European Commission

Study on the Electronics Ecosystem

OVERVIEW, DEVELOPMENTS AND EUROPE'S POSITION IN THE WORLD

Annex 4 & 5

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

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Annex 4 - Health and Care

Overview

Healthcare electronics are a very particular market, largely dominated by health organisations (hospitals, clinics, social security and insurance) who are the customers, the operators, and who often finance patient expenses. The Healthcare electronics segment is small today, compared to the other end user segments

But Healthcare electronics is a very high growth segment (8% annual growth rate globally, and 4% for Europe and 5% for the USA)

- In the “professional” sub-segment (90% of the total) driven by better health facilities in Asia, Latin America, and Africa;
- In the “consumer” sub-segment (10% today, very fast growing) driven by the IoT and connected wearables, and the coming e-health.

The USA dominates this segment with 41% of global production, and leading global companies (Medtronic, GE Healthcare).

Europe is relatively strong (18% of global production), and is still comparable to China in size, but the Chinese healthcare industry is growing very much faster. Europe has leading global companies (with Philips and Siemens) well established in the institutional markets.

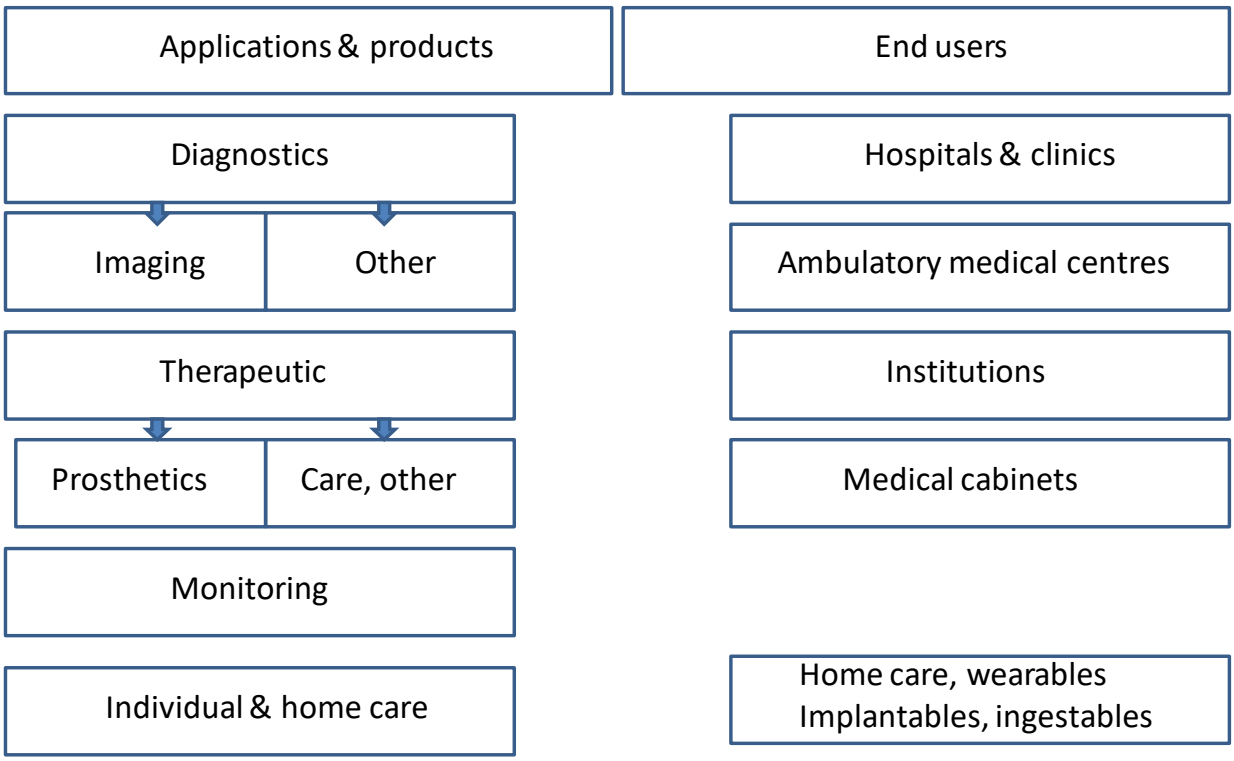
In Europe healthcare electronics production was 13.6 B€ in 2016, and the industry employed over 40 000 people.

Japan is very present, but mostly on its domestic market, and less in the rest of the world.

