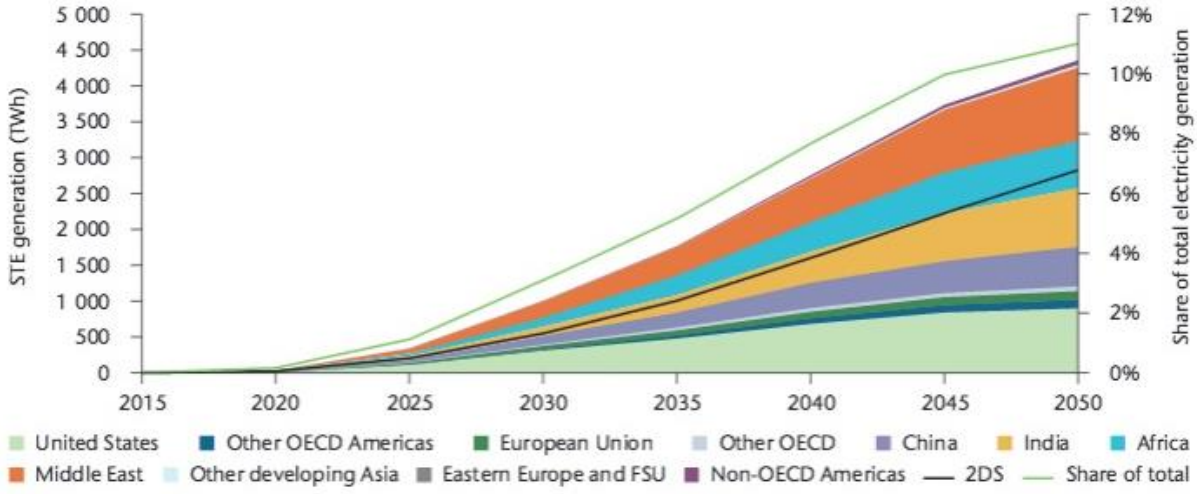


Source: International Energy Agency. Technology Roadmap. 2014

By using storage of special superheated liquids in insulated tanks. CSP can overcome one of the major weaknesses of photovoltaic panels that can only produce electricity in direct sunlight. Battery storage is expensive and can cancel out the PV cost advantage.

Among the most interesting use of CSP technologies is water desalination. One of the main challenges for emerging countries in the future is population water access, particularly in arid regions. CSP plants will be often installed in such regions and they could be designed to produce fresh water along with electricity. Another promising application is production of industrial process heat. Concentrating sunlight can be used for artisanal productions, as developing countries need more independence from fossil resources and deforestation limitation.

Graph - Share of total electricity generation by STE generation till 2050



Source: International Energy Agency. Technology Roadmap. 2014

CSP installation involves thousands of kilometers of cables with associated connectors, communication nodes (hard wired or wireless), heat and flow sensors, power regulation, stepper motors as well as the core sun-tracking software and related electronics that are at the heart of the CSP technology. Presently Europe and the USA are in the lead of the CSP technology globally, but this will change as Chinese companies get up to speed to serve both their internal market as well as international markets.

The principal proponents of these two CSP technologies are Abengoa (Spain), Solar Reserve (USA) and Brightsource Energy (USA). Other players include Areva (France), Acciona (Spain), eSolar (USA), Siemens (Germany), Chiyoda (Japan). Development of these technologies has begun to accelerate, however the stability of costs in the face or probable fluctuation in fossil energy prices makes these technologies relatively attractive. According to “CSP Today” the installed CSP capacity stands at 5 GW in 2017, of which 2.3 in Europe.

CSP Electronic content estimate are still low in 2016 compared to other industrial segments as CSP is a recent technology, the volume of electronic content in the CSP global market is expected to grow rapidly to reach € 2.0 billion in 2022.

C. Electronic Lighting

Our definition of electronic lighting equipment includes LED assemblies and equipment as well as electronic lighting control systems. Fluorescent tubes, CFL and HID bulbs are not included.

The technological disruption of the lighting market is causing the progressive decline of its three historical players who, until very recently, accounted for 50% of the total lighting business: General Electric, Philips and Siemens. The Lumileds division of Philips has been sold and the Osram branch of Siemens has been spun off, probably to be followed in the same manner by GE’s Lighting Division. Indeed, in February 2018, GE agreed to sell parts of its lighting business to a company led by Joerg Bauer, a former GE Lighting executive. The move was the conglomerate’s first step in the divestiture of the lighting business.

The market leaders of electronic lighting and especially packaged LEDs now come from the semiconductor industry and are typically based in Asia. The rapid decline in component pricing and product innovation causes regular reshuffling of the leadership ranking in this field.

In the market for ballasts and electronic lighting control systems, apart from light bulb suppliers, new players (notably home automation specialists) are gaining market positions. We now find players like Legrand, Schneider Electric and Zumtobel in Europe and Acuity Brands Lighting and Eaton Lighting in the USA.

The production of packaged LEDs is geographically concentrated in Asia. Japan (home of global leader Nichia with 7 factories), South Korea, China and Malaysia are the principal Asian manufacturing countries. The production of electronic ballasts is principally located in China while the manufacture of control systems is much more distributed in view of the large number of players and the proximity of manufacturers and “Big Box” distributors of domestic and industrial lighting systems.

The global market for electronic lighting was € 18.9 billion in 2016. Growth is anticipated to reach 9.1% annually to achieve sales of € 31.9 billion in 2022.

a. LED Lighting

LED lighting is progressively replacing older technologies. Prohibition of use of incandescent bulbs everywhere in the world is the most obvious sign of this transformation. The other technologies such as fluorescent strips, compact fluorescent lamps (CFL) and halogen lights will continue to be used for a while.

Table - Packaged LED top 10 manufacturers 2017

Rank 2017	Manufacturer	Country	Employees, sales
1	Nichia	Japan	8 600 (2015)
2	Osram (ex Siemens) Opto Semiconductors	Europe, factories in Germany, Malaysia, China	6 000
3	Lumileds (ex Philips)	Europe	9 000
4	MLS	China	Empl 10 000, Sales 1 B €
5	Seoul Semiconductor	South Korea	Sales 0.74 B €
6	Samsung Electronics	South Korea	
7	Everlight	Taiwan	4 000
8	Cree	USA	Empl 6 400, Sales 1.5 B €
9	LG Innotek	South Korea, factories in Vietnam, China, Taiwan, Indonesia, Poland, Mexico	
10	Foshan Nationstar	China	

Source: LED Inside, Company reports, DECISION Etudes & Conseil

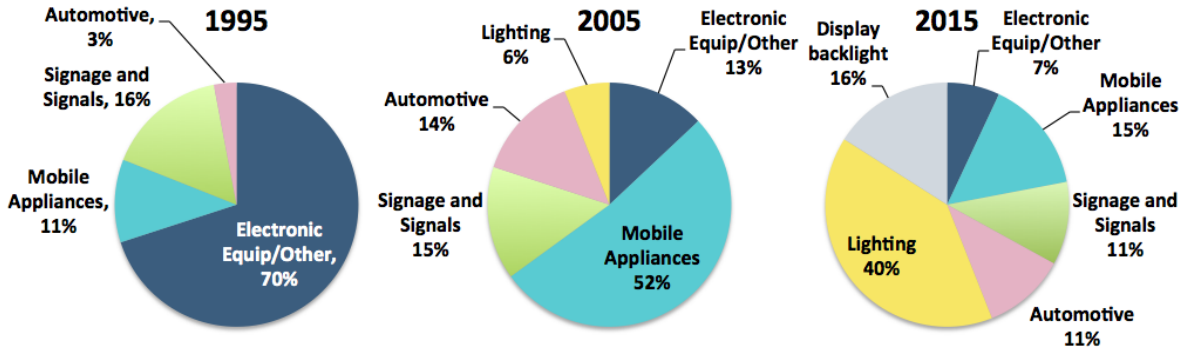
In this report we deal with the packaged LED and not solely the semiconductor content. According to LEDInside, the world market for packaged LEDs reached €14.5 billion in 2016. Growth should continue at an average rate of 8% annually between 2016 and 2022, a result of a fast market growth slowed by price erosion.

The LED market is developing fast, but value growth is limited by the rapid decline in unit prices. Haitz’s Law, a remarkable analogue to Moore’s Law for silicon semiconductors, shows that the cost-per-lumen of LEDs declines by 90 percent per decade, while the output of LEDs (flux per lamp, measured in lumens) rises by a factor of 20 with every decade. Advances in device efficiency have gone hand-in-hand with substantial improvements in packaging technology, especially in high-power LEDs, including dramatic reductions in material content. This, coupled with increasing production volumes, has spurred a rapid decline in the cost-per-lumen of LEDs in general, and in particular, white emitters.

Although a lot of production is in Asia and in particular in China, the top ten manufacturers still include two European headquartered companies, Osram and Lumileds, remnants of the once powerful lighting divisions of Siemens and Philips (Philips' LED activity came from Hewlett Packard through Agilent). The others include one American, Cree, and seven Asians of which three Koreans, two Chinese, one Taiwanese and one Japanese.

Nichia, the Japanese world leader, financially supports a Polish company, Ammono, which is a world leader in manufacturing of 2-inch diameter high quality bulk c-plane GaN substrates as well as non-polar M-plane, A-plane and semi-polar GaN wafer. Nichia funds a joint research project with Ammono to develop ammonothermal gallium nitride growth, and in return Nichia took a stake in Ammono's intellectual property, as well as access to the crystals made.

Pie chart - Evolution of LED market by application 1995-2015



Source: Compound Semiconductor

Historically the LED market started with displays for electronic equipment. This was displaced 10 years later by displays and backlights for mobile devices, and this in turn is now displaced by the booming general lighting market.

LED usage comprises high growth segments on the one hand and stable or declining segments on the other.

General Lighting; the principal area of LED use is also the one that will boost market growth over the coming years. In 2014, the replacement of old technology light bulbs alone accounted for 50% of this segment. Other applications are office lighting, stores and shops, hospitals and clinics, new residential construction and public exterior lighting.

From 2016 through 2022, the general lighting segment will grow annually at an average rate of 14%. From a share of the total LED market of 40% in 2015, this will rise to 90% in 2022.

LED applications in the **Automotive** segment will also experience strong growth, estimated to be 8% annually between 2016 and 2022. Typically, exterior applications, (such as Headlamps, Daytime Running Lamps, Stop/Tail) will drive this growth while internal lamp applications are already saturated.

Horticultural applications are a new and promising market. The horticultural lighting market's current boom is driven mostly by greenhouse applications, for which artificial lighting is used to compensate for natural light variations and increase production yield. For these applications, traditional light sources like fluorescent and high-pressure sodium (HPS) lamps are currently the most popular solutions. However, LED technology is catching up and recent developments have allowed the technology to enter the horticultural lighting market.

Greenhouse applications represent only the tip of the iceberg in this business, and new applications, mainly driven by urban farming, are likely to make the horticultural lighting market boom in the mid to long-term. Nowadays, arable land is usually far from big cities with millions of people, and as consumers become more conscious of how and where their food is produced, city farming represents a potential solution to handle these needs and challenges by allowing for the growth of plants, fruits, and vegetables in a confined environment, on multiple layers (to maximize production), and without sunlight (i.e. using only artificial light).

According to LpS, the 2017 horticultural lighting market (i.e. system level) represents a business of ~$3.8B. And it should grow to more than $8B in 2022, driven by the transition to LED technology and the emergence of new applications. But this is only a starting point. Indeed, indoor and vertical farms are poised to boom from 2022 – 2027, propelling the total market to more than $17B in 2027.

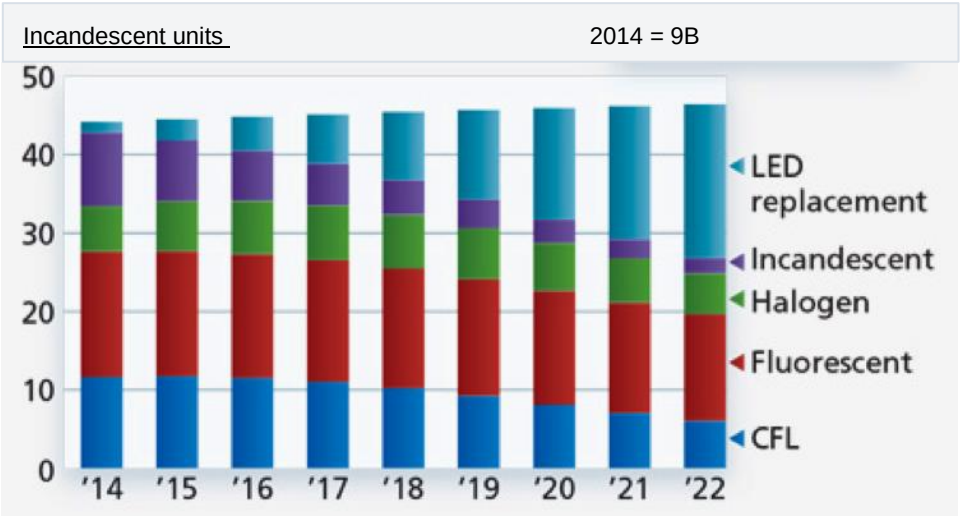
On the other hand, LED applications in **Mobile Devices** and **Backlight,** already in decline before 2016, will continue in this downward trend at an average rate of 3% annually until 2022. This is due to the continuing price decline for LEDs in these low and medium power applications, combined with the stagnation of volume usage in these markets.

b. Other Lighting Technologies

While the principal cause of the growth of the LED market is the progressive decline and disappearance of older technologies (in particular incandescent and halogen), these will nonetheless continue to represent a significant market over the next five years as illustrated in the following chart that tracks the evolution by technology of the number of light bulbs in use.

However new sales of incandescence bulbs have now practically ceased, and the same will shortly happen for halogen bulbs.

Bar chart - Global lamp installed base (in billion units) from 2014 till 2022



Source: Strategies Unlimited

Sales of fluorescent tube lamps in particular will remain significant although in progressive decline.

c. Intelligent Electronic Lighting

The continuous search for energy efficiency calls for increasing use of systems and equipment for the electronic control of lighting. This induces an increase of the electronic content of lighting equipment, particularly with LED lighting, as the LED is itself an electronic component.

And, most important, the lighting segment will enter the IoT world, as lighting devices will increasingly be connected and remote controlled.

This segment includes:

- Electronic ballasts (which have almost entirely replaced magnetic ballasts) and which equip fluorescent tubes and CFL bulbs as well as HID (High Intensity Discharge) light bulbs, LED bulbs and groups of LED bulbs;
- All types of electronic control systems (that can be connected to the IoT) including sensors, actuators, control units and interfaces, etc.

This market segment accounted for sales of € 4.4 billion in 2016 and is expected to grow rapidly to € 8.0 billion in 2022, an average annual growth rate of 12.5%.

A new activity that complements this market is *Li-Fi* (Light Fidelity) which is a communication method using light in the place of wiring. Numerous new applications are being planned, notably indoor object position tracking. This recently emerging market was worth only a few million euros in 2016 but is expected to grow to several billion euros in the years to come. No estimation of this market has been included in the value of the electronic lighting market. It would in fact more appropriately belong in the communications segment.

1.1.7 Appendix II: Handling & logistics

Automation equipment can be installed in factories, or in machines or equipment which are then installed in the factories. We have not estimated the electronic content in the various machines and equipment in a bottom-up approach.

Robots are a different case, machines have long worked without electronics, but a robot is essentially an electronic mechanism, it cannot exist without electronics, which are their essence. For this reason, the whole robot is considered as an “automation product”, and not only its electronic content.

Handling and logistics equipment are in a hybrid situation. Handling equipment has existed long before electronics, but today electronics in handling systems (and particularly in fork lift trucks) is transforming them into autonomous mobile systems, similar to robots.

For this reason, we have looked particularly at the fork lift truck field in the following pages.

i. Material handling & logistics

The handling and logistics functions in general are end use segments for control and automation products, which are normally already counted as industrial automation and control equipment. They are described here as the players concerned are often involved in the design and sometimes manufacture of their electronic controls.

The Material Handling market can be best described as the internal logistics of a business. It is composed of several segments: transport equipment, positioning equipment, inventory movement, and material identification and control. Each of these segments is composed of a variety of diverse parts the goal of which is to maximize logistical efficiency and minimize costs. A new factor is the development of autonomous robots in this field (these are included in the “robotics” segment). The global market for material handling equipment can be estimated at 170 billion € in 2016.

ii. Fork Lift Trucks

The global market for fork lift trucks was about 33 billion euros in 2016, with over a million units. Asian markets took 40%, Europe 36%, and the Americas 23%.

The ratio of fork lift use varies by country. According to the Kion Groip. In 2014 the installed base was 930 units per million inhabitants in Germany, 640 in Japan and in the USA, 200 in China, 110 in Brazil and 10 in India. This shows the potential represented by the emerging and developing economies.

Globally, in terms of volume, the electrically powered type forklift truck is increasingly the predominant technology segment, accounting for a 60% share of the global forklift truck market in 2016, and the segment is estimated to account for a 65% share of the overall market by 2022, which is attributed to the increasing demand for electric type forklift trucks in emerging markets such as China, India, and Brazil.

A new technology for electric fork lifts is the fuel cell. Plug Power offers a fuel cell system for fork lift trucks that speeds up work in warehouses, replacing battery charging with proton exchange membrane (PEM) fuel cells and hydrogen systems designed to make forklift operation more efficient (although batteries are still used in the forklifts for surges). Amazon has concluded a deal with Plug Power in 2017, a multi-site agreement with fuel-cell forklifts being deployed at 11 warehouses.

Bloom and FuelCell Energy have competing equipment running on natural gas and requiring a reformer, Plug Power's PEM fuels cells run on "five nines" hydrogen and work most productively with a hydrogen infrastructure at the customer site. (Note that the European industrial giant Air Liquide is an investor in Plug Power.)

Amazon is in an efficiency race with Wal-Mart to dominate retail product customer satisfaction, and fuel cells give the company an edge. Wal-Mart is already a Plug Power customer and has 250 forklifts at just one location (thousands in all), - and powering that fleet's batteries can account for up to 25 percent of the facility's electric bill.

Even though the hydraulic power system is still today a major element of a fork lift truck cost, electronic or hybrid electronic-hydraulic components are more and more introduced in the new generations. Between now and 2022 an annual average growth of 6% is anticipated.

The principal market leaders are Toyota Industries (Japan), Kion (Europe), Jungheinrich (Europe), Hyster-Yale (USA), Crown (USA), Mitsubishi (Japan), Komatsu (Japan), Manitou (Europe), UniCarriers (USA), Anhui (China).

Table - Top 20 industrial fork lift truck suppliers

2016 Rank	Company 2016 Rank	2016 Revenue* (in millions)	% Change 2015-2016	World headquarters
1	Toyota Industries Corporation	8 563	0	Aichi, Japan
2	KION Group	5 879	3.9%	Wiesbaden, Germany
3	Mitsubishi Nichiyu Forklift Co., Ltd.	3 407	69.3%	Kyoto, Japan
4	Jungheinrich AG	3 252	8.5%	Hamburg, Germany
5	Crown Equipment Corp.	2 910	10.2%	New Bremen, Ohio
6	Hyster-Yale Materials Handling, Inc.	2 570	-0.3%	Cleveland, Ohio
7	Anhui Forklift Truck Group Corp.	928	2.3%	Hefei, Anhui, China
8	Doosan Industrial Vehicle	781	10.6%	Seoul, South Korea
9	Hangcha Group Co., Ltd.	774	9.9%	Hangzhou, China
10	Clark Material Handling International, Inc.	740	0.1%	Seoul, South Korea
11	Komatsu Ltd.	616	-18.9%	Tokyo, Japan
12	Hyundai Heavy Industries	477*	0	Ulsan, South Korea
13	Combilift Ltd.	227	7.1%	Monaghan, Ireland
14	EP Equipment, Ltd.	200	25.0%	Hangzhou, China
15	Konecranes	185*	0	Hyvinkää, Finland
16	Lonking Forklift Co., Ltd.	163*	0	Shanghai, China
17	Manitou	136	18.3%	Ancenis Cedex, France
18	Hubtex	76*	0	Fulda, Germany
19	Paletrans Equipment	69*	0	Cravinhos, Brazil
20	Godrej & Boyce Manufacturing	67	6.3%	Mumbai, India
* 2016 revenues were not available.				
Source: Modern Materials Handling				

iii. Other handling & logistics equipment

RFID (Radio Frequency Identification) technology now finds multiple applications on the factory floor in the identification and control segment. RFID will be a very fast-growing horizontal segment over the coming period, as it is closely linked to robots, connected objects and the Internet of Things, and is involved in a vast number of applications all over the economy among which logistics is about 8%, and medical and healthcare should be one of the fastest application growths (over 20%) from a small share today. Globally this market is expected to grow from 9 billion € in 2016 to reach between 13 and 20 billion € by 2022 according to different analysts, for all applications (of which 0.7 billion € for logistics).

In the positioning segment, logistic service robots are largely used in storage areas of industrial enterprises.

In transport equipment, conveyor systems, AR/AS (Automated Storage/Retrieval Storage) and AGVs (Automated Guided Vehicles) are used in the search for optimum efficiency.

Cranes are another major segment in the handling domain.