1.1.1 The Healthcare value chain

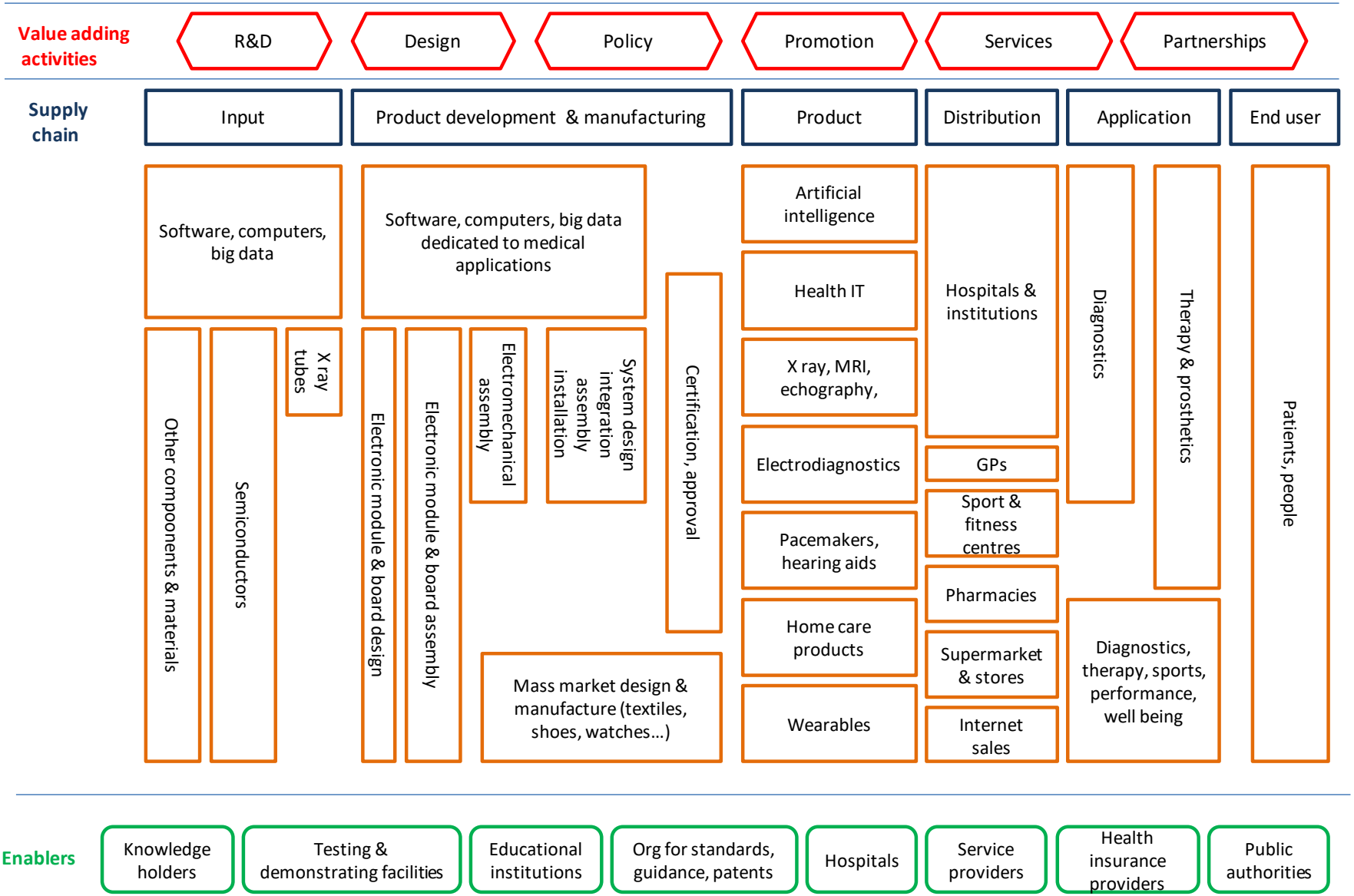
i. Healthcare electronics market description

Diagram – Medical electronics: overview



Source: DECISION Etudes & Conseil

Diagram – Electronic medical equipment general value chain



Source: DECISION Etudes & Conseil

The field of medical electronics is undergoing a major shift.

- It was until recently mainly a professional segment, with imaging and monitoring equipment often in hospital settings, and analytical and therapeutic systems;
- Then smaller diagnostic equipment for practitioners;
- Hearing aids and pacemakers have long been worn by patients, but now new wearables are arriving, and house care products (e.g. blood pressure or sugar measure, cardiac rhythm...) and even the traditional thermometer has become electronic. All these instruments can be connected as components of an e-health system.

The professional segment addresses primarily hospitals and clinics as well as specialized practices such as radiology, dentists or laboratories.

A related but functionally separate area of great growth potential encompasses the various technologies enabling the patient to participate in the management of his or her fitness and health in relation or not with relevant medical personnel and structures, in the individual or family healthcare environment.

The global market for electronic medical and healthcare equipment and products in 2016 is evaluated at €73.4 billion.

Around 90% of this is made up of professional medical equipment, such as imaging, implanted devices (CRM. Neuromodulation), and other diagnostic and therapeutic equipment.

The remaining 10% are in two new product categories, connected devices related to health care, and well-being and electronic equipment related to in-home health supervision and maintenance. This is a very fast-growing sub-segment, that can be expected to reach 14% of the market in 2022.

The share of equipment produced in Europe and in North America is declining, in the face of strong competition from the Chinese healthcare industry, which is supported by active government policies.

A. Medical instrumentation

a. Imaging systems

Medical imaging systems are broken down into the following sub-categories:

- Conventional and digital Radiography (X-rays);
- Scanners and tomography;
- Magnetic Resonance Imaging (MRI);
- Ultrasounds;
- Nuclear Medicine.

This market is very concentrated with three leading manufacturers: General Electric. Siemens and Philips who together represent 2/3 of the global market. The 4th largest. Toshiba. operates primarily in Japan. The remaining players include Hitachi and Shimadzu in Japan, Samsung Medison in South Korea, Carestream Health and Hologic in the US, and Mindray and Wandong in China.

Sales of digital radiography equipment are expected to grow at an annual rate of 15%.

In terms of the number of machines sold, ultrasound imaging is the leading technology with over 200.000 units supplied, worldwide and this technology is expected to continue to lead in unit sales over the coming five years.

b. Heart Stimulators (Cardiac Rhythm Management or CRM)

The market for CRM devices is estimated to be €11 billion in 2016. This is a very mature market and should grow at about.4% annually. The principal technology development related to CRM devices is the appearance of devices compatible with MRI examinations.

- The global market for pacemakers, roughly €3 billion, is stable. It will grow only by 1.5% per year and this due to increasing use in emerging countries. The highest growth model is the cardiac resynchronizer (Cardiac Resynchronization Therapy Pacemaker, or CRT-P);
- The market for implantable defibrillators will grow more rapidly than that of pacemakers and there also it is the market for devices that can achieve cardiac resynchronization (CRT-D) that will grow most rapidly. The global market for defibrillators reached €7.5 billion in 2016 and is expected to grow by 5.5% annually.

c. Other Diagnostic and Treatment Equipment

A certain number of medical devices used for diagnostic or treatment are also considered as actual or potential electronic equipment. such as:

- Anaesthetic equipment, respiratory assistance, oxygenation machines, gas delivery, etc.;
- Dental surgery, intraoral X-ray radiography, digital dental imaging, etc.;
- Body function monitoring: ECG, EEG, Holter mobile electrocardiography devices, etc.;
- Patient vital sign monitoring Cardio/respiratory, blood gas analysers, etc.;
- Surgical equipment: Operating theatre equipment, colonoscopy, endoscopy, medical lasers, etc.;
- Functional substitution devices: dialysis, hearing aids, cochlear implants, etc.;
- Therapeutic equipment: Lithotripters, incubators, sleep apnoea devices, glucose monitoring and insulin pumps etc.;
- Analysis equipments (lab on chip) used to detect diseases or epidemics. Can also be used out of classical medical structure (like in airports or for detection in the field);
- Etc.