Annex 2

Aerospace, Defence and Security

Overview

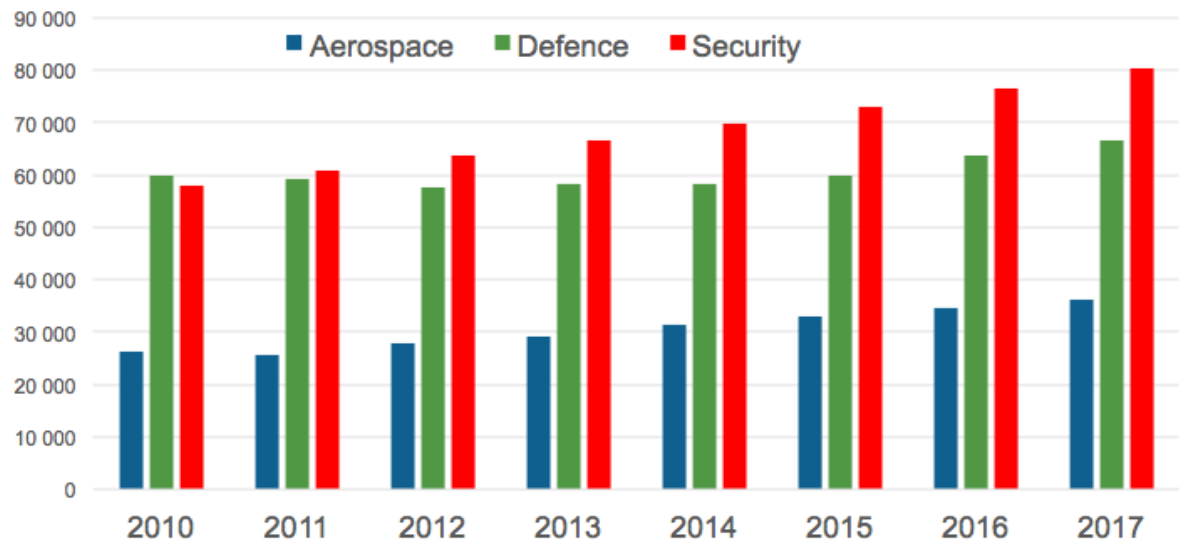
Like the automotive industry, the aerospace and defence industries are made up of a complex supply chain ranging from parts and components to general supplies and commodities, electronic systems, and complete assemblies (aircraft, ships, etc.). Historically, this industry developed in Europe, in the USA, in Japan and in the USSR. Both technology and production have remained strongly concentrated in these areas (except in Japan), despite a developing industry in emerging countries such as China, India, Brazil or Israel. The sequels of World War II and American military leadership during the Cold War led to a dominant position of American industry worldwide. Today, this dominance is challenged by Europe, as shown by the success of Airbus in civil aviation and by the emerging powers like China in the defence sector.

Over the past years, the success of the European Airbus Commercial Aircraft, Airbus Helicopters (ex. Eurocopter) and Arianespace on civil markets consolidated Europe as the worldwide number one or two supplier of civil platforms. Over the past 30 years, Airbus managed to raise as the undisputed rival of Boeing transforming the market from a monopoly situation into a duopoly. With only 42 deliveries and 13% of market share in 1985, the European-based maker managed to catch up and to overtake its historic competitor Boeing and now claims more than 50% of the market. Airbus succeeded from 2012 to 2017 to deliver more planes than its American competitor. Like Airbus, its subsidiary Airbus Helicopters has achieved the same success by being for several years now, the worldwide leader in the civil helicopters market segment.

On the defence side, the industry is heavily fuelled by the growth of US military expenditure. The wars in Iraq and Afghanistan have reinforced the North American territory as the leading production region of defence equipment but with the withdrawal of its troops on these theatres of operation, the USA lowered their military expenses. Furthermore, the economic crisis of 2008 led to budgetary cuts in defence spending in all western countries. Therefore, like the US, Europe faced a sluggish domestic defence market, which led to a fierce competition between the US and Europe to promote their defence equipment and win export markets. Besides the quality of its own products, the European defence industry will have to show flexibility in this competition: product adaptation and technology transfer are its specific advantages.

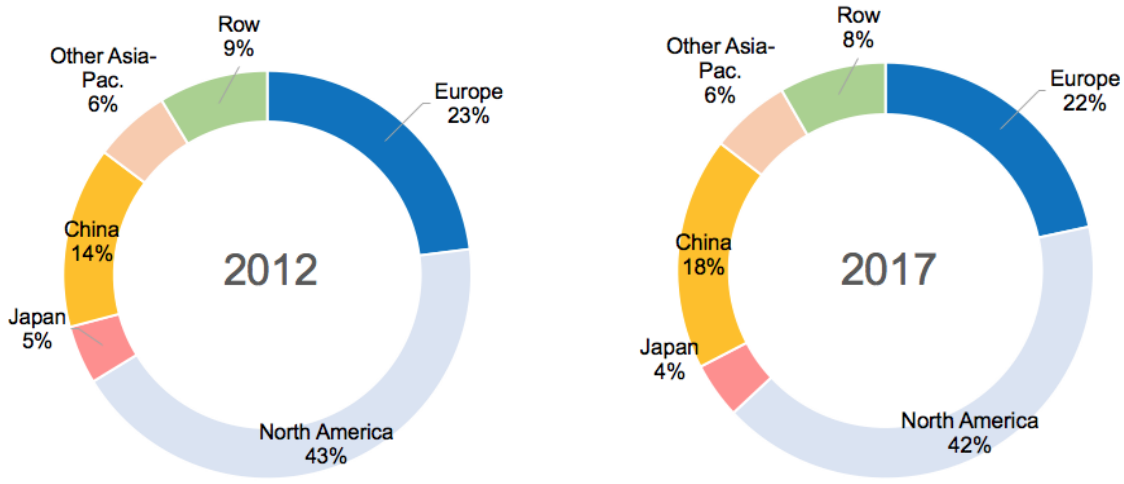
About the Security industry, the structure of the value chain production is not as regionally concentrated as for the Aerospace and Defence one.

Bar chart – Evolution of Aerospace – Defence – Security electronics equipment production by segment from 2010 to 2017



Source: DECISION Etudes & Conseil

Chart – Aerospace – Defence – Security electronics equipment production breakdown by region in 2012 and 2017



Source: DECISION Etudes & Conseil

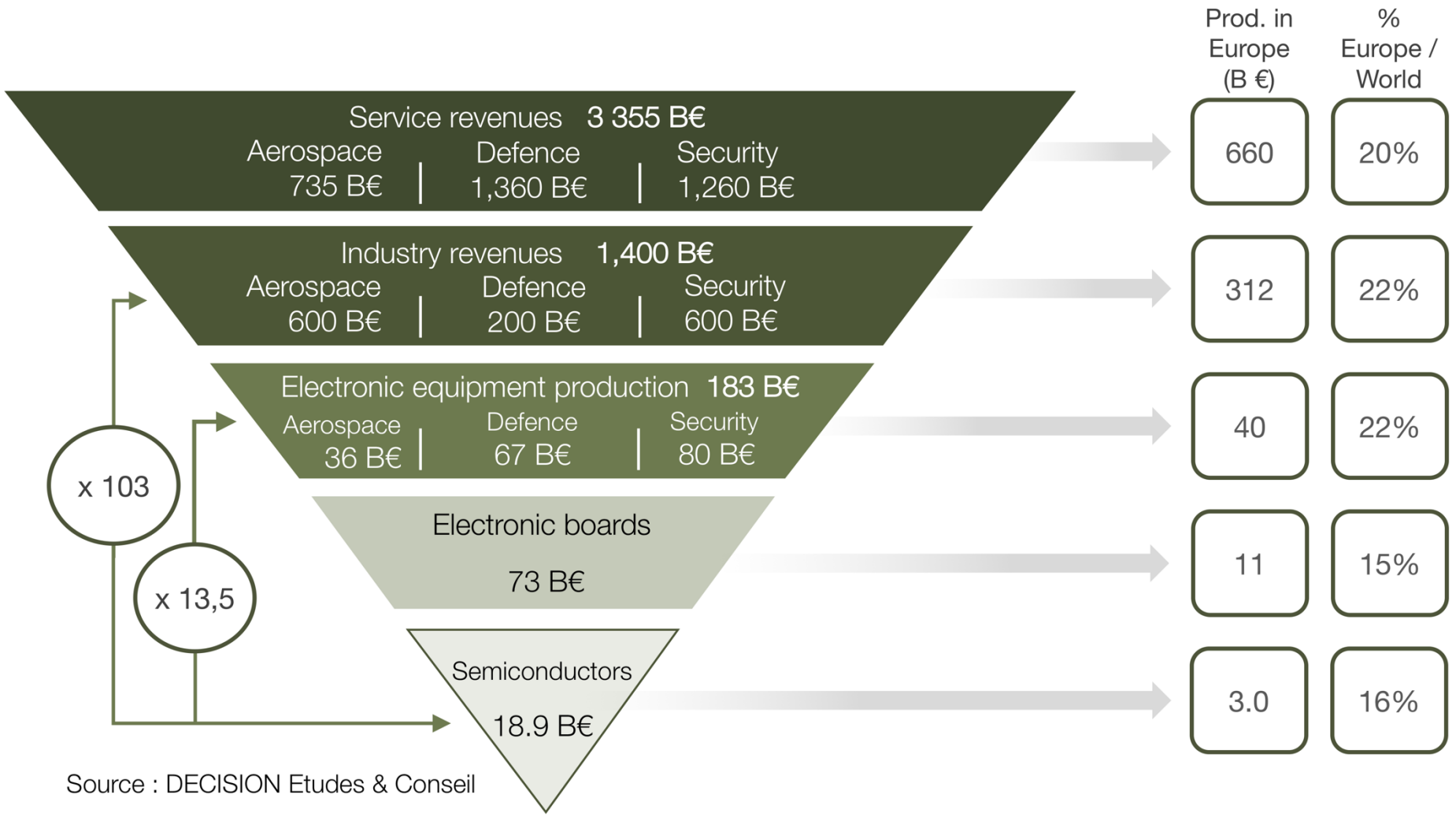
Aerospace and defence electronic systems are designed close to their final assembly location, i.e. Europe and the USA. In 2012, Europe represented 23% of world production (including security electronics). Combined with North America, the two regions accounted for two-third of total world production in 2012, a share that diminished slightly to 64% in 2017 due to decreasing budgets in the military segment whereas other countries like China and India have fast-growing markets and are engaged in dynamic policies to build larger local industries.

In 2017, the world market/production for electronic aerospace, defence and security systems was 183.2 billion Euro, of which 36.2 billion Euro for aerospace systems, 66.6 billion Euro for defence systems, and 80.3 billion Euro for security systems. Civil systems for marine and land transport applications are included under the “industrial and medical electronics” chapter.

With an average annual rate of 5.5% for the 2017-2022 period, growth in world demand for aerospace, defence and security electronic systems is more dynamic than the previous period 2012 to 2017 (+4.2%) and performed better than the electronics industry globally. All the aerospace – defence - security segments will grow faster over the 2017 - 2022 period than over the 2012 - 2017 period. Aerospace electronics will grow at 5.4 % per year on average from 2017 to 2022 (compared to 5.3% from 2012 to 2017). Defence electronics production should go up significantly over the next five years (+5.3% compared to a mere 2.9% from 2012 to 2017) du increasing investment in military budgets worldwide. Security electronics on its side should experience an average annual growth of 5.7% worldwide till 2022 compared to 4.8% over the 2012 – 2017 period.

With 4.6% of expected growth from 2017 to 2022 (compared to 2.9% between 2012 and 2017), the prospects for European electronics production are rather favourable. This is because the European military industry should benefit from increasing defence budget dedicated to the procurement of equipment from European countries after many years of budgetary cuts in the major Defence-spending countries. In addition, excellent prospects in civil aeronautics driven by a continuing growth of the electronics content in civil aircraft with the arrival of a “more-electric” new generation of aircraft as well as continuing satisfactory aircraft delivery levels pulled by fast-growing demand in world air passenger traffic, especially in Asia and the Middle-East will drive civil airborne electronics equipment production in Europe.

Worldwide Aerospace – Defence – Security electronics value chain in 2017



Focus on Aerospace

The electronics for the aerospace sector is composed of:

- Civil airborne systems: including avionics electronics (communication, navigation, radars, flight control, aircraft management systems, etc.), electronic control units embedded into aircraft sub-systems (engines, landing systems, etc.), In-Flight Entertainment electronics, disseminated electronics and power electronics;
- Military airborne systems: Fire & arms systems, cockpit, navigation, instruments, communications and other aircraft embedded systems;
- Civil space: Satellite and rocket embedded electronic systems for civil purposes;
- Military space: Satellite and rocket embedded electronic systems for military purposes.

Analyses

- In 2017, the EU production (million euros) of aerospace electronics accounted for 32% of the global production. Thus, in 2017, the EU was the second largest producing region in terms of aerospace electronics after North America (42%);
- Production of airborne systems (encompassing both civil and military application) in Europe grew at 6.5% per year on average between 2012 and 2017 (above the worldwide trend of 5.6%) driven by excellent perspective in the civil on-board electronic production. This trend should continue in Europe with a forecasted annual growth of 5.9% till 2022;
- Europe is even the first electronics production area for the civil airborne systems with 42% of the world production (5.5 billion euros). The excellent market positions of Airbus and the European aircraft equipment suppliers (Safran, Thales, Liebherr, Rolls-Royce, etc.) drive the on-board electronic production on the European territory. All those players are well positioned to address the More-Electric Aircraft (like the Boeing B787 and the Airbus A350), which are new generation of jetliners fitted with higher contents of electronics. In addition, the European civil airborne electronics industry also benefits from the worldwide increasing demand in new aircraft;
- Military airborne systems represented an electronic production valued at 12.3 billion euros in 2017 with Europe accounting for 26% of this global production (behind the US with 55%). However, thanks to increasing defense budgets and strong performance at exports, the segment should outperform the US in terms of CAGR over the 2017 – 2022 period with 4.7% of growth (compared to 4.0% for the US);
- European space electronics production worldwide is estimated at 2.9 billion euros in 2017 and is the second highest worldwide (behind the US). A segment which should grow at 3.0% till 2022 below the world trend of 4.2% due to lack of military contracts.

Focus on Defence

The electronics for the defense sector is composed of:

- Military communications and naval & ground systems gathering all defense and government dedicated communication systems: tactical, mobile, all ground civil & military government radar & air traffic management or surveillance, all communication, commandment & electronic defense systems for combat or support ships and submarines;
- Missiles electronics, which encompasses embedded missile electronics (without launchers, pads, etc.).

Analyses

- In 2017, with 16.8 billion euros the EU production of defense electronics accounted for 25% of the global production. Thus, the EU was the second largest producing region in terms of aerospace electronics after North America (41%);
- From 2012 to 2017, the production of electronics dedicated to the defense sector grew at a slow 2.9% worldwide. Europe did not perform well with 0.7% of growth over the period. Like the US (with 1.5% growth), Europe suffered from harsh budgetary cuts in defense spending in France, the UK, Germany and Italy, which were partially offset by exports successes;
- On the other hand, emerging countries from Asia and China especially carried on developing their own defense industry and increased their defense electronics production simultaneously. Chinese production of electronics equipment for defense boomed from 7 billion euros in 2012 to 11.6 billion euros in 2017 (i.e. a CAGR of 10.4% during the period).
- Till 2022, growth should be back in Europe thanks to the rise of equipment procurement in all major European countries. A 4.3% growth on average in the defense electronics production from 2017 to 2022 is forecasted. Europe should remain the second largest production zone of defense electronics equipment in 2022.

Focus on Security

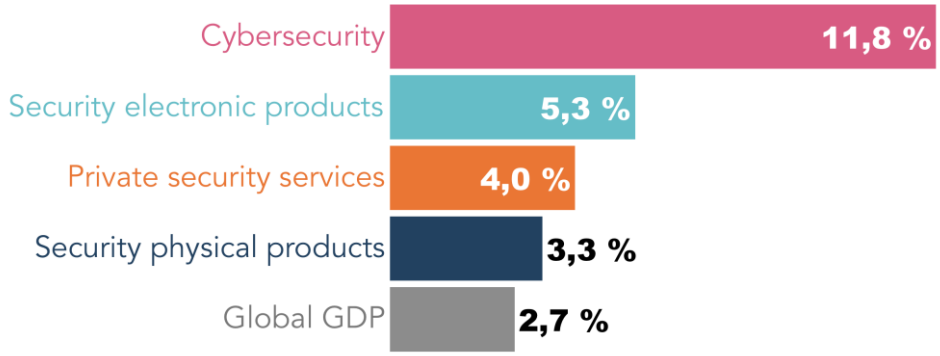
The security sector is composed of:

- Physical security products (police, customs and fire brigades' vehicles, coastal surveillance boats, customs aircraft, helicopters, etc.);
- ***Electronic security products*** (CCTV cameras, fire alarms, intrusion alarms, surveillance radars, detection equipments, etc.);
- ***Cybersecurity software and services*** (that is electronic software);
- Private security services (Guarding, CCTV, investigation, etc.).

The electronic security sector is composed of electronic security products (hardware) and cybersecurity software and services.

- Security is currently one of the global industries that generates the highest growth.
- This high growth is driven by the growth of cybersecurity and the growth of the security electronic products.

World – Compound annual growth rate 2013-2016



Source: DECISION Études & Conseil

Analyses

- In 2017, the EU production (factory-fate figures, million euros), accounted for 14,5% of the global production. In other words, in 2017, the EU was the third region in terms of automotive electronics production (hardware only), after North America (43%) and China (24%);
- In other words, the global production of electronics equipment dedicated to security is clearly led by the USA that concentrates 35% to 40% of the global production;
- China is the global challenger with 24% of the global production and a very high growth (in particular linked to the rise of the public torture market in China: electric chairs, tasers, electric shock batons, etc.). The expected average CAGR of China is 9% over the 2017-2022 period;
- Asia as a whole (that is China, Japan and rest of Asia & Pacific), represented 18% of the global production in 2012, represents 34% of the global production in 2017 and is expected to represent 33% of the global production in 2022;
- The USA are therefore expected to remain the global leader in terms of electronics equipment dedicated to security until 2022 (with 38% of the global production in 2022);
- Israel, considered in the figures of the rest of the world, is also a significant competitor at the global scale with 8% to 10% of the global production shares.

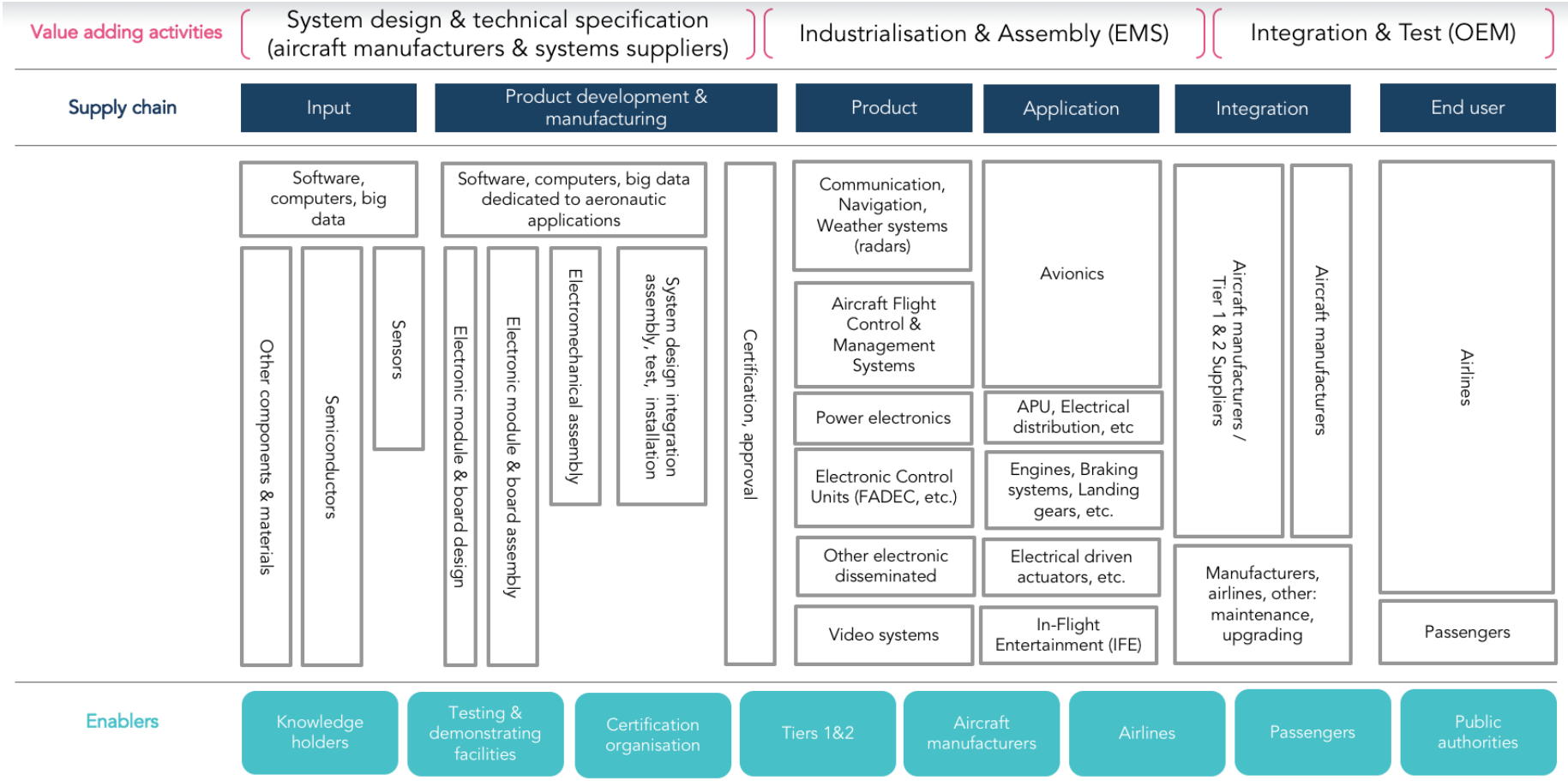
1.1.8 Aerospace

i. Civil aeronautics

A. Scope and presentation of the segment and its value chain

The civil aeronautics value chain is comprised of numerous types of products (and therefore industrial players) due to the complexity of design and production of an aircraft. Among them metallic or now composite-made structures for the airframes, sub-systems like engines or landing gears and of course electronics systems like avionics but also electronics for the sub-systems and fitted into the airframe (electronics in the wings, etc.). As a consequence, and because of the presence of electronics in all the parts of an aircraft, electronics systems are manufactured by different industrial players from the manufacturer (especially for the avionics where production strategies differ between Airbus and Boeing) and by Tier-1 and Tier-2 equipment manufacturers (for example for electronics systems of the engines).

Diagram - Electronic civil aeronautics value chain



Source: DECISION Etudes & Conseil

This part aims at analyzing the evolution of all the electronics systems embedded into an aircraft i.e.:

1. All the electronics systems which refer to the common term “avionics” and which gather the electronics devices and modules located in the cockpit (communication, navigation and radar systems, plus all the aircraft flight and control systems);

2. The electronics control units fitted with the engines, the landing gears, the braking systems (also called work packages), etc. which are mainly designed and made by Tier- 1 and -2 equipment suppliers like Safran, Thales, Rolls-Royce in Europe or by UTC, Honeywell, General Electrics in the US;

3. According to our estimates, around one-third of the total amount of electronics embedded into large commercial plane are disseminated all over the plane structure i.e. these boards / modules (including sensors and actuators) are present into the wings, the tail, etc. or power electronics systems with the development of the More-Electric Aircraft concept;

4. In-Flight Entertainment (IFE) systems which are dedicated to the passengers’ comfort and whose main actors are Thales, Panasonic and Rockwell Collins.

B. Developments (market & production growth, company positioning, technology & ecosystem)

d. Market and production trends

The production of civil aeronautics electronic equipment is driven by three factors:

- Deliveries and production paces of new aircraft;
- The number of aircraft rotations, determining the aftermarket activity;
- Arrival of new generations of aircraft incorporating more electronics and more electrical systems: towards the « more electric aircraft » like the Boeing B787 or the Airbus A350.

The two first factors are directly linked to the air travel and freight demand and in 2017, international passenger traffic (expressed in revenue passenger kilometers) grew at a rate of 8.1% well above the 10-year average annual growth rate of 5.5%. In addition, the air cargo business posted growth of 9.7%, the strongest since 2010.

Globally, air travel was unusually robust in the face of difficult economic conditions as in the past 20 years, its growth has averaged 1.8 times that of global GDP growth. But in 2017, it grew 2.1 times as fast as global GDP. On its side air freight grew more than twice as fast as global trade volumes overall during 2017.

The main reason for this robustness was the strength of emerging markets whereas economic growth and air travel have been weaker in the developed economies (except in Europe). On the contrary, emerging markets in Asia, Latin America, Middle East and Africa have experienced strong economic growth. This, in turn, has supported the growth of air travel by more than global GDP numbers suggest. During 2017, more than 50% of the revenue passenger kilometers took place in markets linked to emerging economies. Asia Pacific accounted for for more than one-third of the global industry revenues. Furthermore, important growth markets were between Europe and Asia and on segments connecting Europe and Asia via the Middle East. Markets from Africa to the Middle East and to

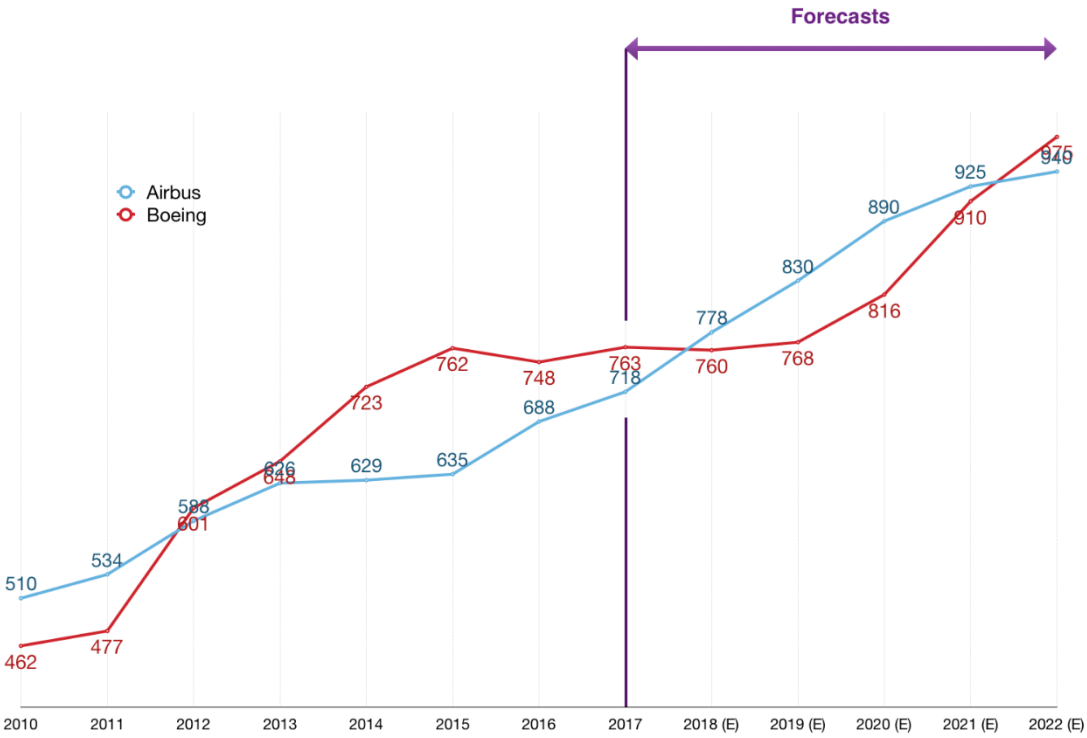
Asia, reflecting the development of new South–South trade lanes. The fastest growth came from emerging domestic markets such as India at 17.4% and China at 13.5%. Globally, domestic passenger market climbed 7% in 2017.

At the international level, Asia-Pacific region posted annual demand growth of 9.4%, compared to 2016, driven by robust regional economic expansion and an increase in route options for travelers. This was the first time since 1994 that Asia-Pacific led all the regions in annual growth rate. Asia Pacific should remain in the coming years the fastest growing market in terms of air travels as according to IATA's forecasts, by 2036 there will be 7.8 billion people traveling, almost half of them to, from and within Asia-Pacific.

Surprisingly, Europe was the third most dynamic region in 2017, experiencing an 8.2% in 2017 compared to the previous year, underpinned by buoyant economic conditions in the region. In comparison, North America faced a much more sluggish situation as it rose by only 4.8% partly attributable to the new immigration and security restrictions put in place for travel to the US.

As a consequence, the aircraft manufacturing industry experienced and will carry on experiencing strong growth to satisfy airlines demand in new aircraft.

Graph - Deliveries of aircraft manufactured by Airbus and Boeing

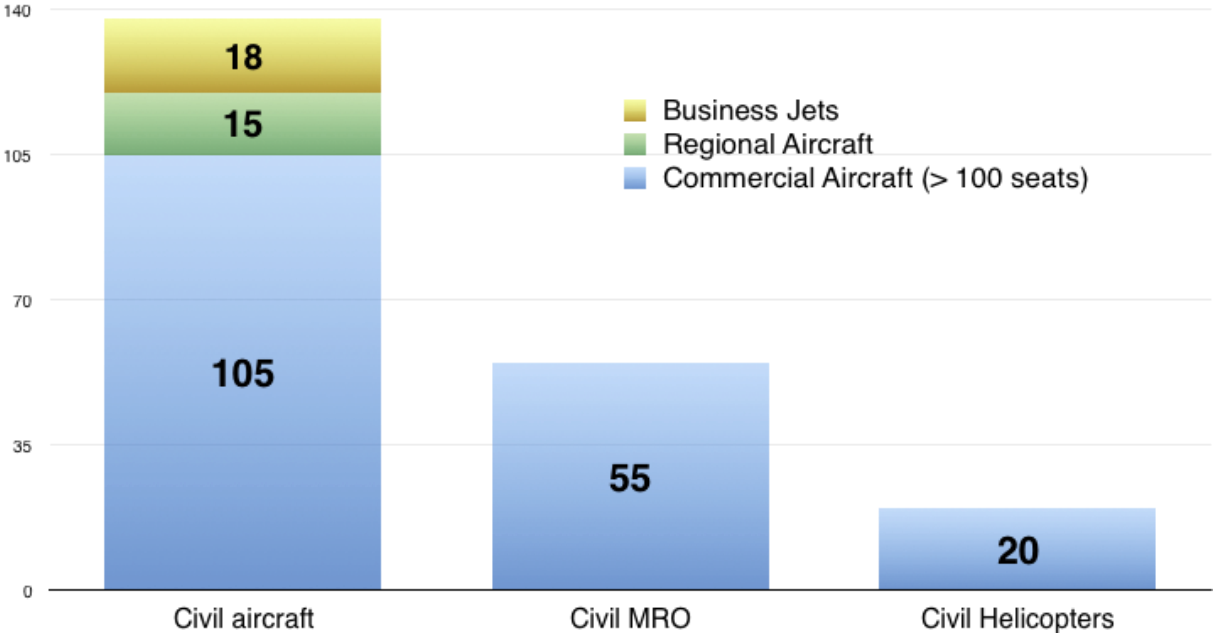


Source: Company Reports / DECISION (for the estimates based on forecasted production rates)

From 2010 to 2017, Airbus and Boeing combined production boomed from 972 to 1,481 aircrafts delivered (i.e +52% growth over the period). According to production rates given by the two manufacturers, their production could increase to more than 1,900 in 2022 (i.e. +29% growth between 2017 and 2022).

Airbus and Boeing are positioned on the largest market segment in value, which is the segment of the commercial aircraft over 100 seats. Other main segments are the business jets segment, the regional aircraft segment (i.e. aircraft with less than 100 seats) and the civil helicopter market segment.

Bar chart - Turnover of the civil aircraft industry worldwide in 2017



Source: Company Reports / DECISION Etudes & Conseil

In addition, the large commercial aircraft market segment is also set to be the largest in units delivered and the most dynamic one according the backlog of orders at the end of 2017.

Table – 2017 – Major aircraft deliveries and backlog of orders by programs

Aircraft manufacturers	Deliveries	Backlog order at the end
A320 Family	558	6 141
Other Airbus programs	160	1 124
B737 Family	529	4 668
Other Boeing programs	234	1 196
Bombardier regional jets	43	390
Embraer regional jets	109	435
ATR regional turboprop	78	235
Bombardier regional turboprop (now Airbus since 2018)	30	43
Russia SSJ100	25	69
Russia MS21	0	231
China ARJ21	3	110
China C919	0	655
Japan MRJ	0	233

Source: DECISION Etudes & Conseil / Company Reports

- **The success of the A320 and B737 family on the single-aisle market**

Airbus A320 and Boeing B737 family programs accounted for more than 73% of Airbus and Boeing total deliveries and more than 60% of total commercial aircraft deliveries in 2017. With a respective backlog of orders of 6,141 for its A320 family, the European manufacturers is ahead of its American competitor who had 4,668 B737 to deliver at the end of 2017.

A success for both jet makers explained by the entry into commercial operation of the modernized versions of the A320 and the B737. Respectively named A320 NEO for New Engine Option and B737 MAX, these new variants required some redesign work (landing gear, wings, etc.) and are be equipped with new engines to fulfill plane makers' promises of 15% less fuel-consumption than for the previous generation.

These new derivatives allow Airbus and Boeing to delay the launch of the successors of their most successful products (especially in terms of margins as these programs are paid off since several years) that should embed breakthrough technologies like open- rotors, new fuselage design, etc.

Unveiled in early 2011, the NEO range with 5,347 firm orders already accounts for more than half of the A320 backlog of orders. Becoming the most successful commercial aircraft launch in history, this situation forced Boeing to react and to unveil the B737 MAX 8 months later. With 4,285 firm orders, Boeing can also claim success. The A320 NEO first deliveries started in 2016 and in 2017 for the American B737 MAX. Quite interestingly, Airbus A320 (including the NEO) has encountered a true success in Asia as where now more than half of all single aisle aircraft flying in the region are A320 Family aircraft.

In terms of deliveries, in 2017, Airbus delivered around 270 A320 aircraft to Chinese customers, i.e. 48% of Airbus' total A320 production. A success explained by the installation of an assembly line in Tianjin (China) in 2008, which is perceived as a true advantage compared to Boeing which still continues to manufacture exclusively in the US. Since the opening of the Tianjin site, Airbus market share in China doubled from 25% to 50% in 2013. And with 378 A320 produced so far and delivered to Chinese companies, this sales argument also boosts production of the assembly lines in Europe since deliveries to the region included almost 100 new widebody aircraft assembled in Europe.

In addition to preserve their margins, the NEO and the MAX are also excellent arms to prevent emerging competitors like Bombardier with its C Series or Sukhoi with its Superjets to tap this lucrative market and therefore to preserve their market shares. Furthermore, in 2018, Airbus sealed a deal with the largest aerospace Canadian player Bombardier to assume control of its C Series program. Planes are planned to be assembled in Canada and in the Airbus' US factory in Alabama. With this acquisition, Airbus reinforces its position on the single-aisle market forcing Boeing to conclude a partnership with Bombardier's main competitor, the Brazilian planemaker Embraer.

The strong demand worldwide for narrowbody aircraft like the A320 and B737 family pushes Airbus and Boeing to dramatically increase their production rates. Monthly production rates of Airbus single-aisle jets ramped up from 34 units in 2010 to 47 in 2017 and are predicted to reach 60 planes a month by mid-2019.

Designed several decades ago, both A320 and B737 aircraft family can be considered as « old-generation » aircraft and embed, according to our estimates around 7% of electronics equipment (value based of the discounted price of the aircraft). This share of embedded electronics into an A320/B737 should change significantly in spite of the arrival of the redesigned A320 NEO and B737 MAX.

Therefore, the production of electronics for the narrow-body is driven structurally by the increasing demand and the raising output in units.

Considering the aftermarket activity and driven by growth deliveries, the production of electronics dedicated to the single-aisle market went up reached 4.6 billion euros in 2017 compared to 3.2 billion euros five years earlier. This production should achieve almost 7.1 billion euros in 2022.

- **New generation aircraft: towards the More Electric Aircraft (MEA)**

The value of electronic equipment fitted into aircraft increased dramatically with the arrival of the generation of "More Electric Aircraft" (MEA) such as the B787 Dreamliner and the A350. This name defines new generation aircraft incorporating new electric and electronic technologies/equipment designed to improve the reliability and the security of the aircraft as well as reducing operational costs.

One of the main developments introduced by the MEA is the replacement of mechanical (hydraulic and pneumatic) actuators by electrically-driven actuators. Therefore, the huge amount of "hidden" electronics that already accounts for a third of the entire electronic content of aircraft will increase in the future. In addition, the management of high levels of electrical power entails the use of more and more power electronics.

The emergence of MEA bolsters innovation in electric systems, here are a few examples:

- Braking systems will no longer be actuated hydraulically but electrically on the B787;
- Thrust reversers follow the same trend (A380);
- In the future: green-taxiing, etc. All these innovations combined with the ramp-up of B787, A350 production rates heighten the share of on-board electronic equipment from 7% to 11%; naturally boosting electronics production for the aeronautics market.

New generation of MEA commercial aircraft: B787 and A350 deliveries

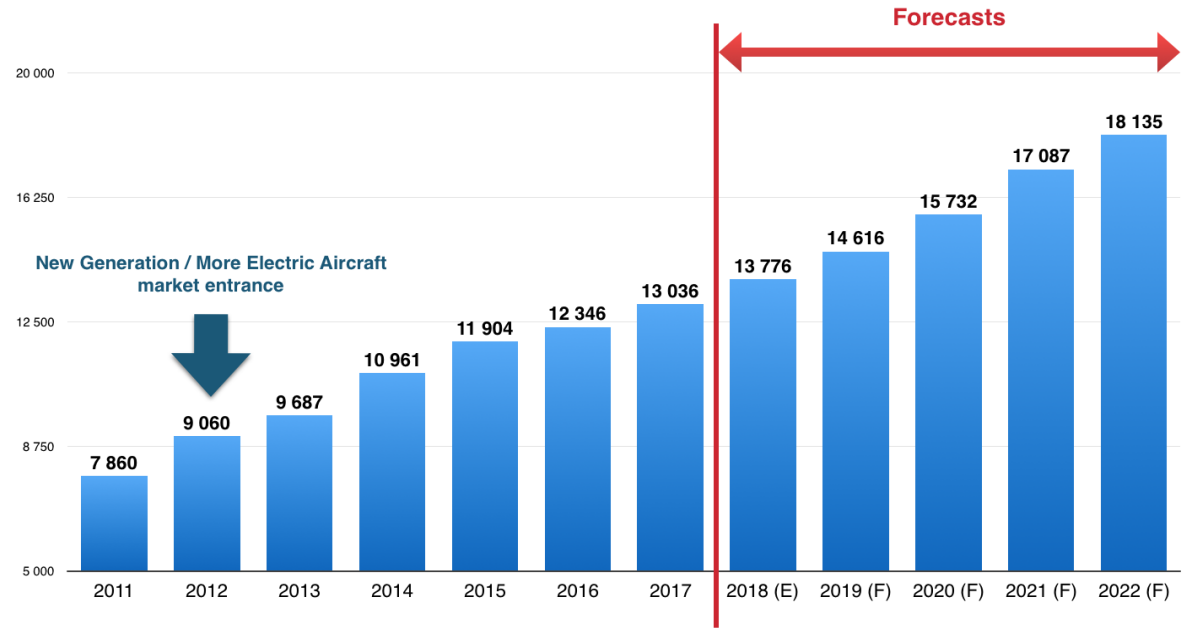
Year	Boeing B787	Airbus A350	Total
2011	3	-	3
2012	46	-	46
2013	65	-	65
2014	114	1	115
2015	135	14	149
2016	137	49	186
2017	136	78	214

Source: Airbus/Boeing company data / DECISION

As concerns electronics, combined production dedicated to these two aircraft skyrocketed in 2012 to reach 732 million euros. With the entry into operation of the A350 in 2014, the demand of electronic equipment accelerated to reach a global production of almost 4.1 billion euros in 2017. It overtook the embedded electronics production for the old generation of wide-bodies (Airbus A330/340 and Boeing B747/767/777) with 6% electronic content on average.

Including all the plane makers from large commercial jet manufacturers to general aviation makers, the total electronic equipment production for civil aeronautics reached 13 billion euros in 2017 compared to 7.9 billion euros in 2011. The market should achieve a global output of more than 18.1 billion euros in 2022 according to our estimates.

Bar chart - Civil aeronautics electronic equipment production
World Electronic civil aircraft equipment production (in Million euros)



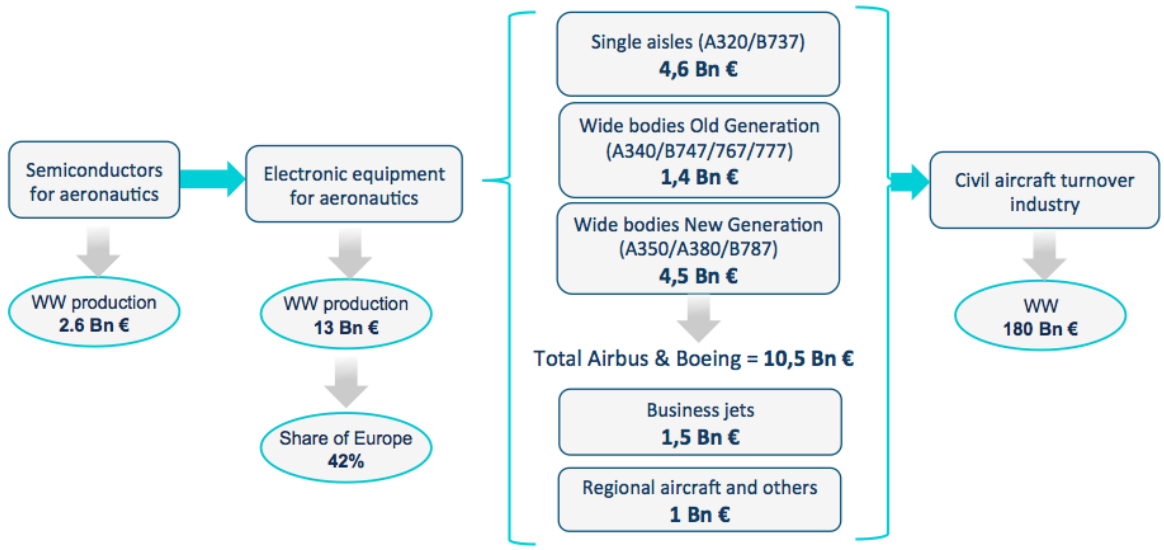
Source: DECISION Etudes & Conseil

If the share of electronics in civil aircraft is rightly perceived as growing, it is often overestimated in literature. The feeling that electronics are ubiquitous in the management of aeronautical systems may explain this mistake and, in turn, some of the difficulties inherent to the economic model of civil aviation. Although some electronic functions are relatively easy to identify (communications, radar, flight management systems, Integrated Modular Avionics, etc.), others are less visible; for example, those controlling certain traditional mechanical functions such as brakes, landing gear, flight controls, etc. Moreover, even if Electronic Control Units (ECUs) are clearly identifiable electronic sub- systems, other electronic equipment is disseminated in electronic systems (e.g. electronic equipment related to sensors and actuators).