Most of these devices are manufactured in small quantities. For example, the global market for haemodialysis machines is scarcely 50.000 units per year. An example of a small market that is destined to become very large is that of external defibrillators. In Europe, around 500.000 people die suddenly each year (most of who are at home) as the consequence of a variety of cardiac problems. The majority of these victims could be saved if they could be treated in the minutes following the onset of the problem with an external defibrillator. A growing trend is not only to equip public spaces (airports. train stations and hotels) with these devices, but also to prescribe them, for any patient at risk, for home use. On a worldwide scale, the market for external cardiac reanimation devices (external pacemakers, reanimation fluid pumps, automatic external defibrillators and related soft and hardware) was around 2 million euros in 2016 and is expected to grow rapidly.

B. Citizen medical environment

It can be claimed everywhere in the world that health care delivery methods are inefficient and that an increasingly unacceptable portion of health care costs can be avoided. Societal changes, in all fields, e.g. in the transportation domain with Uber or in e-commerce with Amazon, show us that in an increasingly individualistic human environment, the role of the consumer has become the true agent of change influencing the business models of many activities.

The same is becoming true in health care. Individuals increasingly seek advice about healthy lifestyles, such as diet and exercise and to be kept abreast of the status of their health so as to integrate into a health maintenance network that will advise on the actions and procedures to be pursued. The concept of “Patient” is shifting, the new idea is that everyone has health issues that need maintenance and monitoring.

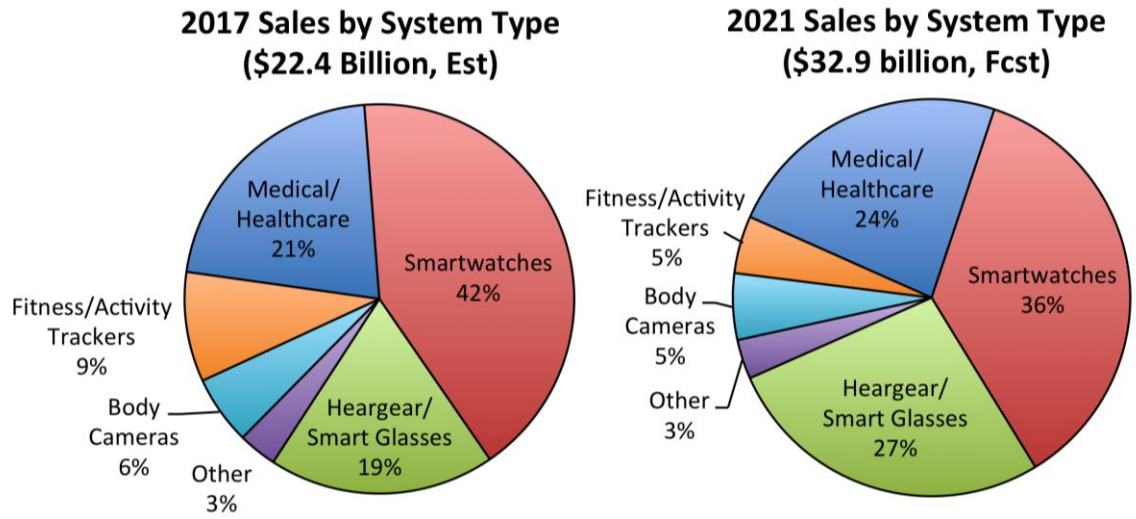
The idea of living better and more independently when under treatment while staying in one’s own home is being promoted by many organisations. The Continua Alliance, a leading organisation, has released a specification on end-to-end connectivity and interoperability in health delivery systems.

While treating patients using various medical devices is a big market, another growing area of opportunity is fitness and preventative health. This includes exercise gear and personal health monitoring gadgets. This market is aimed at consumers who want to stay fit, and the expected volume for devices is large.

A variety of devices are already available to monitor the condition of a person who wants to stay healthy and live independently. They include digital thermometers, pulse oximeters, pulse/blood pressure monitors, weight scales, glucose meters, cardio exercise machines, electrocardiogram devices and insulin pumps. Over the years, the features of lower power combined with more functions, including the front-end input/output (I/O) into a single chip, have made medical devices more portable. Homecare devices, such as blood pressure monitors and glucose meters, are frequently battery operated. Overall, they are more compact and convenient to use.