If we take the case of the A320 and B737 (single-aisle aircraft which represent more than 75% of jet deliveries), which were originally designed 30 years ago, the share of electronics per aircraft is around 7% of the discounted price of an aircraft. For the new generation of aircraft designed in the 2000s (B787, A350), the share of on-board electronics is around 11% of the price. On this basis, there is about 3.3 million euros of on-board electronics on an A320 or a B737, whereas the figure for the B787 and the A350 reached 14 million euros (i.e. more than 4 times more) in 2017 (compared 6.5 million euros for their predecessors).

Therefore, in 2017, the global assessment of the civil aeronautical on-board electronics market was as follows:

Diagram - Electronic civil aeronautics value chain in key figures in 2017



Source: DECISION Etudes & Conseil

With around 10.5 billion euros in 2017, Airbus and Boeing aircraft accounted for 81% of electronic civil airborne systems.

e. Company positioning, Europe, World

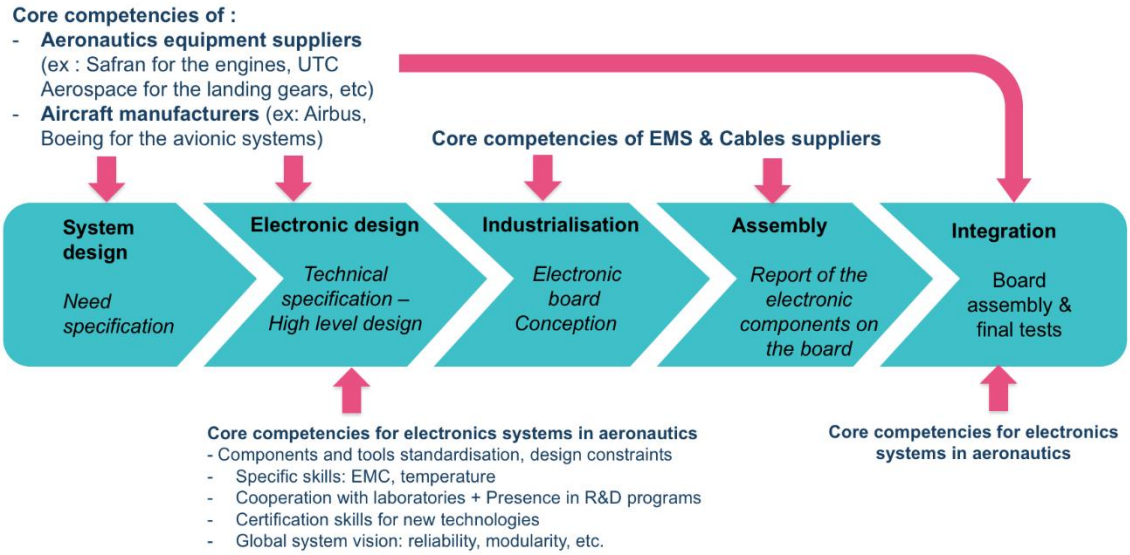
Electronics equipment for aeronautics are manufactured by a variety of players from aircraft makers directly for critical systems to Tier-1, -2 or -3 equipment makers for electronics sub-systems. Furthermore, each of these actors can produce their electronics internally or decide sub-contract it to an international or specialized EMS. Production strategies and organizations vary from one company to another and have evolved during the past years.

Globally, the two leading regions in electronic equipment production remain Europe and the USA due the strong market positions of their two giants: Airbus and Boeing which have organized the manufacturing process by sub-contracting some parts of their production to regional players. For example, leading aircraft engine makers are the American General Electric and Pratt & Whitney plus the European Safran (ex SNECMA) and Rolls-Royce. The two main suppliers of landing gears and braking systems for Airbus and Boeing are the European Safran and the American UTC. The majority of equipment suppliers are either European or American. If they have a global presence worldwide, the essential of their output is manufactured close to the assembly lines of their clients. It is also the case for their electronics especially when it is made in-house or sub-contracted to specialized EMS.

Generally speaking, electronics equipments are carried out close to the equipment integration location, which is principally Europe or the USA. However, for less critical on-board electronic equipment like In-Flight Entertainment (IFE) systems, the production can easily be made by international and non-specialized EMS like Flex, Jabil or Celestica in their Asian plants.

The following scheme presents the different production steps of electronics equipment for civil aeronautics applications with the position of the core competencies applied to the different value chain suppliers.

Diagram - Core competencies of the electronic civil aeronautics value chain



Source: DECISION Etudes & Conseil

Major aircraft equipment supplier turnover

Company	Nationality	Aerospace Turnover 2017 (in billion euros)	Main products including electronics
Safran	France	26.3	Propulsion systems for commercial aircraft, military transport, training and combat aircraft, rocket engines, civil and military helicopters, tactical missile, mechanical, hydromechanical and electromechanical equipment.
UTC*	The USA	26.1	Engines, Air Management Systems, Engine Systems, Aerostructures, Electric Systems, Interior, ISR & Space Systems, Sensors & Integrated Systems, landing gears and braking systems
General Electric	The USA	23.1	Engines for civil and military airplanes
Honeywell	The USA	12.5	Turbine engines, avionics, radars, auxiliary power units, brakes, wheels, black boxes
Leonardo	Italy	11.5	Helicopters, avionics, radars, surveillance systems, space systems for commercial and military applications
Cobham	The UK	9.5	Aviation services, electronic solutions, communication & connectivity systems, mission systems for civil and military aircraft
Rolls-Royce	The UK	9.0	Engines for commercial airplanes
Rockwell Collins**	The USA	5.8	Interior systems, air transport aviation electronics for commercial, business and regional jets (communications, radars, etc.)
Zodiac***	France	5.1	Systems and equipment for critical functions on board aircraft or on the ground: cabin systems, seats, etc.
Thales	France	3.6	Avionics, radars, airborne systems, IFE for civil aircraft
Meggitt	The UK	1.6	Braking systems, control systems, sensing systems for civil and military aircraft
Diehl AeroSystems	Germany	1.5	Electronic systems for civil and military planes
Liebherr	Germany	1.3	Aircraft flight control and actuation systems, landing gear, air management systems, on-board electronics as well as gears and gearboxes for the aerospace industry

Source: DECISION Etudes & Conseil / Company data
* including Pratt & Whitney
** acquired by UTC in 2017
***acquired by Safran in 2018

All these equipment suppliers include electronics in their systems. However, and except for few exceptions, like Rockwell Collins or Diehl Aerospace whose products are electronics-centric, no equipment suppliers provide figures about their electronics business activity and therefore no splits is made between civil, military or space activities. The table above only gives indications about the position of the supplier on the global aircraft value chain and its size through its turnover.

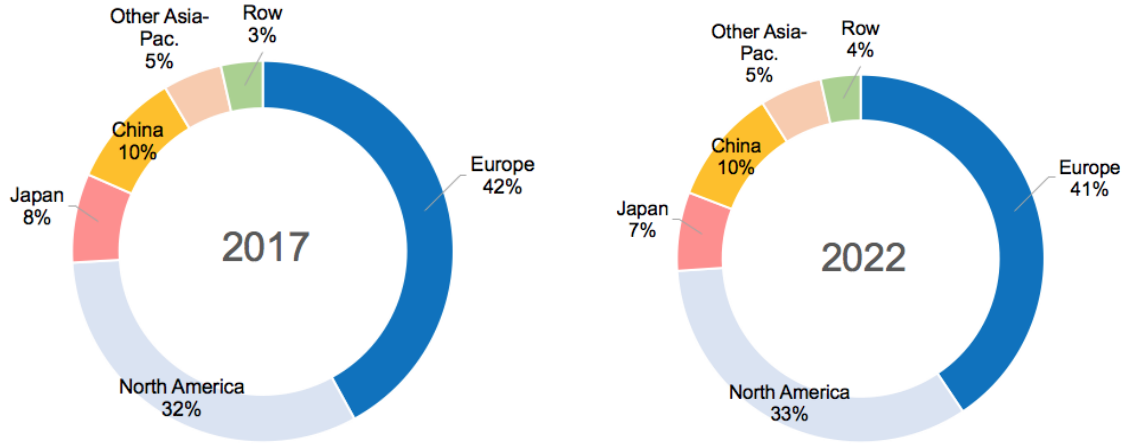
In addition, as explained previously, each of these suppliers is organized differently for the conception, production and assembly of its electronics. For example, Rockwell Collins, which is very integrated keeps the manufacturing essentially in the US with very little outsourcing in Asia. On its side, Honeywell has outsourced in the late 2000s to an international EMS, which produces in the US and in Asia. The giant UTC keeps 100% of the design but the industrialization and the assembly of its electronics are sub-contracted to a specialized EMS, which manufactures at around 70% in the US and 30% in low cost regions.

For the European equipment suppliers like Safran, a share is still produced in the intern manufacturing facilities in France especially. But, Safran also relies on local specialized EMS in Europe or international EMS. For Thales, the strategy is based on a rather intensive use of sub-contracting for the electronics assembly step (around 1/3 international EMS like Celestica and 2/3 specialized EMS like Eolane, Asteel Flash).

For the aircraft manufacturers, Boeing who had sold its electronics activities to UK-based BAE Systems in 2003 but the US plane maker has recently acquired some electronics activities back to its catalog.

Airbus has another strategy. For the critical flight systems, Airbus has kept all competencies internally from design to production, assembly and integration. The European manufacturer relies on local specialized EMS like Selha, Actia or Tronico.

Chart- Civil airborne electronics equipment production breakdown by region in 2017 and 2022



Source: DECISION Etudes & Conseil

C. Figures, Europe 2010-2017, world and main countries

Table - Civil and military aeronautics electronic equipment production worldwide in million euros & growth

	2012	2013	2014	2015	2016	2017	CAGR 2012-17	CAGR 2017-22
Military airborne systems	10 213	10 157	10 457	10 799	11 885	12 331	3,8%	4,7%
Civil airborne systems	9 060	9 687	10 961	11 904	12 346	13 036	7,5%	6,8%
World Total	19 272	19 844	21 418	22 703	24 231	25 367	5,6%	5,8%
Military airborne systems	6,9%	3,0%	7,9%	6,0%	6,7%	4,7%	3,8%	4,7%
Civil airborne systems	0,4%	-0,5%	3,0%	3,3%	10,1%	3,8%	7,5%	6,8%
World Growth	16,0%	6,9%	13,1%	8,6%	3,7%	5,6%	5,6%	5,8%

Source: DECISION Etudes & Conseil

Table - Civil and military aeronautics electronic equipment production by region in million euros & growth

	2012	2013	2014	2015	2016	2017	CAGR 2012-17	CAGR 2017-22
Military airborne systems	2 630	2 670	2 905	2 939	3 122	3 187	3,9%	4,7%
Civil airborne systems	3 696	4 010	4 552	4 984	5 188	5 479	8,2%	6,6%
Europe Total	6 326	6 680	7 456	7 923	8 310	8 666	6,5%	5,9%
Military airborne systems	5 807	5 558	5 474	5 666	6 436	6 732	3,0%	4,0%
Civil airborne systems	3 029	3 211	3 644	3 881	3 978	4 177	6,6%	7,3%
North America Total	8 836	8 768	9 118	9 547	10 414	10 909	4,3%	5,3%
Military airborne systems	412	449	458	433	452	438	1,3%	3,7%
Civil airborne systems	762	797	872	932	946	984	5,2%	4,7%
Japan Total	1 174	1 246	1 330	1 364	1 398	1 422	3,9%	4,4%
Military airborne systems	723	799	904	972	1 035	1 089	8,5%	7,7%
Civil airborne systems	843	894	1 008	1 125	1 188	1 282	8,7%	7,3%
China Total	1 566	1 693	1 912	2 097	2 223	2 371	8,6%	7,5%
Military airborne systems	213	227	241	267	277	294	6,6%	7,4%
Civil airborne systems	413	439	508	573	607	653	9,6%	8,4%
Other Asia-Pac. Total	626	666	748	840	884	947	8,6%	8,1%
Military airborne systems	427	455	475	523	563	590	6,7%	6,9%
Civil airborne systems	316	337	377	409	439	461	7,9%	6,3%
ROW Total	743	792	852	931	1 002	1 051	7,2%	6,7%

Source: DECISION Etudes & Conseil

Table - Civil and military aeronautics electronic equipment production by region in annual growth rates

	2012	2013	2014	2015	2016	2017	CAGR 2012-17	CAGR 2017-22
Military airborne systems	6,9%	3,0%	7,9%	6,0%	6,7%	4,7%	3,9%	4,7%
Civil airborne systems	0,4%	-0,5%	3,0%	3,3%	10,1%	3,8%	8,2%	6,6%
Europe Total	16,0%	6,9%	13,1%	8,6%	3,7%	5,6%	6,5%	5,9%
Military airborne systems	-2,0%	-4,3%	-1,5%	3,5%	13,6%	4,6%	3,0%	4,0%
Civil airborne systems	16,5%	6,0%	13,5%	6,5%	2,5%	5,0%	6,6%	7,3%
North America Total	3,6%	-0,8%	4,0%	4,7%	9,1%	4,8%	4,3%	5,3%
Military airborne systems	-8,2%	9,0%	2,0%	-5,5%	4,5%	-3,0%	1,3%	3,7%
Civil airborne systems	10,5%	4,5%	9,5%	6,8%	1,5%	4,0%	5,2%	4,7%
Japan Total	3,1%	6,1%	6,8%	2,6%	2,5%	1,7%	3,9%	4,4%
Military airborne systems	9,5%	10,5%	13,2%	7,5%	6,5%	5,2%	8,5%	7,7%
Civil airborne systems	15,5%	6,0%	12,8%	11,6%	5,6%	7,9%	8,7%	7,3%
China Total	12,7%	8,1%	13,0%	9,7%	6,0%	6,6%	8,6%	7,5%
Military airborne systems	7,5%	6,5%	6,0%	10,8%	3,8%	6,2%	6,6%	7,4%
Civil airborne systems	18,0%	6,3%	15,6%	13,0%	5,8%	7,6%	9,6%	8,4%
Other Asia-Pac Total	7,5%	13,5%	9,5%	12,5%	5,5%	5,0%	8,6%	8,1%
Military airborne systems	7,0%	6,5%	4,5%	9,9%	7,7%	4,8%	6,7%	6,9%
Civil airborne systems	9,0%	6,5%	12,0%	8,4%	7,5%	5,0%	7,9%	6,3%
ROW Total	7,8%	6,5%	7,7%	9,2%	7,6%	4,9%	7,2%	6,7%
World Total	16,0%	6,9%	13,1%	8,6%	3,7%	5,6%	5,6%	5,8%

Source: DECISION Etudes & Conseil

ii. Space

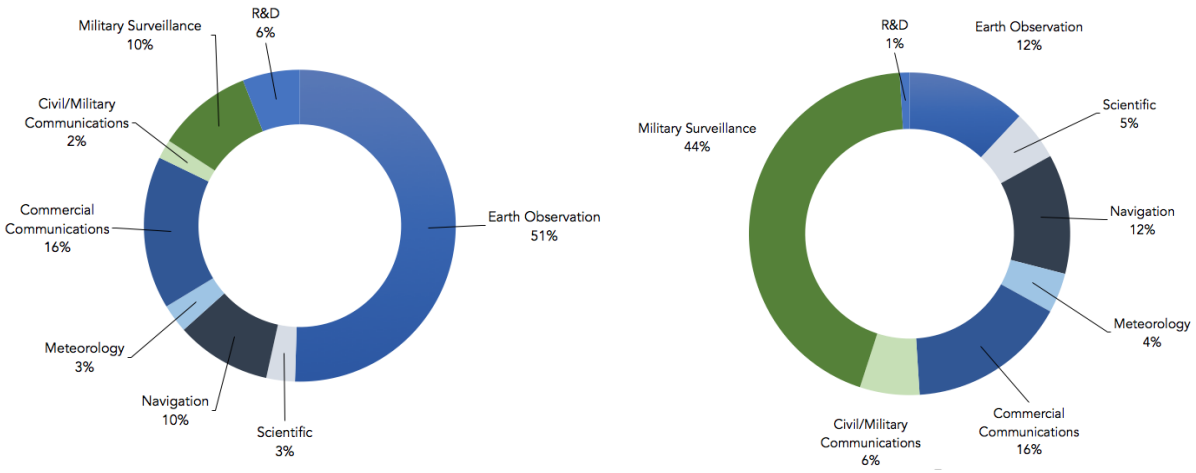
D. Scope and presentation of the segment and its value chain

The space industry consists of three main industrial segments which are the satellite manufacturing segment, the rocket (also called launcher) manufacturing segment and the ground equipment segment plus a service segment dedicated to operating satellites.

This part, which aims at analyzing the electronics value chain and trends of the space electronics, will focus on the satellite and the rocket manufacturing segments only. The ground equipment segment mainly encompasses telecommunication and computing equipment which are studied in those respective parts.

In this par, the scope of analysis of the electronics space sector will be split into two main categories: the electronics dedicated to civil purposes and the electronics dedicated to military missions. If launchers are similar for both types of applications, satellites manufacturing follows different business cycles which entails specific analyses. The military segment of the space market is characterized by its low volume and rather cyclical trends. Moreover, unlike the civil space segment, the sensitive and strategic nature of military satellites means that they are launched by the countries that manufacture them.

Diagram - Number (left) and value (right) of satellites launched by mission in 2016

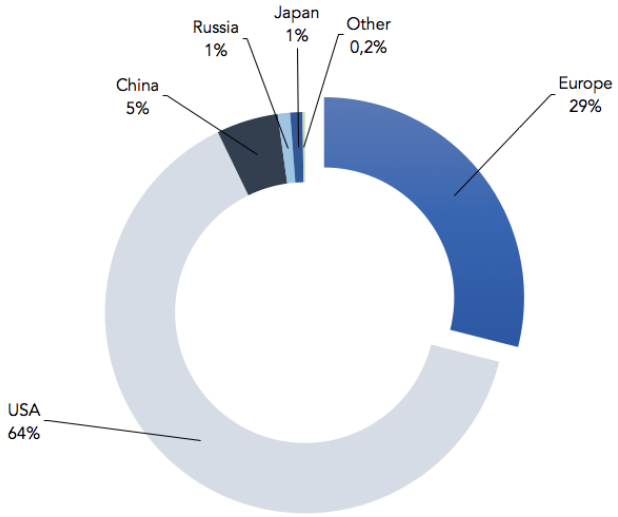


Source: Bryce

Due the massive investment and high technology required to manufacture and launch spacecrafts (launchers and satellites), only a very limited numbers of countries can claim to have access to space. Historically the US and Russia where the two main players, however Europe managed to develop its own technologies and grab market shares on the manufacturing part through Arianespace for the launchers plus Airbus Defense & Space and Thales Alenia Space (and more recently OHB) on the satellite manufacturing segment. Currently, Russia has been overtaken by China in terms of business activity. The strategic choice to master its own technology to put into orbit its in-house made spacecrafts combined with increasing public fundings have pushed China into the front of the scene.

As a consequence, these three regions accounts for the largest production areas of spacecrafts in value. And in 2016, among the 17 ordered commercial geostationary satellites, 10 where won by US manufacturers (59%), 5 by European manufacturers (29%) and 2 by Chinese manufacturers (12%).

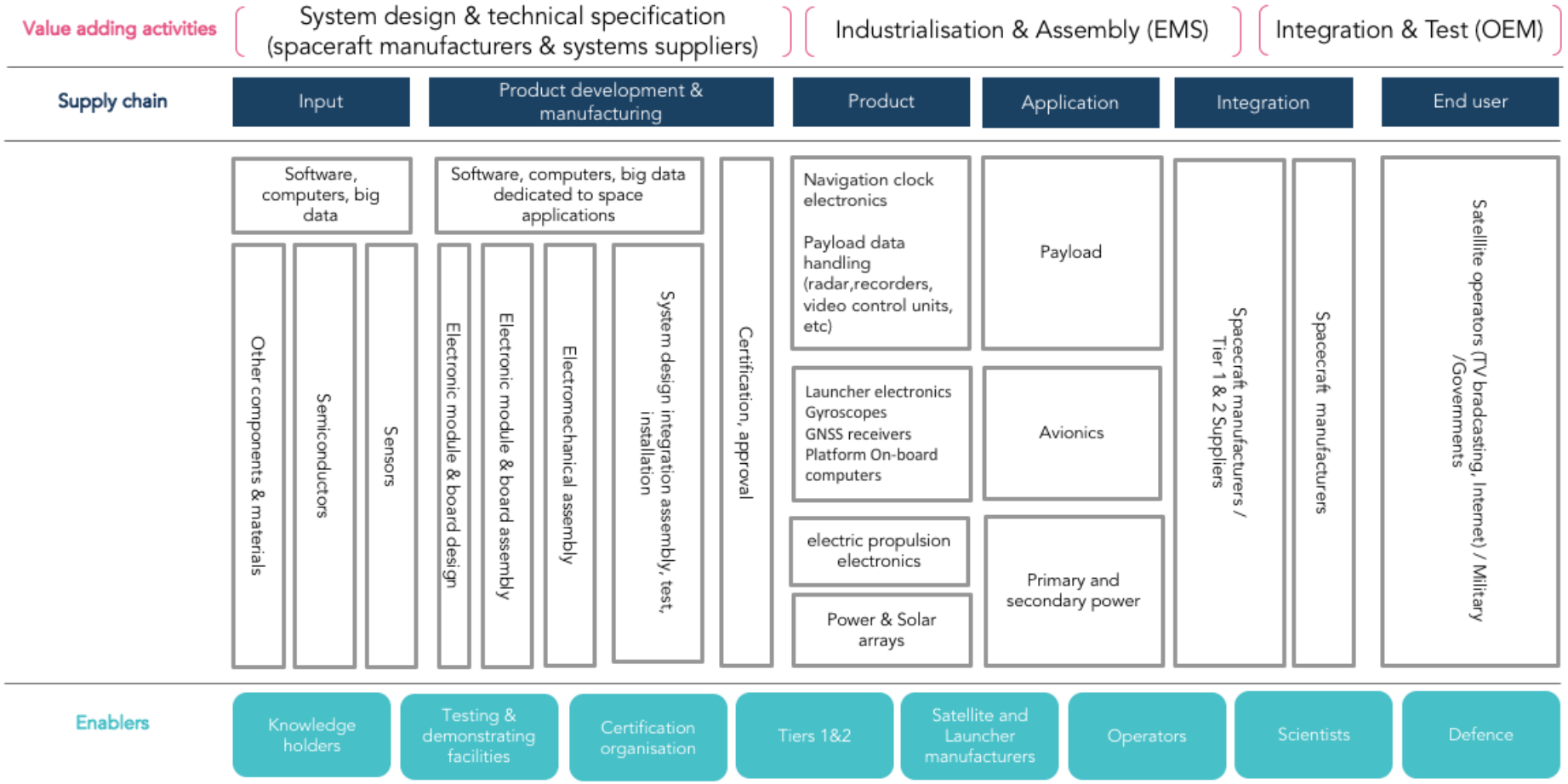
Diagram - Estimated Value of Spacecraft Launched by Country/Region of Manufacturer (2016)



Source: Bryce

In terms of production process, the space industry is characterized by its long and meticulous manufacturing process as well as its highly reliable components and embedded equipment. As a consequence, it makes advances relatively slow compared to other electronics sectors. However, the worldwide demand for more connectivity has been skyrocketing pushing the space industry the adopt new development and production processes to satisfy the need of ever-more capable satellites.

Diagram - Space electronics value chain



Source: DECISION Etudes & Conseil

E. Developments (market & production growth, company positioning, technology & ecosystem)

The space business activity was globally on the rise from 2012 to 2017 essentially driven by commercial civil activities. During this period, the number of satellites launched increased by 53% mostly thanks to small or very small satellites. In 2016, 126 satellites were launched among them 46 were CubeSats (Nano-satellites between 1 to 10kg) principally for commercial earth observation.

The satellite market is now shared between two types of satellites:

- The legacy satellites, which use to be heavy (between few hundred kilos to over 6 tons, and cost more than 100 million euros), equipped with highly reliable embedded systems (especially the payload which is specific to the satellite mission and which consists of electronics systems) and take two to three years to build, and lasts well over a decade, sometimes two for a typical geostationary spacecraft;

- The development of new concepts called constellation consisting for some projects of hundreds of small/mini/nano-satellites (from 1 to 150 kilos), whose development and production methods are inspired by non-space industries, with quicker production rates, shorter lead times and a strong use of Commercial Off-The-Shelf (COTS) components.

As a consequence, and in spite of the boom of number of spacecrafts produced and launched, the revenues of the satellite industry grew at much more moderate pace because of the low prices of these new small spacecrafts compared to the legacy satellites.

f. Developments

The satellite industry is driven by satellite services and especially the consumer services which are the key drivers. Among them, satellite TV services are the largest segment accounting for almost 80% of the satellite services revenues. The growth of High Definition TV has entailed an increasing demand for communication satellites.

Accounting for two-thirds of the satellite business of European companies, communication satellites are a fast-growing market all over the world. Demonstrating Europe's capability to deliver satellites at the cutting-edge of technology. In late 2010, Thales Alenia Space defeated Lockheed-Martin in the contest launched by Iridium for 81 communication satellites (2.1 billion $). Built between 2012 and 2016, the 81 satellites of 800 kg each were launched in 2017 and 2018.

The constant demand for satellites with more connectivity capabilities has two impacts on the space industry:

- Development of High Throughput Satellites (HTS) which combine the use of several technologies for far greater efficiency, including frequency re-use, spot beams, and on-board processing to maximize available spectrum (primarily in Ku- and Ka-band);

- The arrival of new investors coming from the Internet world with specific business models relying on constellations of small satellites to address new market needs. For example, the American OneWeb constellation should be composed of 648 microsatellites with the mission to provide Internet services to people with no broadband access. The satellites will be manufactured by Airbus Defence & Space at production rate of 2 to 3 per day at its peak, which means between 300 and 450 kg of spacecraft produced

every day. The fact that those satellites are structurally identical in terms of architecture design, payload systems and therefore embedded electronics has pushed spacecraft manufacturers to adopt new production processes based on automatization and COTS components to satisfy the rhythm of deliveries and to rely on large economy of scales to reduces their production costs.

However, if the deployment of several constellations is on preparation, the operation of the constellations has not been demonstrated since no one is in orbit. It is only in early 2019 that the first constellation should be commercially operational and therefore validate their capacity to operate with "full commercial" components.

g. Impacts of small satellites and new technologies on the electronics equipment production for space

From a general point of view and both for legacy and small-sized satellites, the electronic content is growing in satellites pushed by two main trends. Like the trend of the More Electrical Aircraft (MEA) in civil aeronautics, electronics has reached enough reliability and security to replace more and more mechanical and hydraulic functions like pumps and actuators, etc. Secondly, the generalization of the adoption of electrically powered spacecraft propulsion (replacing the chemical propulsion that previously required the control of valves) requires complete electronics systems that must handle high voltages is also increasing the average content of electronics per satellite.

Furthermore, the embedded electronics for satellites also benefits from constant progresses made by the electronic components industry.

First of all: miniaturization, which in the context of space is key because satellites are charged per kilogram launched. Therefore, the lighter a satellite is, the less expensive it will be to be launched. As customers also want a reduction in the cost of the equipment itself, miniaturization is perceived as a solution to lower the costs. However, miniaturization leads to additional costs in production (or components) related to the constraints like greater heat dissipation leading to develop new design of the packaging of electronic systems. Other factors such as testing, must be reduced manufacturers to offset this constraint.

Secondly, this miniaturization also leads to a "digitalization" of the analog part. Twenty years ago, the difficulty of space electronics lay in its design, in particular of the design of electronic boards, that is to say associating a component with another one. Today, electronics is much more "digital design" which closer to the software: that is to say digital processing with an analog part and an important packaging development to manage the increased heat dissipation created by miniaturization.

In addition, digitalization involves hardware changes (FPGA, COTS, etc.) but also software functions that were previously realized in by hardware components. There is an increase in embedded software volumes due to a rising demand for more electronics flexibility. Flexibility allows the reconfiguration of payload electronics based on the services and new standards required from the ground.

Even if new production methods in electronics assembly had been adopted before the arrival of mini-satellites (like automatization of the production, etc.), the development of several constellations of hundreds of these small-sized spacecrafts has pushed manufacturers to higher levels of productivity in order to satisfy the needs brought by the actors of the New Space.

With prices than can be up to 15 times less expensive than legacy satellites (for giant satellite constellations of several hundred satellites), mini-satellites are produced in a radically new way to achieve new space requirements to lower cost and and maintain high performances:

- Constellation satellites are built with an extensive use of COTS. These standard components are generally chosen for their excellent quality/price/reliability ratio and their validation is based on statistics to reduce the bill-of-materials and testing costs;

- Increased robotic assembly and automation are optimizing the way satellites are constructed. These methods remove touch-labor, shortening the time and effort needed to complete rote tasks and in fine reduce the assembly cost;

- Design of digital payload with the ability to test itself, eliminating the need for additional tests or additional test equipment.

As a consequence, a pressure on prices of electronics equipment has developed which is not offset by the increasing amount of electronic in spacecraft. However, if automatic assembly lines have been existing for years in major satellite manufacturers plants, the trend to use COTS is not to oppose (but to add) to the use of "high reliability" components that are still tested individually (like equipment, etc.) for legacy satellites as they in fine provide a longer guarantee of life, reliability and ultimately prove the quality of the satellite.

h. Company positioning, Europe, World

For historical reasons of technology mastering, space systems manufacturers have almost all kept internally capacities to produce electronics systems for two main reasons: first of all, satellites architecture and payloads are essentially composed of electronics and therefore it is one of their core competencies to manufactures electronics equipment. Secondly, as the majority of spacecraft manufacturers both work for civil and military including sensitive technologies, production on the national territory are required. If spacecraft makers use sub-contractors for their electronics production, they rely on local players. As a consequence, the nationality of the spacecraft platforms tends to indicate precisely places of production of the its electronics systems.

Major spacecraft manufacturers

Company	Nationality	Turnover 2017 (in billion euros)	Main production locations
Thales Alenia Space	France-Italy	2.2	14 industrial sites: • Toulouse (Fra – HQ) • Cannes (Fra – Operationnal HQ) • Colombes (Fra) • Rome (Ita) • L'Aquila (Ita) • Rome (Ita) • Turin (Ita) • Madrid (Esp) • Charleroi (Bel – electronics equipment for Ariane rockets) • Stuttgart (Ger – Ground equipment) • Harwell (UK – propulsion systems) • Bristol (UK) • Zurich (Switz. - optoelectronics) • Warsaw (Pol) • Cupertino (USA)
Airbus Space	Fra-Ger-Spa-Ita	-	• Airbus' satellite business is managed from a large site in the southeast area of Toulouse (Fra), where the company develops, assembles, integrates and tests satellite systems for a whole range of applications including Earth observation, meteorology, science and telecommunications. • Airbus employees in Ottobrunn/Taufkirchen, near Munich (Ger), produce solar panels for satellites, as well as design, develop and manufacture rocket engines and thrust chambers for the Ariane 5 commercial launch vehicle. • Bremen (Ger) is a centre of competence for space transportation, manned space flight and space robotics. • Airbus engineers in Friedrichshafen (Ger) are currently developing the second generation of MetOp weather satellites, which will be launched from 2021 • The Barajas and Tres Cantos sites in the Madrid (Spa) region carry out work for most European space programmes, such as: the Ariane 5 and Ariane 6 commercial launch vehicles, the Copernicus Earth observation platforms and the Galileo satellite navigation constellation. • A total of 4,000 people based in Portsmouth and Stevenage support the UK's military satellite communications services to the country's armed forces, including mobile voice, video, internet and broadcast communications.
Orbital ATK*	USA	1.1	• Dulles (VA – USA)
OHB	Germany	0.66	• Bremen & Oberpfaffenhofen (Germany) • Milan (Italy) • Betzdorf (Luxembourg) • Antwerp (Belgium) • Stockholm (Sweden)
Boeing Space	USA	-	• Huntsville (Alabama – USA - Spacelab, International Space Station, Delta) • El Segundo (California – USA – satellites) • Palmdale (California – USA - Space Shuttle) • Seal Beach (California – USA - Saturn V rocket and Skylab projects) • Huntington Beach (California – USA - Saturn V, X-51A, Apollo, Skylab, Space Shuttle, Delta, and ISS) • New Orleans (Louisiana – USA - S-IC stage) • El Paso (Texas – USA - power and electronics components for ISS)
Lockheed Martin Space	USA	8.0	• Sunnyvale, CA, USA • Denver, CO, USA • Valley Forge, PA, USA • Reading, UK
Surrey Satellite**	UK	-	• 500 people on 2 sites in the UK

Source: DECISION Etudes & Conseil / Company data

*acquired by Northrop Grumman in 2018

** acquired by Airbus (Ex. EADS Astrium) in 2008

F. Figures, Europe 2010-2017, world and main countries

Space electronic equipment production worldwide in million euros & growth

	2012	2013	2014	2015	2016	2017	CAGR 2012-17	CAGR 2017-22
Military space	2 557	2 231	2 626	2 334	2 314	2 444	-0.9%	5.4%
Civil space	6 195	7 222	7 465	7 834	8 090	8 388	6.2%	3.9%
World Total	8 752	9 454	10 092	10 168	10 404	10 832	4.4%	4.2%
Military space	11,9%	-12,7%	17,7%	-11,1%	-0,9%	5,6%	-0.9%	5.4%
Civil space	13,9%	16,6%	3,4%	4,9%	3,3%	3,7%	6.2%	3.9%
World Growth	13,3%	8,0%	6,8%	0,8%	2,3%	4,1%	4.4%	4.2%

Source: DECISION Etudes & Conseil

Space electronic equipment production by region in million euros

	2012	2013	2014	2015	2016	2017	CAGR 2012-17	CAGR 2017-22
Military space	337	168	261	264	195	215	-8.6%	2.5%
Civil space	2 176	2 067	2 460	2 546	2 622	2 622	3.8%	3.1%
Europe Total	2 513	2 236	2 721	2 810	2 818	2 837	2.5%	3.0%
Military space	1 617	1 343	1 584	1 236	1 211	1 253	-5.0%	4.9%
Civil space	2 637	3 560	3 204	3 316	3 366	3 517	5.9%	3.4%
North America Total	4 254	4 902	4 788	4 552	4 577	4 770	2.3%	3.8%
Military space	149	160	157	159	159	159	1.3%	1.8%
Civil space	760	802	866	905	945	993	5.5%	2.0%
Japan Total	909	961	1 022	1 064	1 104	1 152	4.9%	2.0%
Military space	158	200	244	269	312	352	17.4%	10.5%
Civil space	423	542	645	741	804	877	15.7%	8.8%
China Total	581	742	889	1 010	1 116	1 229	16.2%	9.3%
Military space	208	255	267	284	308	330	9.6%	5.7%
Civil space	133	157	178	198	217	237	12.2%	6.5%
Other Asia-Pac. Total	342	412	444	482	525	566	10.6%	6.0%
Military space	88	105	114	124	129	136	9.0%	4.2%
Civil space	65	95	113	127	135	142	16.8%	5.6%
ROW Total	154	200	227	251	264	278	12.6%	4.9%

Source: DECISION Etudes & Conseil

Space electronic equipment production by region in annual growth rates

	2012	2013	2014	2015	2016	2017	CAGR 2012-17	CAGR 2017-22
Military space	-7,0%	-50,0%	55,0%	1,0%	-26,0%	10,0%	-8.6%	2.5%
Civil space	11,0%	-5,0%	19,0%	3,5%	3,0%	0,0%	3.8%	3.1%
Europe Total	8,2%	-11,0%	21,7%	3,3%	0,3%	0,7%	2.5%	3.0%
Military space	18,0%	-17,0%	18,0%	-22,0%	-2,0%	3,5%	-5.0%	4.9%
Civil space	15,0%	35,0%	-10,0%	3,5%	1,5%	4,5%	5.9%	3.4%
North America Total	16,1%	15,2%	-2,3%	-4,9%	0,5%	4,2%	2.3%	3.8%
Military space	-4,5%	7,5%	-2,0%	1,5%	0,0%	0,0%	1.3%	1.8%
Civil space	13,0%	5,5%	8,0%	4,5%	4,5%	5,0%	5.5%	2.0%
Japan Total	9,7%	5,8%	6,3%	4,0%	3,8%	4,3%	4.9%	2.0%
Military space	31,0%	27,0%	22,0%	10,0%	16,0%	13,0%	17.4%	10.5%
Civil space	25,0%	28,0%	19,0%	15,0%	8,5%	9,0%	15.7%	8.8%
China Total	26,6%	27,7%	19,8%	13,6%	10,5%	10,1%	16.2%	9.3%
Military space	8,5%	22,5%	4,5%	6,5%	8,5%	7,0%	9.6%	5.7%
Civil space	26,0%	17,5%	13,5%	11,5%	9,5%	9,0%	12.2%	6.5%
Other Asia-Pac Total	14,7%	20,5%	7,9%	8,5%	8,9%	7,8%	10.6%	6.0%
Military space	5,5%	19,5%	8,0%	8,5%	4,5%	5,0%	9.0%	4.2%
Civil space	-7,0%	45,0%	19,0%	12,5%	6,0%	5,5%	16.8%	5.6%
ROW Total	-0,2%	30,4%	13,2%	10,5%	5,3%	5,3%	12.6%	4.9%
World Total	13,3%	8,0%	6,8%	0,8%	2,3%	4,1%	4.4%	4.2%

Source: DECISION Etudes & Conseil

Over the past five years, the world production of space electronics equipment grew on yearly average at 4.4%. The European production grew at a mere 2.5%, a performance slightly above the growth of the North American region.

Despite a decrease in the size of the satellites brought by the constellations that causes a reduction in the amount of on-board electronic equipment, the volume of business brought by these new businesses, overall, the production of space electronics tends to increase.

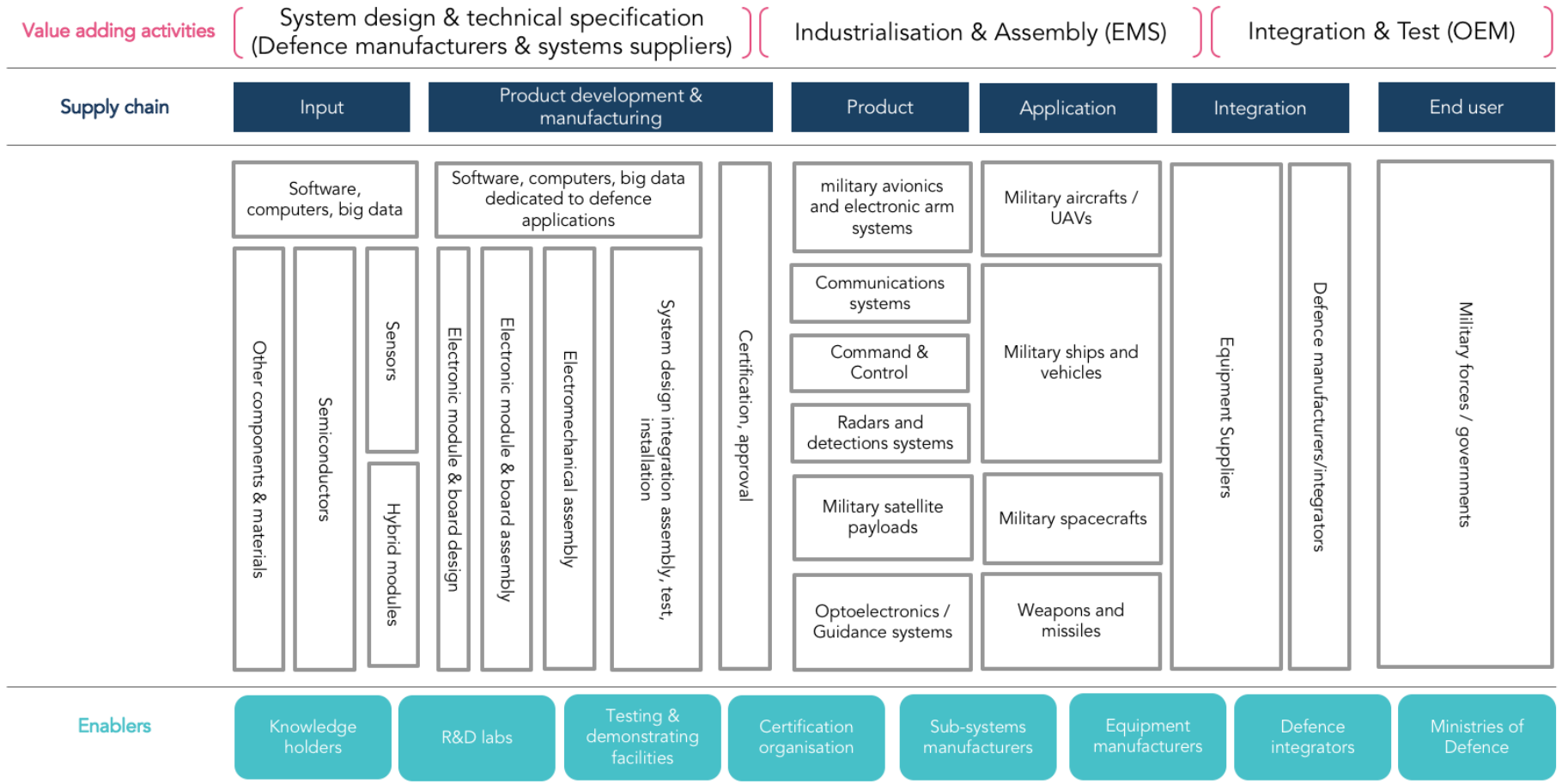
1.1.9 Defense

iii. Value Chain description, scope, subsegmentation

The defence equipment value chain encompasses a large scope of products ranging from terrestrial vehicles (like tanks, armored-vehicles), to naval shipbuilding (aircraft-carriers, submarines, etc.), combat aircraft (jet fighters, military helicopters, etc) and missiles (from inter-ballistic missiles to portable rocket-launchers). The following chapter aims at analyzing the electronic content embedded into these equipments. As no statistics cover the defence electronics segment, estimates from DECISION based on a close study of defence budgets worldwide and major defence equipment supplier's business activities. The following breakdown into three categories will be carried out:

- Military communications and naval & ground systems gathering all defence and government dedicated communication systems: tactical, mobile, all ground civil & military government radar & air traffic management or surveillance, all communication, commandment & electronic defence systems for combat or support ships and submarines;
- Missiles electronics, which encompasses embedded missile electronics (without launchers, pads, etc.)
- Military airborne systems taking into account fire & arms systems, cockpit electronics, navigation instruments, communications and other aircraft embedded systems.