a. Connected objects

Pie chart – Wearable Systems Market share by category

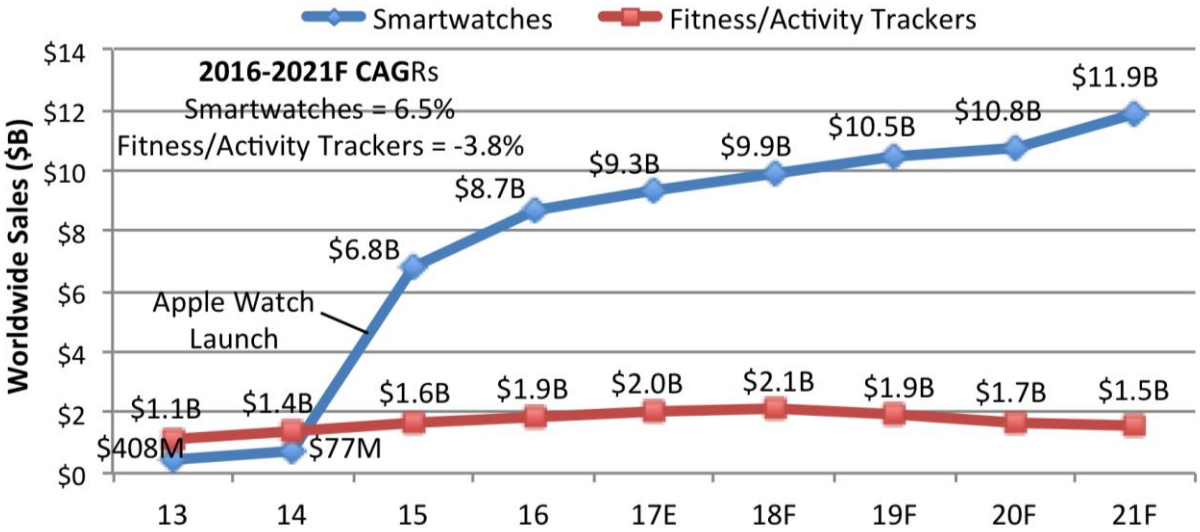


Source: IC Insights

The revenue from wearables alone was about € 9 B in 2016 according to IC Insights and is expected to nearly double by 2022. Wearables accounted for 13% of IoT system sales in 2016.

Connected objects in the home add to that (e.g. scales, thermometers, blood pressure and sugar measurers...) will also be connected.

Graph – Smartwatch sales grow as fitness/activity trackers fade



Source: IC Insights

The revenue from smartwatch sales alone rose from € 0.6 B in 2014 to nearly € 8 B in 2016 in line with the launch of the apple watch. During the same period of time, the global revenues from fitness/activity trackers remained stable, from € 1.2 B in 2014 to € 1.7 B in 2016.

b. Domestic patient environment

The increase in the number of the elderly in the populations of developed countries and then progressively in other regions leads to increases the number of the chronically ill suffering from various afflictions (high blood pressure, asthma, diabetes, kidney disease, Alzheimer's disease, cardiac problems, respiratory ailments) as well as medically dependent seniors. This has given rise to the rapid development of remote systems supervising home-based patients.

These systems include some typical domestic equipment used to facilitate certain gestures and to reduce the risk of accident as well as more specifically medical-related devices allowing for remote supervision and potentially the direct intervention of a relative, or of medical personnel (remote surveillance, remote diagnosis and remote medical consultation). The principal characteristic of these devices is their ability to communicate with the health network that is directly related to the person or patient. This includes in particular:

- Telecommunication systems adapted to the health situation of the individual;
- Related Audio and video systems;
- Monitoring systems;
- Bedroom and mobility equipment: Electrically operated bed, electronically controlled seats, environmental sensors, security systems (movement sensors. alarm systems);
- Vital sign sensors;
- Respiratory assistance equipment;
- Remotely controlled medication delivery devices.

It is difficult to estimate the size and shape of the domestic patient environment. It is still an emerging market where no specific business models have yet been established. Certain points of reference can nevertheless be provided: it is estimated that in 2013 approximately 3 million people, worldwide, suffered from chronic diseases and were equipped with a remote monitoring system, and of these two thirds were cardiac patients who had an implanted pacemaker or an implanted defibrillator. In these cases, the implanted device manufacturer provided both the implants and the associated remote monitoring equipment.

The remaining one third of patients in 2013 using remote monitoring equipment suffered from sleep apnea, respiratory ailments or required remote supervision related to medication delivery. What is clear is that sales of this type of equipment are expected to increase rapidly in developed countries with the aging of the population and the concurrent need to limit the high costs of in-hospital care.

1.1.2 Healthcare electronics in figures

i. Methodology notes

European production is measured by the Eurostat Prodcom database, which give production in value and quantity. Prodcom data presents the value (in euros) and quantity (in units) produced in the EU in a detailed 8 digits code.

Yet, DECISION undertook a critical analysis of the Prodcom figures and completed the Prodcom's figures in order to take into account the entire scope of Health & Care electronic equipments as defined in the chapter "i. Healthcare electronics market description".

Therefore, two different figures are presented in this report and are supposed to measure the Health & Care electronic equipments production in Europe:

1. **Eurostat Prodcom database figure: Europe's production is estimated at 13.55 B € in 2016;**

2. **DECISION's figure (that is the final figure retained, highly based on the Prodcom figure with marginal adaptations): Europe's production is estimated at 16.55 B € in 2016. In the figures presented by DECISION in the pyramids/overview and used to undertake comparisons with the other end-user electronic segments, this figure has been selected and is supposed to provide a precise measure of the production level and location.**