Defence electronics value chain



Source: DECISION Etudes & Conseil

iv. Evolution of defense expenditure worldwide

Military expenditure* by region in constant US dollars in 2017

Rank		2010 Spending ($ billion)	2017 Spending ($ billion)	Change (growth over 2016)	Share of total (%)
1	**Americas**	**841**	**676**	**0.0%**	**40%**
	North America	785	617		
	(incl. USA)	*769*	*600*		*35%*
	South America	49.5	51.5		
	Central America	6.3	7.3		
2	**Asia and Oceania**	**340**	**469**	**3.6%**	**27%**
	East Asia	224	322		19%
	Central & South Asia	62.7	77.8		
	South East Asia	30.9	40.5		
	Oceania	23.5	28.4		
3	**Europe**	**322**	**327**	**-2.2%**	**20%**
	Western Europe	256	243		14%
	Central Europe	17.9	23.1		
	Eastern Europe	48.2	61.5		
4	**Middle-East**	**148**	**178**	**-**	**10.5%**
5	**Africa**	**33.2**	**38.7**	**-0.5%**	**2.5%**
	Sub-Saharan Africa	21.8	19.1		
	North Africa	11.4	19.6		
	World Total	**1,684**	**1,693**		**100%**

Source: SIPRI
** Equipment and all other Defence expenditure (retirement pensions, foreign operations spending, etc.)*

In 2017, with 600 billion USD of expenditure, the US military budget still accounted for around 35% of worldwide defence spending. As a consequence, military production and markets are heavily driven by US government contracts and, therefore, by US foreign policy. However, with troops withdrawn from Iraq and subsequent austerity measures imposed in North America, US military had to tighten their belts decreasing from 785 billion USD in 2010 to 600 in 2017.

Europe, the third major Defence-spending region, coped with harsh budgetary cuts. Although the general trend is to reduce personnel costs before equipment procurement, Europe's equipment providers did not escape the budgetary restrictions. According to the SIPRI Institute, European military budgets represented 20% of total worldwide (compared to 23% in 2012) remained steady over the 2010-2017 period with a light decrease of 2.2% over 2016 to achieve 327 billion USD.

On the other hand, military expenditure literally boomed in Asia driven by strong augmentation of East Asian (especially Chinese) spending from 224 to 322 billion USD. Asia and Oceania strengthened their position of second largest spending region in defence budget.

The ten countries with the largest Defence expenditure accounted for nearly 75% of this total are the USA, China, Saudi Arabia, Russia, India, France, the UK, Japan, Germany and South Korea.

With 610 billion USD spent in 2017, US military budget is nearly three times as much as China's one, which was the second highest in 2017 with around 230 billion USD.

Table - The main importers and exporters of Defence equipment, 2013 - 2017

Rank	Exporter	Global Share	Importer	Global Share
1	USA	34%	India	12%
2	Russia	22%	Saudi Arabia	10%
3	France	6.7%	Egypt	4.5%
4	Germany	5.8%	UAE	4.4%
5	China	5.7%	China	4.0%
6	UK	4.8%	Australia	3.8%
7	Spain	2.9%	Algeria	3.7%
8	Israel	2.9%	Iraq	3.4%
9	Italy	2.5%	Pakistan	2.8%
10	The Netherlands	2.1%	Indonesia	2.8%

Source: SIPRI

The volume of international transfers of major weapons rose by 10 per cent between 2008 and 2012 as well as between 2013 and 2017. In 2017, among the top ten Defence equipment exporters, six countries out of ten were European for a combined global share of almost 25% ranking Europe as the second highest Defence equipment seller in the world behind the US (34%) and in front of Russia (22%).

Less concentrated than exporters, importers from emerging countries appear to be large consumers of defence equipment and import a significant share from the USA, Europe or Russia. In turn, exports for these regions help to offset slowdowns or losses in revenues caused by reduced domestic procurement. They are a significant source of revenue for US and European companies and a field of fierce competition as in addition to extend their arsenals in volume, emerging countries also want to shift to the latest technological equipment entailing complex production agreements.

Table - Equipment Procurement Spending of European Countries (in billion euros)

	2013	2014	2015	2016	2017
France	16 600	16 400	16 700	17 000	17 300
United-Kingdom	13 806	14 811	14 880	14 865	15 130
Germany	7 682	6 180	6 037	5 420	6 011
Italy	3 395	3 220	2 373	2 176	2 141

Source: National Ministries of Defence

Table - Top 20 arms-producing and military services companies in the world (excluding China) in 2012 and 2016

Rank	Company	Country	2012 sales ($billion)	2016 sales ($billion)	% of Defence sales (2016)	Total employment (2016)
1	Lockheed-Martin		36.0	40.8	86%	97,000
2	Boeing		27.6	29.5	31%	150,500
3	Raytheon		26.9	22.9	95%	63,000
4	BAE Systems		22.5	22.8	95%	83,000
5	Northrop Grumman		19.4	21.4	87%	67,000
6	General Dynamics		20.9	19.2	61%	98,800
7	Airbus Group		15.4	12.5	17%	134,000
S*	BAE Systems Inc.		-	9.3	93%	29,500
8	L-3 Communications		10.8	8.9	85%	38,000
9	Leonardo (Ex. Finmeccanica)		12.5	8.5	64%	45,600
10	Thales		8.9	8.2	50%	64,100
11	UTC		13.5	6.9	12%	-
12	Huntington Ingalls Industries		6.4	6.7	95%	37,000
13	UAC		4.4	5.2	83%	-
14	Bechtel Corp.		-	4.9	-	53,000
15	Textron		-	4.8	35%	36,000
S	Pratt & Whitney**		-	4.5	30%	35,000
16	Rolls-Royce		5.0	4.5	24%	50,000
17	Leidos		7.8	4.3	61%	32,000
18	Harris Corp.		-	4.2	71%	17,000
19	United Shipbuilding Corp.		-	4.0	90%	90,000
20	Booz Allen Hamilton		-	4.0	69%	23,300

* Subsidiary of BAE System

** Subsidiary of UTC

Source: SIPRI, Figures are in US$, at constant prices and exchange rates

Table - Top 21 to 40 arms-producing and military services companies in the world (excluding China) in 2012 and 2016

Rank	Company	Country	2012 sales ($billion)	2016 sales ($billion)	% of Defence sales (2016)	Total employment (2016)
21	Mitsubishi Heavy Industries		-	3.7	10%	-
22	Honeywell		5.1	3.5	9%	-
23	Naval Group (Ex. DCNS)		-	3.5	99%	12,800
24	Almaz-Antei		5.5	3.4	92%	125,000
25	MBDA		-	3.3	98%	10,340
26	Rheinmetall		-	3.3	52%	21,000
27	Elbit Systems		-	3.1	95%	-
28	Babcock International		-	3.0	48%	35,000
29	Russian Helicopters		-	2.9	91%	-
30	Saab		-	2.8	83%	15,500
31	SAIC		-	2.6	59%	15,500
32	Israel Aerospace Industries		-	2.6	73%	-
S	Sandia		-	2.6	85%	12,200
33	Safran		5.3	2.6	14%	62,500
34	CACI International		-	2.5	68%	19,900
35	Tactical Missiles Corp.		-	2.5	98%	50,600
36	General Electric		4.1	2.5	2%	295,000
37	Hindustan Aeronautics		-	2.4	92%	-
38	AECOM		-	2.3	13%	87,000
39	CSRA		-	2.3	45%	18,500
40	Indian Ordnance Factories		-	2.2	98%	85,900

* Subsidiary of Lockheed Martin

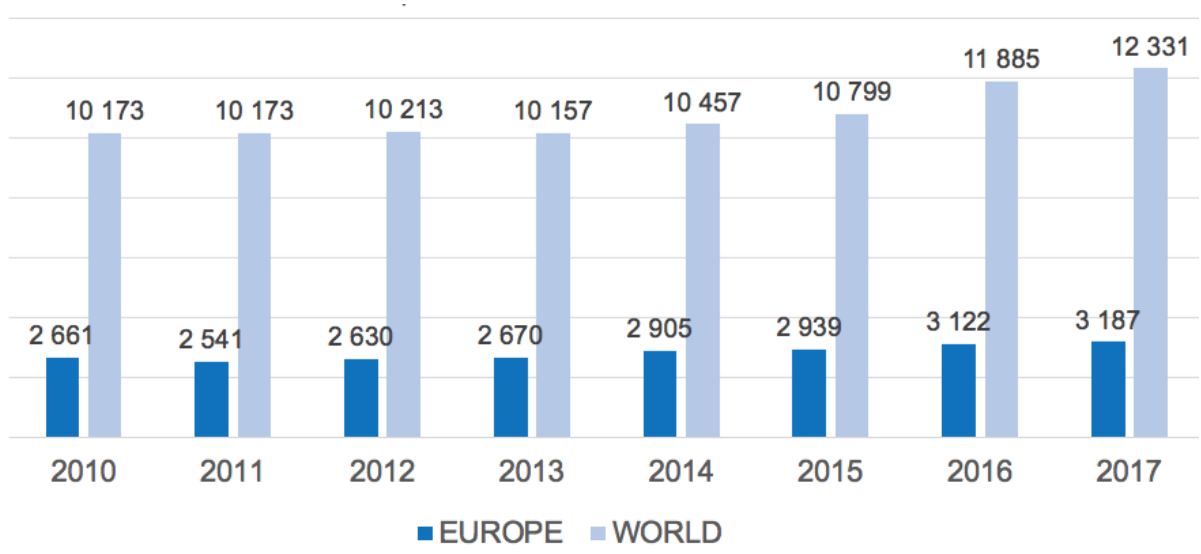
Source: *SIPRI, Figures are in US$, at constant prices and exchange rates*

These defence budgets include all the military spending necessary to run an army, from personnel costs (wages, retirement pensions, etc) to equipment procurement. However in these budgets only the part concerning equipment procurement is relevant to analyse and to forecast the evolution of defence electronic equipment. Besides, according to the different national defence equipment procurement policies, the various sub-segment budgets (i.e. military airborne, naval/ground systems and missiles) can experience different evolutions. As the defence procurement budget of the United-States is the biggest in the world, the following texts will primarily focus on the military equipment expenditure/programmes of this region.

v. Military Airborne electronic systems

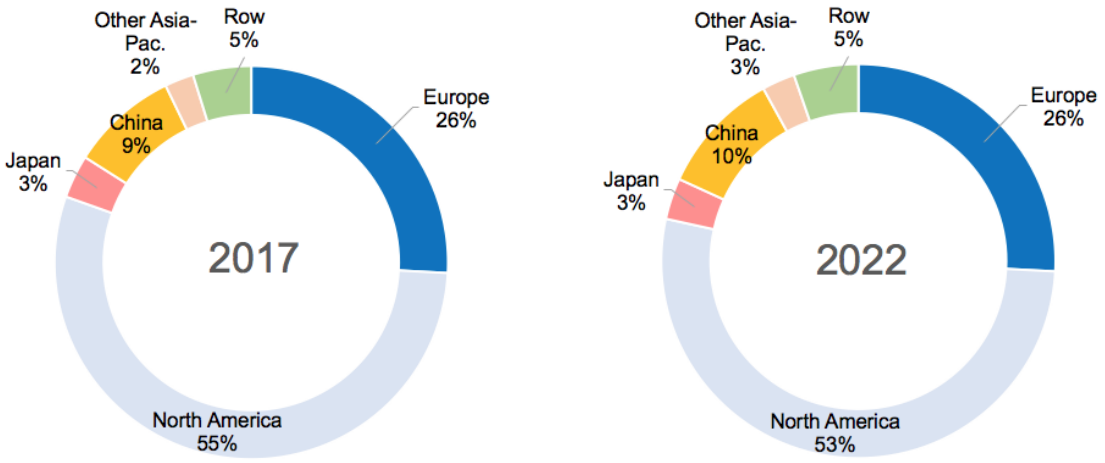
Globally, the electronic content of military aircraft represented a worldwide production and market of 12.3 billion euros in 2017, of which American production supplied 6.7 billion euros (55%) and European production 3.2 billion euros (26%).

Military airborne electronics equipment production worldwide and in Europe from 2010 to 2017 (in billion euros)



Source: DECISION Etudes & Conseil

Military airborne electronics equipment production breakdown by region in 2017 and 2022



Source: DECISION Etudes & Conseil

G. The US

With $27 billion in 2017 (compared to $35 billion in 2012), the procurement budget for aeronautic equipment is the largest segment of US Department of Defence (DoD) purchases. In 2017, it declined by 11%, a negative trend which followed a sharp boom of +33% in 2016 but which should continue to decrease in 2018 (-11%).

Table - Top 10 US Aircraft Procurement programmes spending (in billion USD)

Rank		FY 2016	FY 2017	% Change 2016	% Change 2017
1	F-35 JSF	9,877	9,173	41%	-7%
2	KC-46A Tanker	2,404	2,890	53%	20%
3	UAV (all MQ and RQ programs)	2,357	2,108	69%	-11%
4	P-8A Poseidon	3,229	1,983	49%	-39%
5	V-22 Osprey	1,505	1,658	-4%	10%
6	C-130 Hercules	2,426	1,409	58%	-42%
7	AH-64 Apache	1,353	1,299	20%	-4%
8	UH-60 Black Hawk	1,702	1,259	16%	-26%
9	F/A-18 E/F Super Hornet	350	1,147	-	228%
10	E-2 Advanced Hawkeye	1,032	1,036	-9%	0%
	Total	**29,971**	**26,820**	**33%**	**-11%**

Source: DECISION / US DoD

Table - US DoD procurement budget evolution for Aircraft programs from FY 2010 to FY 2017 (in billion USD)

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Total	**32,514**	**36,925**	**34,882**	**32,264**	**28,754**	**22,496**	**29,971**	**26,820**
Growth	19.8%	13.6%	-5.5%	-10.4%	-8.0%	-21.8%	33.2%	-10.5%

Source: DECISION / US DoD

From 2010 to 20017, the US aircraft procurement budget experienced hectic variations year-on-year but globally declined. The explanations of such a decrease are:

- The US aeronautic equipment procurement budget is driven by a major programme: the F-35 manufactured by Lockheed-Martin.
  The F-35 Joint Strike Fighter (JSF) has benefited from the slowdown of the F-22's budget to become the first US aircraft programme in 2012 in terms of procurement spending. The JSF has attracted contributions from military budgets in many countries outside the USA, and in particular from European countries such as the United Kingdom (BAE Systems for the avionics and Rolls-Royce/GE for engines) as well as Italy and the Netherlands. All these countries are of course committed to purchase the plane.

However, just like the F-22, the JSF programme has suffered from development problems, especially the vertical take-off and landing variant (F-35 B) made for US Marines. In addition, the skyrocketing costs transformed the F-35 programme into the biggest and most expensive acquisition programme ever made (more than 1,100 billion USD). As a consequence, original plan to acquire 3,000 jets has been reduced to a target of 2,500 which could be set at 2,000.

With 9.2 billion USD of procurement in 2012, the F-35 programme accounted for almost 34% of the whole DoD aeronautic procurement budget in 2017 (compared to 20% in FY 2012).

- Pentagon's spending on UAVs (Unmanned Aerial Vehicles) after having experienced a strong growth in 2010 (+61%) and in 2011 (+27%), it sharply declines in 2013 (-28%) and in 2014 (-38%). However, spending for such equipment increased in 2015 by 5% and then boomed in 2016 (+69%).
  Globally, these products require a high share of incorporated electronics and also need to be controlled by specific base stations, which can be remotely located and entail the use of control systems, GPS localisation systems, etc.
  These platforms will be more and more generalised in the future and their number should increase in all air armies.

Several programmes are also dedicated to the upgrade of existing aircraft such as the: E/A-18G, MH-60R/S, F/A-18E/F, AH-64, E-2C and C-5, which consist of removing the avionics, adapting electronics systems to new weapons, etc. Indeed, with a legacy fleet of more than 500 F-15s and thousands of F-18s and with the objective of maintaining the ability to penetrate sophisticated air defence, low-cost solutions consist in up-grading these aircraft with design improvements to reduce the radar signature (F-15 Silent Eagle). Digital Electronic Warfare Systems (DEWS) comprising Active Electronically Scanned Array radar (AESA) and emitters for jamming and electronic attack could also be fitted to the aircraft.

In spite of US domination, Europe is also a major player regarding both production and market. Indeed, the Eurofighter Typhoon, the Dassault Rafale and the Saab Gripen are all fourth-generation jet fighters that are in competition with their US and Russian equivalents and the turboprop airlift platform, the Airbus A400M is a credible alternative to the American-made jet-engine C-17 but also to the ageing C-130 Hercules, which is still ranked as the 3rd most procured aircraft by the US.

On the demand side, three out of the ten largest defence-spending nations are European and as in the US, the economic downturn in 2011 had a deep impact on defence acquisition plans in 2012-2017 period.

H. France

In 2017, if total French defence equipment procurement increased by 1.8% to 17.3 billion Euro, the Loi de Programmation Militaire for the period 2014-2019 adopted by French parliament in late 2013 planned a constant drop in aircraft procurement (2% on average). The French Air Force did not escape these budgetary constraints, but the 2010-2017 period was marked by the purchase of equipment of strategic importance for France including the upgrade of Mirage 2000D aircraft and the replacement of the current inflight refuelling fleet by the new Airbus A330 MRTT, whose first delivery occured in 2018. In early 2014, the French Ministry of Defence signed a contract with Dassault to develop a new standard for the Rafale (FR3). The main changes relate to the integration of future air-to-air Meteor missile, the new generation of laser designation pod and laser-guided version of the modular air-to-ground weapons (AASM). The first Rafale equipped with its new weapon systems is expected in 2018. This contract demonstrated how strategic the Rafale is to the French army, but also to the companies that manufacture it or supply its equipment, so as to maintain their precious technological capabilities.

After several without export success, the Rafale was adopted by Indian, Egyptian and Qatari air forces. The Indian contract for 36 Multi-role medium fighter aircraft was valued at 8 billion USD with first deliveries planned in 2019. Despite the fact that the Indian authorities are eager to produce as many parts as possible in India, the vast majority of the Rafale's electronic equipment should still be manufactured in France mainly for strategic reasons. The signature of the Indian contract should bring a brighter future to Dassault and the French military airborne electronics industry (Thales, etc.).

Combined with the Egyptian and Qatari contract for respectively 24 and 36 Rafale ordered, the impact on the production should only occur in 2018 (12 deliveries compared to steady 8 to 9 deliveries in the previous years) with a doubling production rate in 2019 and 2020 (to deliver 24 units each year).

I. The UK

Table - UK Aircraft equipment procurement budget 2012 – 2017 (in billion £)

	2012	2013	2014	2015	2016	2017
Combat Air	1,190	820	900	1,075	1,050	1,025
Air Support	450	800	760	730	620	430
Helicopters	580	620	490	360	195	205
Total	**2,220**	**2,240**	**2,150**	**2,165**	**1,865**	**1,660**

Source: DECISION based on The Defence Equipment Plan

The UK's military equipment procurement budget for aircrafts dropped significantly from 2012 to 2017 but is planned to grow constantly after that. In 2016-2017:

- In Combat Air: the RAF took delivery of five Eurofighter Typhoon fighters and five F-35;
- In Air Support: the RAF took delivery of its 14th and last Airbus A330 Voyager aerial tanker/ transport and received 8 Airbus A400M;
- In Helicopters: refurbishing and upgrading Chinook helicopters and Airbus Helicopters (ex-Eurocopter) AS330 Puma medium transports.

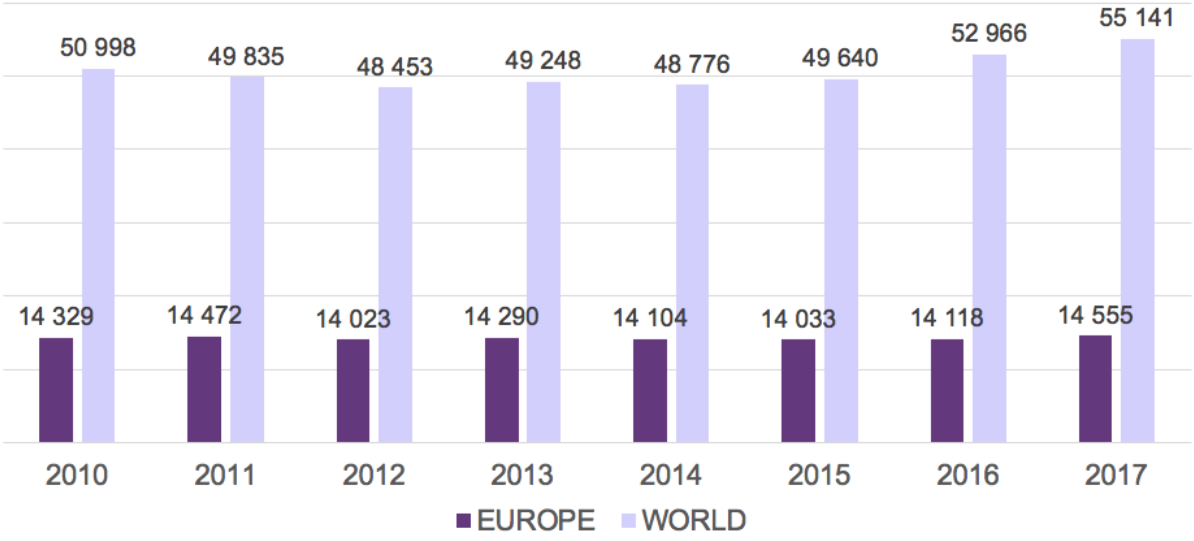
All the major defence-spending European countries underwent severe budgetary constraints over the past years and the future of numerous military programmes developed by Europe will have a future only if they succeed in finding export outlets. Like the Rafale, the production of Eurofighter could be put trickle down to a near stop. In early 2014, the Saudi Arabian Kingdom, which is the main foreign customer of the Typhoon, confirmed an additional order of 48 planes, which would partially compensate the slash of 24 Typhoon for the UK and of 37 Typhoon for Germany.

Outside the USA and Europe, Russia is the third major player for military aircraft able to provide complete solutions (i.e. a combat aircraft with its weapon systems and its missiles). On the export market, Russia chiefly offers modernised versions of its Sukhoi Su-27 (as well as its derivatives like the Su-30) to countries like China, India, Malaysia, etc.

China, on its side, who has heavily relied on Russian technologies and imports to develop its own solutions (like the Chengdu J-7), has recently launched numerous national military aviation programmes like the conventional J-10 or the more advanced and stealth J-20. Thanks to massive financial support, China is progressively bridging its technological handicap as its aircraft already found export outlets like Pakistan for the J-10.

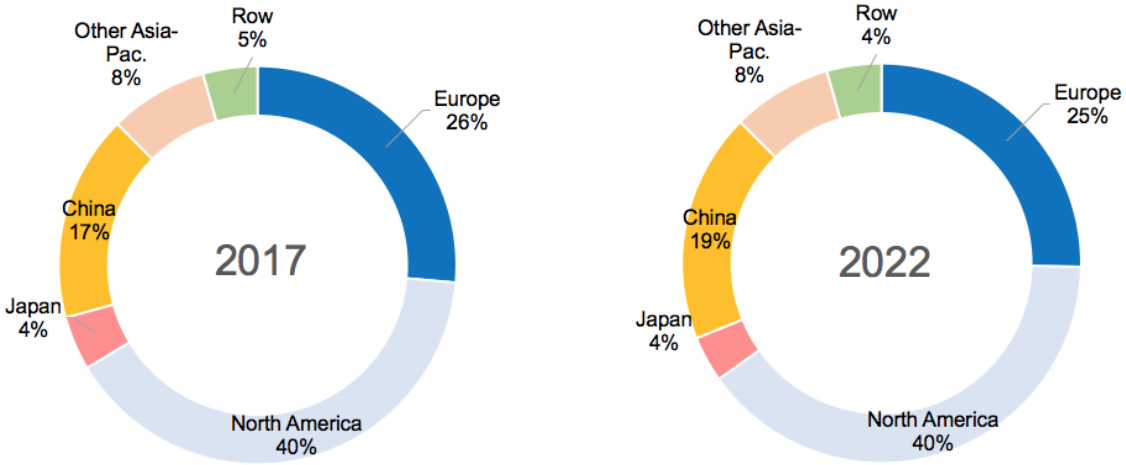
vi. Military communications and naval & ground systems

Table - Military communications and naval & ground systems electronics equipment production worldwide and in Europe from 2010 to 2017 (in million euros)



Source: DECISION Etudes & Conseil

Military communications and naval & ground systems equipment production breakdown by region in 2017 and 2022



Source: DECISION Etudes & Conseil

Globally, the electronic content of military communications and ground & naval systems represented a worldwide production and market of 55.1 billion euros in 2017, of which American production supplied 22 billion euros (40%) and European production 14.6 billion euros (26%).

American production accounts for a large share of the defence equipment markets, both for platforms and for electronic systems. The American Department of Defence (DoD) procurement budgets show the evolution of the American market, and American production also supplies a large share of foreign markets through exports.

Table - US DoD procurement budget evolution for communications, ground and naval systems from FY 2010 to FY 2017

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Ground Systems	**12,207**	**8,541**	**6,302**	**5,130**	**3,524**	**2,056**	**3,089**	**3,467**
	-8,5 %	62,2 %	-10,6 %	-5,0 %	1,3 %	-6,3 %	25,5 %	11,0 %
Shipbuilding	**14,544**	**16,731**	**15,976**	**15,461**	**13,329**	**13,335**	**15,414**	**16,346**
	9,6 %	15,0 %	-4,5 %	-3,2 %	-13,8 %	0,0 %	15,6 %	6,0 %
Total	**26,751**	**25,272**	**22,008**	**20,591**	**16 853**	**15 391**	**18 502**	**19 813**
	0,4 %	-5,5 %	-12,9 %	-6,4 %	-18,2 %	-8,7 %	20,2 %	7,1 %

Source: DECISION Etudes & Conseil / US DoD

From 2010 to 2017, the DoD requested a procurement budget in military communications, naval & ground systems in sharp decline. This decrease was mainly due to higher reduction of ground systems procurement, whose procurement budget was divided by almost four compared, which was not offset by an increase in marine systems.

i. Ground systems and C4

Ground systems encompass several product families: all kind of military vehicles (from tanks like the Abrams to light combat vehicles like the Stryker) but also C4 (Command, Control, Communications, Computers and Intelligence) systems.

Top 5 US Ground systems Procurement programmes spendings (in million USD)

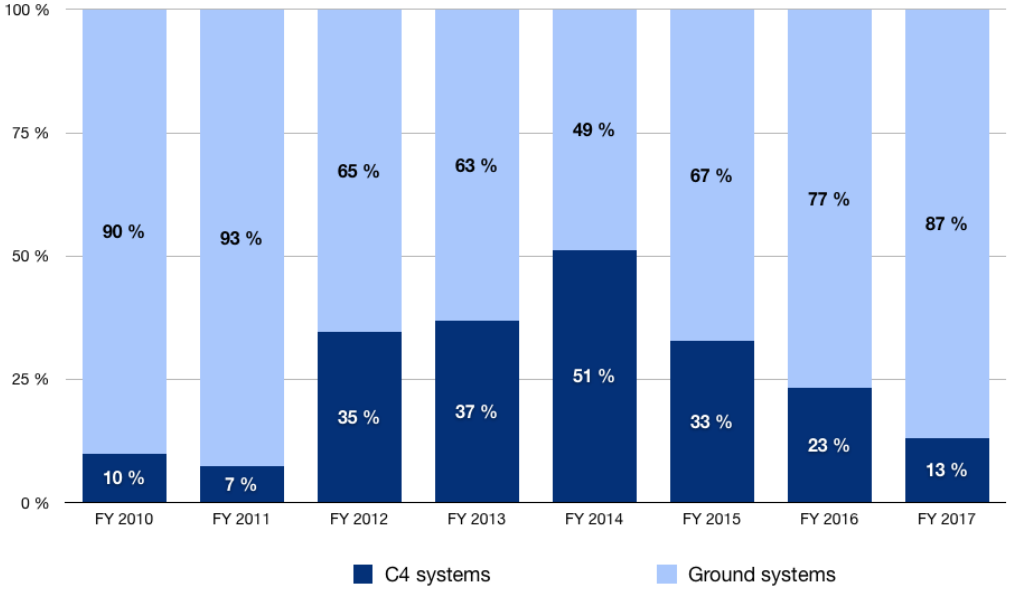
Rank		FY 2016	FY 2017	% Change 2016	% Change 2017
1	Abrams Tank	431	769	82%	78%
2	Joint Light Tactical Vehicle (Remplace les HMMWV)	374	710	67%	90%
3	M109 Paladin Integrated Management (PIM)	274	584	11%	113%
4	Stryker Family of Armored Vehicles	978	573	125%	-41%
5	Warfighter Information Network – Tactical	735	457	6%	-38%
	Total of all ground programs	**3,153**	**3,485**	**50%**	**11%**

Source: DECISION Etudes & Conseil / US DoD

From 2010 to 2017, procurement of ground vehicles (Abrams tanks, Stryker vehicles, etc) by the DoD was divided by four from $12 billion in 2010 to $3.5 billion in 2017. This downward trend had an impact on the overall production of defence electronics. However, since land vehicles are not the ground systems that incorporate the most electronic equipment, this tendency was partly offset by increasing amounts spend to purchase C4 systems (Command, Control, Communications & Computer systems), which comprise a large share of electronic equipment.

Indeed, from 2011 to 2014, expenditure by the DoD for C4 systems more than tripled (from $631 million to $1.8 billion) to account for more than 50% of ground systems equipment. However, since 2015, C4 systems procurement have decreased while spending for other ground systems have been multiplied by almost two.

Evolution of The Share Of C4 Systems In The DoD Total Ground Systems Procurement



Source: DECISION Études & Conseil / US DoD

j. Naval systems

DoD shipbuilding purchases went up in 2017 compared to 2010 figure. After a downward trend from 2011 to 2014, procurement increased till 2017 to reach 16.4 billion USD.

Top 5 US shipbuilding Procurement programmes spending (in million USD)

Rank		FY 2016	FY 2017	% Change 2016	% Change 2017
1	Virginia Class Submarine	5,425	5,191	-9%	-4%
2	AEGIS Destroyer	4,267	3,745	45%	-12%
3	Ford Class Aircraft Carrier	2,655	2,633	45%	-12%
4	CVN Refueling Complex Overhaul	673	1,932	25%	187%
5	Littoral Combat Ship	-	1,871	-	-
	Total of all shipbuilding programs	**15,414**	**16,346**	**16%**	**6%**

Source: DECISION / US DoD

As a consequence, production of electronics equipment in North America linked to these defence products did not perform well over the 2012 – 2017 period with a compound annual growth rate of 0.8% (compared with 2.6% at the worldwide level).

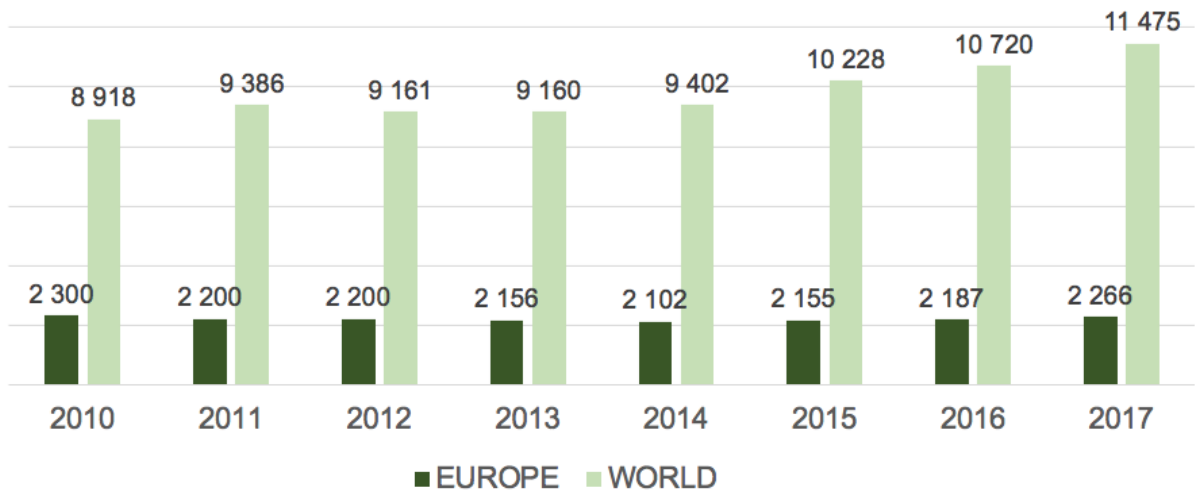
Other regions suffered from differing trends. In Europe defence electronics production experienced a similar trend with a compound annual growth rate of 0.7% between 2012 and 2017.

On the other hand, China has increased its shipbuilding capacity and capability for all types of military projects: submarines, surface warships, naval aviation, aircraft carriers, etc. Modular shipbuilding techniques will allow China to spread production across multiple locations, increasing both efficiency and output. China has already demonstrated an ability to surge submarine and amphibious production.

Nevertheless, even if the country displays its resolution to rely less and less on foreign suppliers to develop and promote its home-made technology instead, Chinese defence production continues to depend on foreign equipment for some propulsion units and to a lesser degree for fire control systems, cruise missiles, surface-to-air missiles, torpedo systems, sensors, and other advanced electronics.

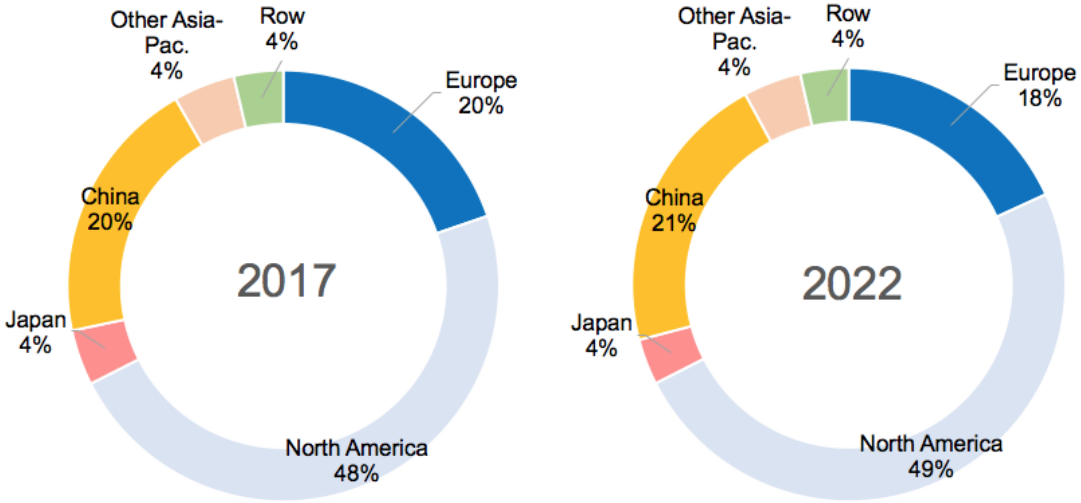
vii. Missile electronics

Chart - Missile electronics equipment production worldwide and in Europe from 2010 to 2017 (in million euros)



Source: DECISION Etudes & Conseil

Missile electronics production breakdown by region in 2017 and 2022



Source: DECISION Etudes & Conseil

viii. Europe and World production 2012 – 2017 by region

Defence electronic equipment production worldwide in million euros & growth

	2012	2013	2014	2015	2016	2017	CAGR 2012-17	CAGR 2017-22
Military communication, ground & naval detection systems	48 453	49 248	48 776	49 640	52 966	55 141	*2,6%*	*5,3%*
Missile electronics	9 161	9 160	9 402	10 228	10 720	11 475	*4,6%*	*5,7%*
World Total	**57 614**	**58 408**	**58 178**	**59 868**	**63 686**	**66 616**	***2,9%***	***5,3%***
Military communication, ground & naval detection systems	*-2,8%*	*1,6%*	*-1,0%*	*1,8%*	*6,7%*	*4,1%*	*2,6%*	*5,3%*
Missile electronics	*-2,4%*	*0,0%*	*2,6%*	*8,8%*	*4,8%*	*7,0%*	*4,6%*	*5,7%*
World Growth	***-2,7%***	***1,4%***	***-0,4%***	***2,9%***	***6,4%***	***4,6%***	***2,9%***	***5,3%***

Source: DECISION Etudes & Conseil

Defence electronic equipment production by region in million euros & growth

	2012	2013	2014	2015	2016	2017	CAGR 2012-17	CAGR 2017-22
Military communication, ground & naval detection systems	14 023	14 290	14 104	14 033	14 118	14 555	*0,7%*	*4,4%*
Missile electronics	2 200	2 156	2 102	2 155	2 187	2 266	*0,6%*	*4,0%*
Europe Total	**16 223**	**16 446**	**16 206**	**16 188**	**16 305**	**16 821**	***0,7%***	***4,3%***
Military communication, ground & naval detection systems	21 225	20 589	19 189	18 805	21 061	22 051	*0,8%*	*5,2%*
Missile electronics	4 305	4 111	4 206	4 736	4 996	5 481	*4,9%*	*6,4%*
North America Total	**25 531**	**24 700**	**23 395**	**23 541**	**26 058**	**27 532**	***1,5%***	***5,4%***
Military communication, ground & naval detection systems	2 130	2 364	2 305	2 358	2 391	2 415	*2,5%*	*1,9%*
Missile electronics	449	488	464	475	477	478	*1,3%*	*1,6%*
Japan Total	**2 578**	**2 852**	**2 769**	**2 833**	**2 868**	**2 893**	***2,3%***	***1,8%***
Military communication, ground & naval detection systems	5 623	6 354	7 383	8 166	8 803	9 261	*10,5%*	*7,4%*
Missile electronics	1 430	1 599	1 800	1 977	2 137	2 297	*9,9%*	*6,9%*
China Total	**7 053**	**7 953**	**9 184**	**10 143**	**10 940**	**11 558**	***10,4%***	***7,3%***
Military communication, ground & naval detection systems	3 617	3 743	3 837	4 078	4 205	4 415	*4,1%*	*5,5%*
Missile electronics	451	465	477	501	510	529	*3,2%*	*4,4%*
Other Asia-Pac. Total	**4 067**	**4 208**	**4 314**	**4 580**	**4 715**	**4 944**	***4,0%***	***5,4%***
Military communication, ground & naval detection systems	1 835	1 909	1 959	2 199	2 389	2 444	*5,9%*	*5,2%*
Missile electronics	326	341	353	384	412	424	*5,4%*	*5,2%*
ROW Total	**2 161**	**2 250**	**2 311**	**2 583**	**2 801**	**2 867**	***5,8%***	***5,2%***

Source: DECISION Etudes & Conseil

Defence electronic equipment production by region in annual growth rates

	2012	2013	2014	2015	2016	2017	CAGR 2012-17	CAGR 2017-22
Military communication, ground & naval detection systems	*-3,1%*	*1,9%*	*-1,3%*	*-0,5%*	*0,6%*	*3,1%*	*0,7%*	*4,4%*
Missile electronics	*0,0%*	*-2,0%*	*-2,5%*	*2,5%*	*1,5%*	*3,6%*	*0,6%*	*4,0%*
Europe Total	***-2,7%***	***1,4%***	***-1,5%***	***-0,1%***	***0,7%***	***3,2%***	***0,7%***	***4,3%***
Military communication, ground & naval detection systems	*-7,0%*	*-3,0%*	*-6,8%*	*-2,0%*	*12,0%*	*4,7%*	*0,8%*	*5,2%*
Missile electronics	*-8,5%*	*-4,5%*	*2,3%*	*12,6%*	*5,5%*	*9,7%*	*4,9%*	*6,4%*
North America Total	***-7,3%***	***-3,3%***	***-5,3%***	***0,6%***	***10,7%***	***5,7%***	***1,5%***	***5,4%***
Military communication, ground & naval detection systems	*-8,2%*	*9,0%*	*2,0%*	*-5,5%*	*4,5%*	*-3,0%*	*2,5%*	*1,9%*
Missile electronics	*10,5%*	*4,5%*	*9,5%*	*6,8%*	*1,5%*	*4,0%*	*1,3%*	*1,6%*
Japan Total	***3,1%***	***6,1%***	***6,8%***	***2,6%***	***2,5%***	***1,7%***	***2,3%***	***1,8%***
Military communication, ground & naval detection systems	*12,0%*	*13,0%*	*16,2%*	*10,6%*	*7,8%*	*5,2%*	*10,5%*	*7,4%*
Missile electronics	*14,5%*	*11,8%*	*12,6%*	*9,8%*	*8,1%*	*7,5%*	*9,9%*	*6,9%*
China Total	***12,5%***	***12,8%***	***15,5%***	***10,4%***	***7,9%***	***5,6%***	***10,4%***	***7,3%***
Military communication, ground & naval detection systems	*4,5%*	*3,5%*	*2,5%*	*6,3%*	*3,1%*	*5,0%*	*4,1%*	*5,5%*
Missile electronics	*4,0%*	*3,1%*	*2,6%*	*5,1%*	*1,8%*	*3,6%*	*3,2%*	*4,4%*
Other Asia-Pac Total	***4,4%***	***3,5%***	***2,5%***	***6,2%***	***3,0%***	***4,8%***	***4,0%***	***5,4%***
Military communication, ground & naval detection systems	*4,5%*	*4,0%*	*2,6%*	*12,3%*	*8,6%*	*2,3%*	*5,9%*	*5,2%*
Missile electronics	*5,0%*	*4,5%*	*3,5%*	*8,9%*	*7,3%*	*2,9%*	*5,4%*	*5,2%*
ROW Total	***4,6%***	***4,1%***	***2,7%***	***11,8%***	***8,4%***	***2,4%***	***5,8%***	***5,2%***
World Total	***-2,7%***	***1,4%***	***-0,4%***	***2,9%***	***6,4%***	***4,6%***	***2,9%***	***5,3%***

Source: DECISION Etudes & Conseil

1.1.10 Security

ix. Context - Security, a growing field

The security sector is composed of:

- Physical security products (police, customs and fire brigades' vehicles, coastal surveillance boats, customs aircraft, helicopters, etc.);
- ***Electronic security products*** (CCTV cameras, fire alarms, intrusion alarms, surveillance radars, detection equipments, etc.);
- ***Cybersecurity software and services*** (that is electronic software);
- Private security services (Guarding, CCTV, investigation, etc.).