ii. Comparison with the other end-user segments

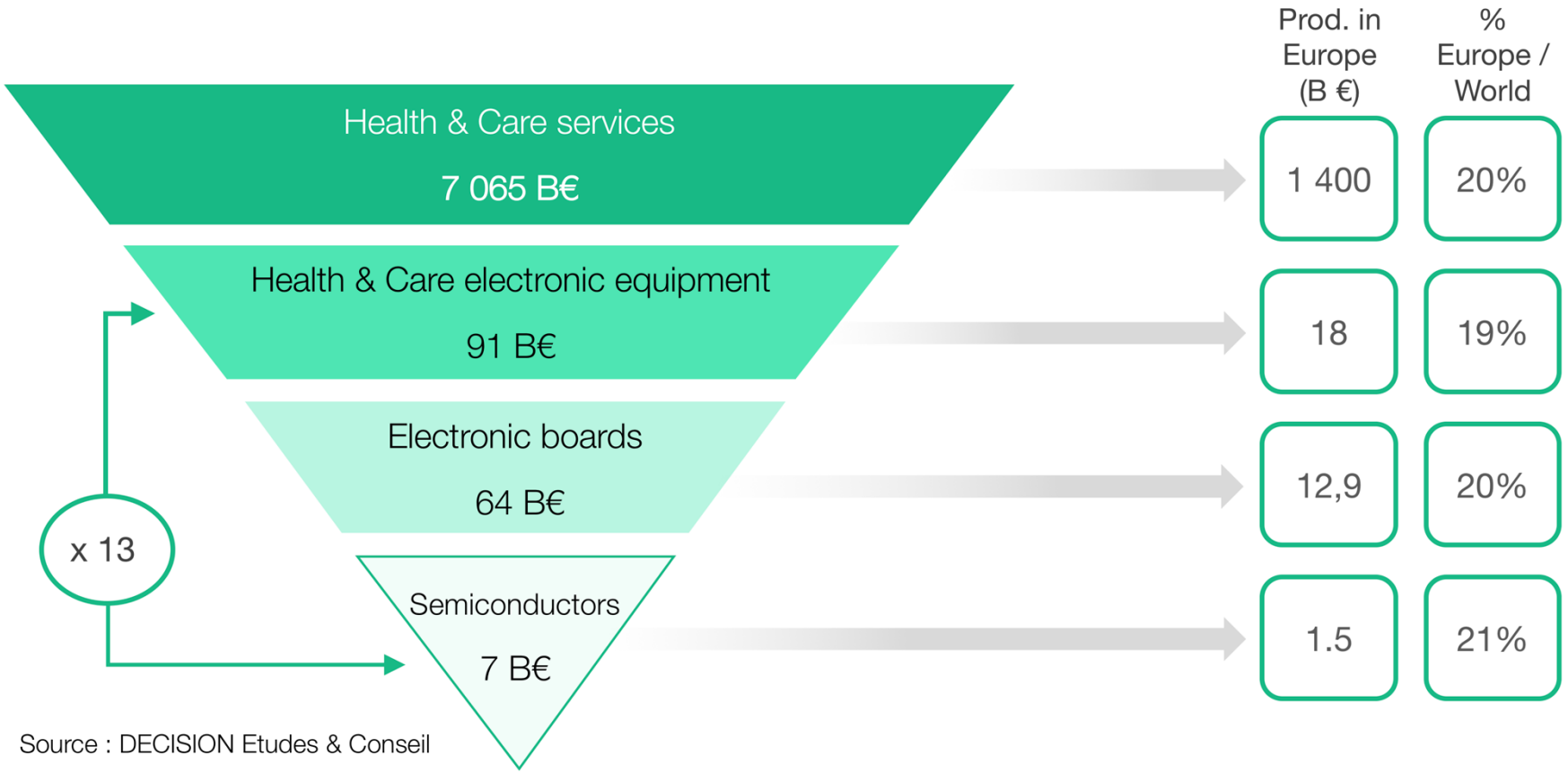
Health & Care is forecast to be the “next Automotive market” in terms of electronic equipments, that is the next “leading electronic equipments market” (Automotive is already the fourth biggest market with 16% of the global electronic equipments production in 2017 and has the highest growth forecast over the 2016-2022 period with almost 10%/year).

Health & Care is still a much smaller market with only 91 B € in 2017 (4,7% of the global electronic equipment production, that is the 7th market in terms of size, just above home appliances), but benefited from a high growth of 7%/year over the 2010-2016 period and will continue to benefit from a high growth over the 2016-2022 period (6,5%/year on average).

Europe is well positioned in terms of electronic equipments dedicated to Health & Care with 19% of the world production in 2017.

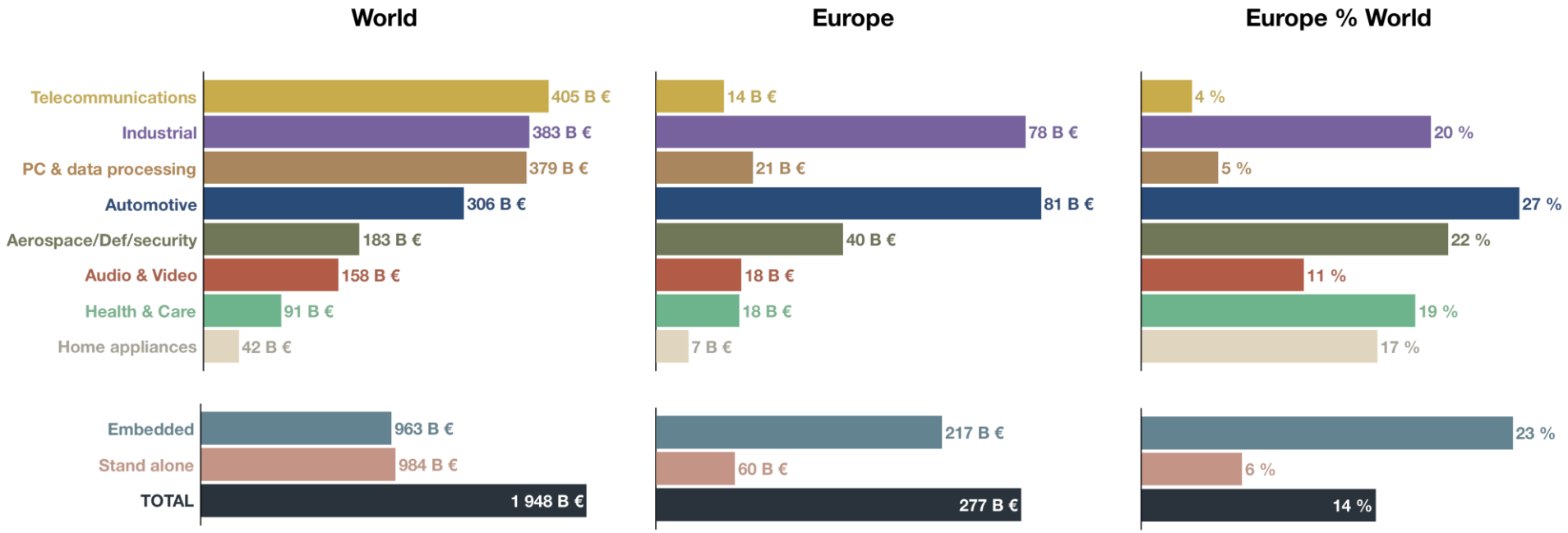
Finally, electronic equipments dedicate to Health & Care represented 6,5% of the European production value of electronic equipments in 2017.