Below is an overview of the security sector at the global scale and of the EU position:

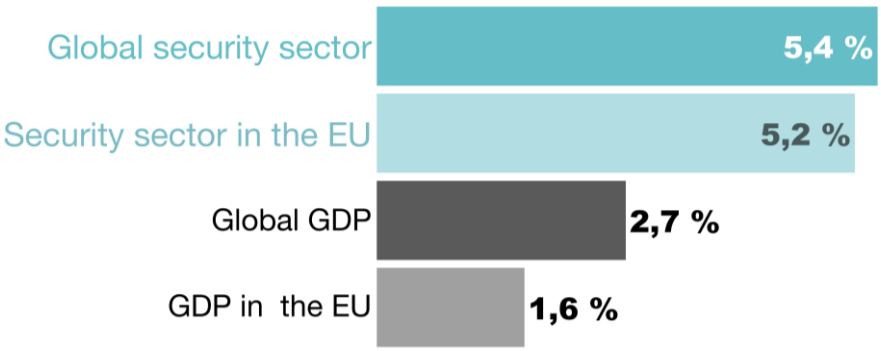
	Global turnover 2016 - B €	Global CAGR 2013-2016	EU turnover 2016 - B €	EU CAGR 2013-2016
Cybersecurity	128	11,8 %	18	12,1 %
Electronic products	189	5,3 %	26	4,4 %
Private security services	196	4,0 %	27	4,7 %
Physical products	242	3,3 %	33	2,5 %
TOTAL Security	755	5,4 %	103	5,2 %

* CAGR = Compound Annual Growth Rate

Source: DECISION Etudes & Conseil

- **Security is currently one of the global industries that generates the highest growth**

Compound annual growth rate 2013-2016



Source: DECISION Etudes & Conseil

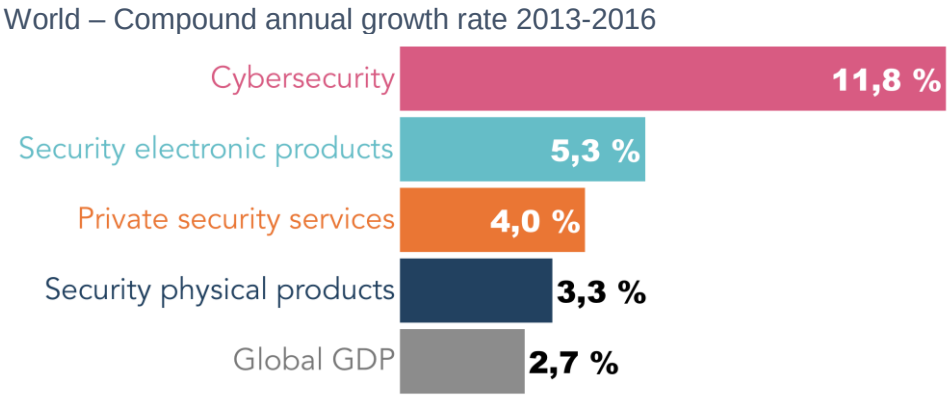
Several trends have emerged between 2013 and 2016 internationally. First of all, at the global level, we estimate that between 2013 and 2016 the market grew at an annual rate of 5.4% driven by growth in all geographical areas. Growing terrorism, increased illegal activity around the world (including cybercrime) and tight government regulations have led to a surge in the adoption or renewal by both governments and individuals of security systems. Other transversal trends such as smart cities, smart grids, etc. have created growth opportunities, particularly in Asia where investments are particularly massive.

From a regional point of view, the world's largest security market is no longer located in the United States but in the rest of the world, particularly in the Asia-Pacific region. In this region, China remains the largest supplier in volume and growth. Explanatory factors include rising internal security spending, growing cybercrime threats, police modernization, replacing and upgrading obsolete security systems, rapid growth of the aviation sector in the region, etc. In addition, the rise of Chinese's Big Brother between 2012 and 2016 transformed China into the world's largest market for video surveillance (50% according to some estimates). The number of public and private security cameras with face recognition installed at the end of 2015 in China was 176 million, this figure is expected to jump to 450 million in 2020. These cameras are made in China by national actors who have become leaders in the past few years at the global scale. In comparison, the United States had 62 million surveillance cameras installed in 2016. The market is further boosted by the Chinese government's security plans and the country's ambitions to become a global leader in artificial intelligence.

Nevertheless, the United States remains a dynamic market and production area whose growth factors have evolved between 2006 and 2016. The market, which was once dominated by the dynamism of the airport security and public infrastructure protection sectors, has since gradually moving towards products and services dedicated to border protection, smart cities and cybersecurity. In addition, the United States holds dominant positions thanks to some of its players in the information and communication technology sectors, whether in terms of services or equipment (Google, Apple, Microsoft, Cisco, IBM, HP, etc.). This comprehensive ecosystem enables them to deploy a global arsenal of solutions and services such as operating systems and associated cybersecurity systems while investing heavily in new technologies such as artificial intelligence, big data cloud computing etc. These solutions could eventually be rivaled by the Chinese whose ambitions of independence in the sector are strong and supported by a huge domestic market in constant development.

Like the United States, the EU can rely on a powerful defense industry (particularly concentrated in France and Italy). In the past, defense technologies and players were the single significant development factors for the security industry in those countries. However, new business opportunities emerge outside the defense world (access control, biometrics, alarms, firefighting, etc.).

- **This high growth is driven by the growth of cybersecurity and the growth of the security electronic products**



Source: DECISION Etudes & Conseil

x. Scope and presentation of the segment and its value chain

J. Scope of the study – Electronics dedicated to security

The three following tables provide a detailed definition of the products included in the segment “electronics dedicated to security”.

Table 1/3 – Definitions of the different segments of electronics dedicated to security

Segments	Definitions
Identification and authentication	Electronic access control systems for buildings or other sites, including smart cards or biometric) and associated physical systems as appropriate
	Other identification, accreditation and authentication devices for persons including biometric (badges, PIN and chip cards, identity cards, passports, etc.)
	Identification and authentication of materials, products and equipment (vehicle recognition, fight against counterfeiting, etc.) - Holography - Hard labels - Security printing chemical and DNA markers - Markers aerosol
Intrusion Detection and Alarm	Intrusion detection systems and alarms (with or without remote monitoring)
Electronic fire safety equipment	Smoke, fire and explosion detection and alarm systems (with or without remote monitoring)
	Electronic fire extinguishing system
Detection and inspection of dangerous or illicit products or concealed persons	Detection equipment for dangerous or illegal products (inspection of persons, baggage, freight). - Portal scanners; - X-ray diffraction; - Camera terahertz; - Tomography; - Spectrometers; - Latent traces analysis; - Gas detectors; - Neutron detector; - Tags; - Etc.
	Concealed people detection equipment
	Specialized detection for CBRNE risks (Chemical, Biological, Radiological, Nuclear, Explosive) or other

Source: DECISION Etudes & Conseil

Table 2/3– Definitions of the different segments of electronics dedicated to security

Segments	Definitions
Observation and surveillance (local)	Video or other surveillance systems including video analysis, with or without remote monitoring, including monitoring of infrastructure or facilities, urban areas, transport nodes, vehicle equipment, etc. - Fixed, deployable or mobile systems; - Integrated systems and control rooms; - Analysis software and data processing (images and others); - Sensors: visible and IR cameras, intensifying light, radars, lidars, acoustic, sonar, etc. - Recording systems, real-time operation and deferred time; - Etc.
Observation and surveillance (large zone)	Large area surveillance systems (aerial, maritime, land border surveillance) - Optronic systems, radars; - Satellite imagery; - Etc.
Tracking and tracing, positioning and location	Labeling and tracing devices and systems (barcodes, RFID, Wi-Fi) - Containers, land vehicles, planes, boats; - People; - Hazardous products (radioactive materials, hazardous chemicals, etc.).
Communications	Communication systems for security services (police, fire brigade, security services) including secure communication systems. - Deployable, embedded, secure communication systems; - Secure terminals; - Satellite communication; - Public and alert information.
Order, control and decision support	Command and control systems for security (including emergency response, rescue, special security missions).
	Information Management and Decision Management Systems for Security
	Other tools and systems to help organize and maintain security and its functions, including simulations, modeling, mapping, etc.
Intelligence and information gathering	Systems and tools for intelligence, collection and processing of information for security, including scientific investigation (technical and scientific police). - Interception, listening, localization, data processing and analysis software; - Technical and scientific police products; - Etc.

Source: DECISION Etudes & Conseil

Table 3/3 – Definitions of the different segments of electronics dedicated to security

Segments	Definitions
Cybersecurity - Governance Software	Security management systems
Cybersecurity - Software dedicated to Identity and access management	Electronic access control systems (identification and authentication) for computer and communications equipment, systems and networks
Cybersecurity - Software dedicated to data security	- Encryption, cryptography and digital signature solutions; - Public Key Infrastructure Solutions; - Content filtering and anti-spam; - Data loss prevention, secure archiving, data recovery solutions.
Cybersecurity - Software dedicated to infrastructure security	- Antivirus; - Firewall; - Secure messaging systems; - Anti-back, intrusion detection, tracing, monitoring.

Source: DECISION Etudes & Conseil

K. Historical evolutions of the value chain in terms of applications

From the 1940s to the 2000s, security was a negligible electronics segment. At first, it consisted only in physical products (trucks, automotive, chips, etc.) and workforce (policemen, private security services, etc.).

Electronics systems dedicated to security purpose (cameras, radars, alarms, etc.), slowly and slightly emerged from the 1960s to the 2010s.

Software dedicated to security purpose (cybersecurity) quickly emerged from the 1990s to the 2010s.

Since the 2010s, electronics dedicated to security is booming so that it is becoming a significant electronics end-user segment at the global level. Such growth of electronic products dedicated to security is driven by two major factors:

1- Miniaturization coupled with lower costs of electronic components. This phenomenon enables the integration of electronic security equipment (cameras, etc.) at large scale in new types of systems. Thus, not only is the volume of electronic security equipment exploding, but physical security devices are integrating more and more electronic subsystems, so that the border between physical security products (police trucks, security chips, etc.), and electronic security products is doomed to fade, even to disappear.

2- The digital transformation. Companies and administrations around the world are digitizing their processes and interconnecting the data networks thereby generated. This phenomenon generates growth in the security industries for two reasons. On the one hand, cybersecurity (and related software), is suddenly becoming a major strategic issue for every organization. On the other hand, the data networks generated by the digital transformation can be used for security purposes by innovative dedicated software (especially in terms of identification and authentication).

- This digital transformation is therefore a gigantic vector of growth for new software dedicated to security (identification, authentication, intelligence and information gathering, etc.). Although this digitization process is just beginning at the global scale, it leads to ever greater growth of the share of software in security tools. In particular, producers of electronic products - who often suffer from low margins - are gradually trying to move up the value chain by developing skills in software. The companies concerned - like Gemalto or Idemia - are increasingly positioning themselves on the development of software dedicated to security applications. The producers of physical and electronic products dedicated to security are therefore dedicating more and more resources in the development of security software.

- In addition, by enabling the interconnection between different data networks, the digital transformation encompasses the theme of connected objects. Indeed, the more the processes and the tools are made electronic, the more it is technically possible and economically interesting to interconnect them. However, interconnection generates a cybersecurity risk by enabling remote attacks. As a result, the interconnection of objects with each other (IoT), represents a tremendous potential growth for cybersecurity products and services. In other words, if each object becomes connected, each object will require a cyber tool to secure it.

The crossing of the two tendencies described above progressively leads the actors of the industrial sector to takes positions on all the segments: physical, electronic and cyber. The physical / electronic / cyber distinction is therefore progressively destined to become less and less meaningful and in the long run it is likely that each product architecture will be global with a physical component, an electronic component and a cyber component.

This trend even affects private security services. While the physical security of the premises was until recently composed only of human resources, its technological and electronic content is constantly increasing (SOC, CCTV cameras, etc.), thanks to the miniaturization and the lowering costs of the electronic products. In addition, in the human surveillance field, net profitability is very low (only 1% to 1.5% over the 2013-2016 period). In electronics dedicated to security, this rentability is higher, although with varying levels depending on the company. The will of a large number of private service providers is therefore to diversify their services by integrating electronic products and going upmarket.

Finally, this trend is also felt by buyers in the sector. From security to cybersecurity, every player concerned by security issues must now also integrate cybersecurity as a strategic issue. Suez is an emblematic example of a player traditionally concerned with safety through the management of drinking water networks in France and who now considers cybersecurity as a strategic issue. Digitization tenders for drinking water management include more and more explicit aspects of cyber-securing the data thereby generated.

xi. Figures, Europe 2010-2017, world and main countries

Methodology notes

Eurostat figures as well as every other national statistic do not provide any specific hard data on the security sector. Indeed, security has only been recently identified as a distinct industry.

DECISION Etudes & Conseil built specific hard data through the detailed analysis of the activities of the world leaders of the security industry.

Figures

The following tables provide detailed information on the regional repartition of security electronics production (hardware only), measured in terms of Factory-gate figures[1].

Analyses

- In 2017, the EU production (factory-fate figures, million euros), accounted for 14,5% of the global production. In other words, in 2017, the EU was the third region in terms of security electronics production (hardware only), after North America (43%) and China (24%);
- In other words, the global production of electronics equipment dedicated to security is clearly led by the USA that concentrates 35% to 40% of the global production;
- China is the global challenger with 24% of the global production and a very high growth (in particular linked to the rise of the public torture market in China: electric chairs, tasers, electric shock batons, etc.). The expected average CAGR of China is 9% over the 2017-2022 period;
- Asia as a whole (that is China, Japan and rest of Asia & Pacific), represented 18% of the global production in 2012, represents 34% of the global production in 2017 and is expected to represent 33% of the global production in 2022;
- The USA are therefore expected to remain the global leader in terms of electronics equipment dedicated to security until 2022 (with 38% of the global production in 2022);
- Israel, considered in the figures of the rest of the world, is also a significant competitor at the global scale with 8% to 10% of the global production shares.

[1] Factory-gate figures: Sum of the production costs of every automotive electronic equipment when it leaves its factory. Sales and marketing costs as well as producers' margin are not considered in those figures.

Security electronics production (hardware only) – Factory-gate-figures – Million euros – 2012-2017

Region	Product	2012	2013	2014	2015	2016	2017	CAGR 2012-2017
World	SECURITY	64	67	70	73	77	81	4,9 %
Europe	SECURITY	9	10	10	10	11	11	4 %
North America	SECURITY	26	27	28	30	31	33	4,7 %
Japan	SECURITY	2	2	2	2	2	3	2 %
China	SECURITY	12	13	14	15	17	18	8 %
Rest of Asia and Pacific	SECURITY	4	4	4	5	5	5	4,2 %
RoW	SECURITY	10	10	10	11	11	11	2,2 %

Factory-gate figures: The production values given in this table correspond to the unit average cost of production multiplied by the quantity of the related products produced by factories.

Source: DECISION Études & Conseil

Security electronics production (hardware only) – Factory-gate-figures – Million euros – 2017-2022

Region	Product	2017	2018	2019	2020	2021	2022	CAGR 2017-2022
World	SECURITY	81	85	90	95	100	106	5,6 %
Europe	SECURITY	11	12	12	13	13	14	4,3 %
North America	SECURITY	33	35	37	39	41	43	5,8 %
Japan	SECURITY	3	3	3	3	3	3	2,1 %
China	SECURITY	18	20	21	23	25	28	9,0 %
Rest of Asia and Pacific	SECURITY	5	5	5	6	6	6	4,5 %
RoW	SECURITY	11	11	12	12	12	12	2,3 %

Factory-gate figures: The production values given in this table correspond to the unit average cost of production multiplied by the quantity of the related products produced by factories.

Source: DECISION Études & Conseil

xii. Company positioning, Europe, World

The security market is less cyclic than the global electronics industry market due to longer term programs and investment patterns.

Despite the absence of a strong and dynamic home market, European security suppliers are finding growth levers abroad including in the USA or Asia. The European security industry today has therefore a positive trade balance. However, this favorable position is threatened, and the European production of security systems is expected to grow below the World trend at 4.3% on average over the forecast period. European industry could thus gradually lose positions against competing industrial bases and may represent only 13% of the World production by 2022, if nothing is done to resist this loss of competitiveness.

Despite this difficult competitive environment and the current lack of a consolidated and dynamic European market, security is still a domain where Europe occupies a leadership position with the presence of major producers and systems integrators coming from the aerospace and defense business (e.g. Thales, Airbus, Leonardo, Smith, Idemia, etc.).

Over the period 2000-2018, two key players who were clearly held by French capital are now held by US capital. Oberthur Technologies and Morpho have been bought by the American company Advent International to create the brand “Idemia”.

Security companies overview – SWOT analyses

United States

Sales of US companies: € 301 B including € 126 B in electronic products and cyber, representing 40% of the global market.

Strengths	Weaknesses
• Most security leaders are American • Privileged access to one of the world's largest markets • Possibilities of fundraising in the United States easier for start-ups, attracting European and French innovative firms (IoT, robotics, etc.) • Strong presence of the Big Five on the cybersecurity sector • A single agency (DHS) for secure purchasing and R & D	• Obligation to safeguard against import rules to fight competition from Asian products
Opportunities	**Threats for the EU**
• Tightening of regulations following the Snowden case, which reinforces the clients' preference for local and local cybersecurity players	• Offensive of major US players with global approaches around digital transformation: IBM, Accenture, CSC, CGI, etc.

European Union

Sales of European companies: € 103 billion including € 44 billion in electronic products and cyber, representing 14% of the global market.

Strengths	Weaknesses
• Existence of a policy of support for R & D (yet insufficient) • The European market is the world's leader in terms of purchasing power • Global players in IoT	• No clear, coordinated and ambitious industrial policy on the public procurement side to support European national actors • Insufficient European standards that would make the link between government purchases and orders received by French and European suppliers
Opportunities	**Threats**
• Digital transformation must be a lever for increasing long-term competitiveness and creating jobs	• Strong competition from the United States or China

China

A powerful and very competitive player.

Sales of Chinese companies: 190 B € including 60 B € in 2016 in products and cyber, or 25% of the global market.

Strengths	Weaknesses
• Large domestic market benefiting from very strong growth • Strong will and power of the Chinese state • Competition between several business models: private companies, private companies-universities partnerships, public defense-related companies • Very strong policy on smart & secure cities • A powerful and exporting industry • 1st market and production area in CCTV cameras	• A very complex and fragmented internal market with a strong focus on urban security • Important penetration of foreign companies
Opportunities	**Threats**
• Strong public and private investment in R & D (including artificial intelligence) • National standards policy that will reduce the penetration of foreign companies • Progressive acceptance of sensitive Chinese products by the global market	• Decreasing Chinese growth • Defiance towards Chinese products abroad (especially in marketing)

European Commission

Study on the Electronics Ecosystem - OVERVIEW, DEVELOPMENTS AND EUROPE'S POSITION IN THE WORLD

Luxembourg, Publications Office of the European Union

2020 – 118 pages

ISBN 978-92-76-02934-2
doi: 10.2759/014809

KK-01-19-383-EN-N

doi: 10.2759/014809 ISBN 978-92-76-02934-2

Publications Office
of the European Union