Worldwide Health & Care electronics value chain in 2017



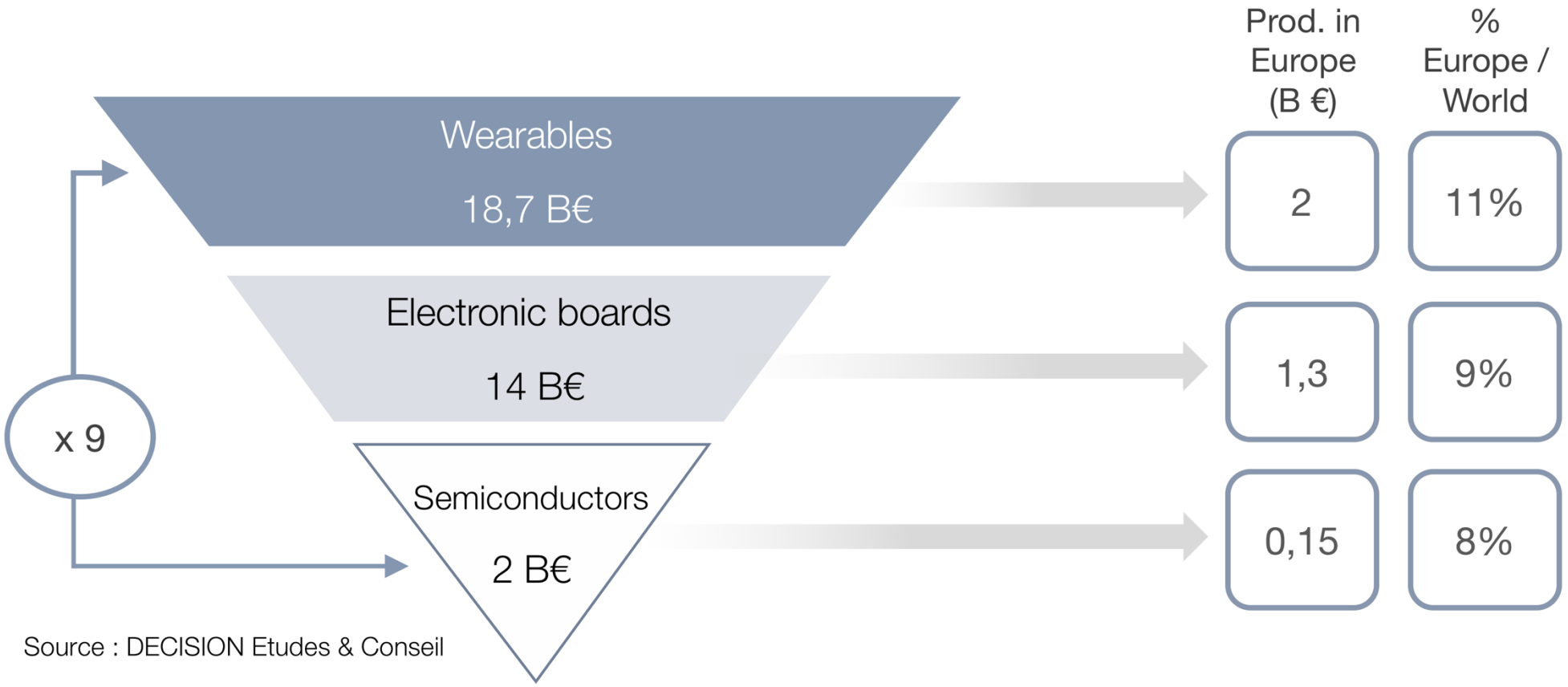
Source : DECISION Etudes & Conseil

Diagrams – Electronic equipment production by segment in 2017 (B€)



Source: DECISION Etudes & Conseil

Worldwide Wearables electronics value chain in 2017



Source : DECISION Etudes & Conseil

iii. Europe in the world

The USA dominates this segment with 42% of global production, and leading global companies (Medtronic, GE Healthcare).

Europe is relatively strong (19% of global production), and is still comparable to China in size, but the Chinese healthcare industry is growing very much faster. Europe has leading global companies (with Philips and Siemens) well established in the institutional markets.

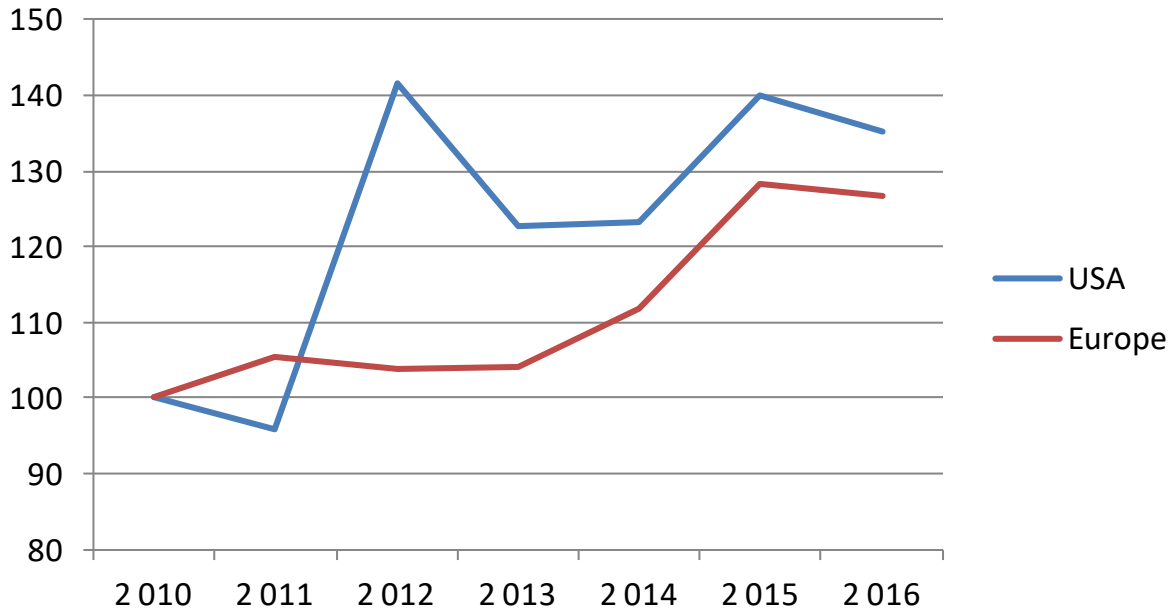
Japan is very present, but mostly on its domestic market, and less in the rest of the world.

Table – World production of professional healthcare electronics

M €	2010	2016	CAGR 2010-2016
Europe	13 000	16 555	4.1 %
The USA	26 035	35 148	5.1 %
Japan	6 514	7 960	3.4 %
China	8 023	16 635	12.9 %
Other Asia	1 897	4 425	15.2 %
Rest of the World	1 653	4 425	10.5 %
TOTAL World	**57 122**	**85 726**	**7 %**

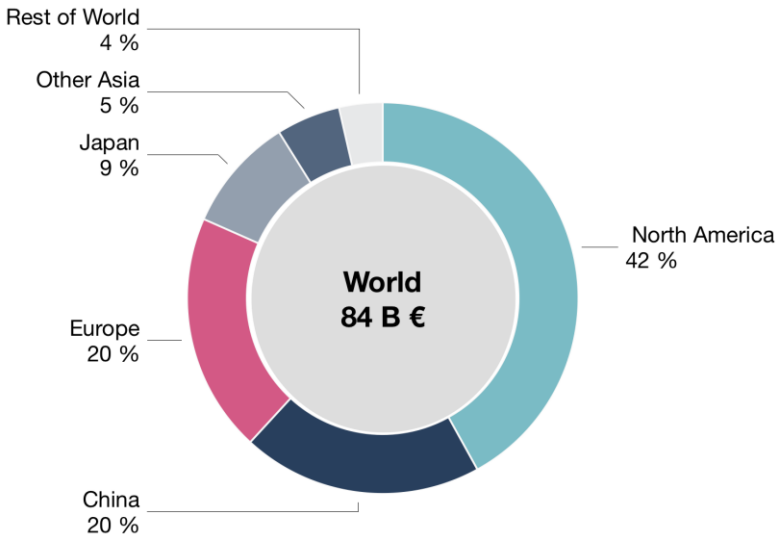
Source: DECISION Études & Conseil, Eurostat, US Census

Graph – Evolution of healthcare electronics production (index 2010=100)



Source: DECISION Études & Conseil

Pie chart – Healthcare electronics production by countries & region in 2016

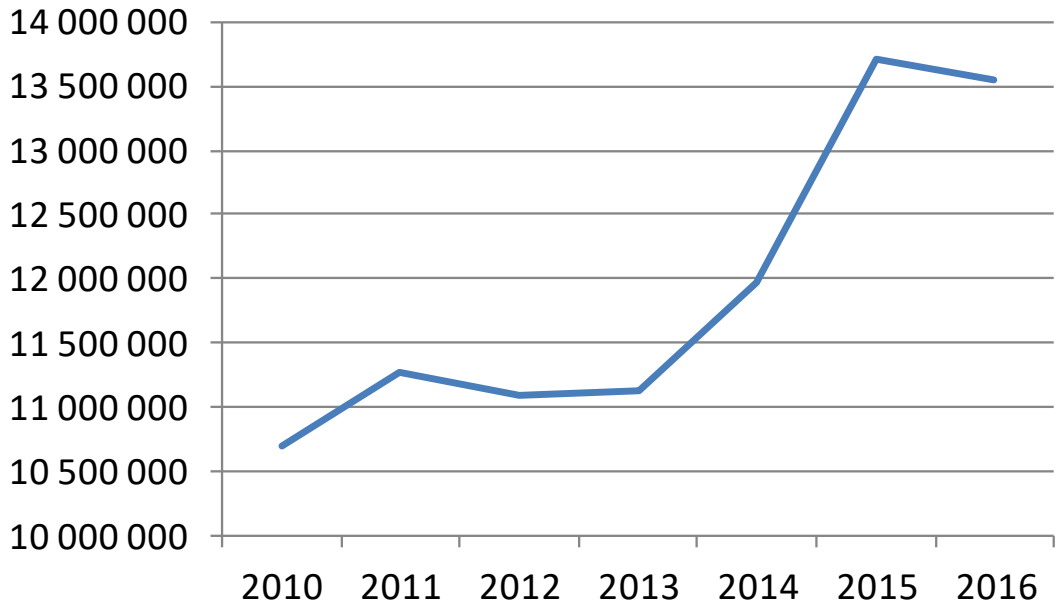


Source: DECISION Études & Conseil

iv. European production (Prodcom database)

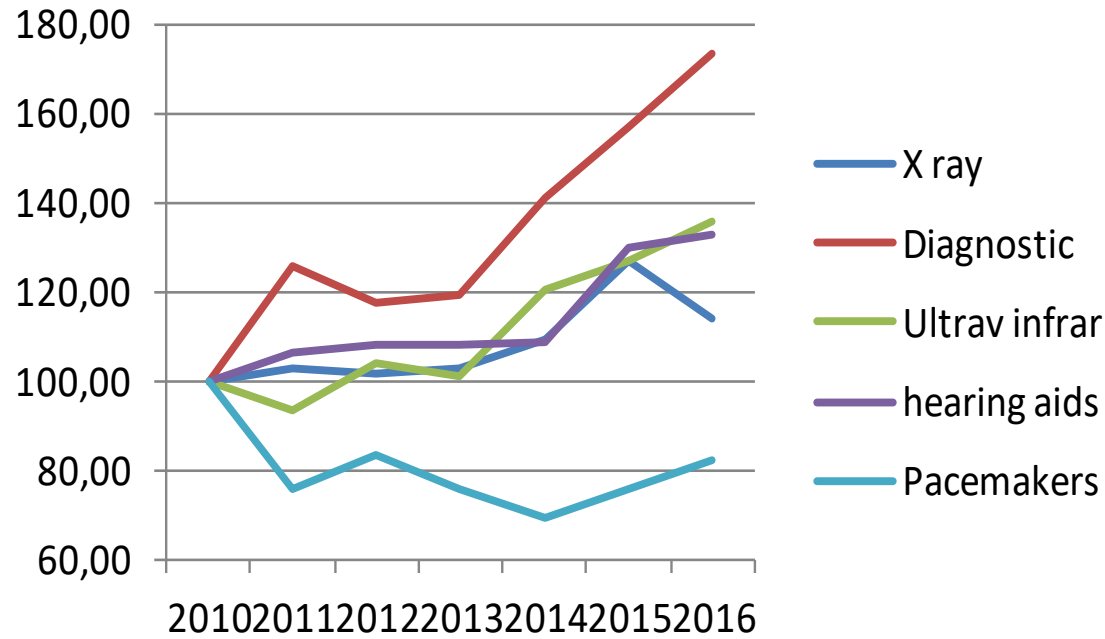
According to the Eurostat Prodcom database, Healthcare electronic equipments production in Europe was nearly 14 billion euros in 2016.

Graph: Prodcom figures - European production of medical electronics (K€)



Source: DECISION Études & Conseil

Graph – European production of medical electronics 2010-2016 (index 2010=100)



Source: DECISION Études & Conseil

Table: Prodcom figures- Health & Care electronics

Prodcom Definition	2 010	2 011	2 012	2 013	2 014	2 015	2 016	CAGR 2010-16
Apparatus based on the use of X-rays,	3 317 574	3 262 916	3 288 845	3 272 327	3 541 879	4 318 022	3 792 773	2,26%
Apparatus based on the use of X-rays	610 274	757 886	933 683	827 624	819 259	851 064	826 372	5,18%
Apparatus based on the use of alpha,	238 966	269 676	267 862	253 211	207 200	193 093	197 173	-3,15%
X-ray tubes (excluding glass envelopes	400 000	400 000	200 000	333 495	353 162	343 311	200 000	-10,91%
X-ray generators, high tension generat	971 709	1 001 107	925 652	1 006 556	1 125 000	1 328 000	1 304 000	5,02%
Radiography & imaging	***5 538 522***	***5 691 585***	***5 616 041***	***5 693 213***	***6 046 499***	***7 033 490***	***6 320 318***	***2,23%***
Electro-cardiographs	135 274	115 988	90 000	102 847	110 993	131 208	118 399	-2,20%
Electro-diagnostic, apparatus (excludi	2 500 000	3 200 000	3 000 000	3 047 349	3 600 000	4 000 000	4 449 036	10,08%
Ultraviolet or infrared apparatus used	79 616	74 230	82 920	80 380	95 713	101 096	108 036	5,22%
Diagnostic & other	***2 714 890***	***3 390 218***	***3 172 920***	***3 230 577***	***3 806 706***	***4 232 304***	***4 675 470***	***9,48%***
Appliances for overcoming deafness (	852 422	915 477	948 193	949 085	934 665	1 084 194	1 097 840	4,31%
Parts and accessories of hearing aids (	237 574	246 278	227 339	227 224	247 403	333 859	352 518	6,80%
Hearing aids	***1 089 997***	***1 161 755***	***1 175 532***	***1 176 309***	***1 182 069***	***1 418 052***	***1 450 358***	***4,88%***
Pacemakers for stimulating heart mus	1 346 594	1 018 249	1 126 203	1 021 419	930 066	1 018 720	1 107 621	-3,20%
Health & care equipment total	**10 690 003**	**11 261 807**	**11 090 696**	**11 121 518**	**11 965 340**	**13 702 565**	**13 553 768**	**4,04%**

Source: DECISION Études & Conseil

v. Intra-European analysis

Table – 2016 – European production of Healthcare electronics in Europe

Country	Persons employed	Share of production
Germany	25 387	28%
Italy	12 234	14%
Switzerland	10 267	11%
France	5 000	6%
Denmark	4 276	5%
United Kingdom	4 154	5%
Netherlands	4 148	5%
Austria	2 478	3%
Finland	2 356	3%
Spain	1 901	2%
TOTAL	90 000	100%

Source: DECISION Études & Conseil

Table – 2015 – European production of Professional Medical equipment

Country	Share of production %
Germany	34.1%
France	10.5%
Italy	12.4%
UK	9.0%
Others	34.0%
Total	100.0%

Source: Eurostat NACE2

1.1.3 Healthcare company positioning

i. Main players in Healthcare

Table – Ranking TOP producers Healthcare electronics

Rank	Company	Country	Employees	Sales Bn € 2016	Comments
1	Medtronic	The USA	91 000	28.0	45% of global CRM Diagnostics and therapy
2	Philips	Europe (NL)	73 951	17.4	All healthcare
3	GE Healthcare	The USA	46 000	17.0	No longer GE Diagnostic and Interventional Imaging Patient Monitoring Maternal and Infant Care Anesthesia and Respiratory Care Diagnostic Cardiology Healthcare IT
4	Siemens Healthineers	Europe (DE)		13.8	All healthcare
5	Mindray Medical	China	10 000		Largest Chinese medical electronics manufacturer
6	Canon Medical Systems	Japan			Toshiba Medical, acquired by Canon in 2016 Imaging
7	Shimadzu	Japan	>10 000	2.5	
8	Carestream Health	The USA	7300	2.5	Ex Kodak Health Group
9	LivaNova	Europe (UK)		1.0	Merger in 2015 between Cyberonics (US) and Sorin (Italy). Sorin had16% of European pacemaker market. Sold CRM (France) in 2017 to MicroPort (China)
10	Biotronik	Europe (DE)			Mostly CRM
11	Terumo	Japan	16 300	1.0	About 4-5 Bn € sales, mostly non-electronic
12	Hitachi	Japan		1.0	In electronic systems division, sales 8.8 Bn€, medical 1.0?
13	Hologic	The USA		1.0	Imaging & surgical devices Sales 2.7 Bn€, maybe 1.0 electronics
14	Samsung Medison	S Korea	420		Ultrasound diagnostic systems

Source: DECISION Etudes & Conseil

ii. US suppliers

The major U.S. medical device companies include: Baxter, Beckman Coulter, Becton Dickinson, Boston Scientific, GE Healthcare Technologies, Johnson & Johnson, Medtronic, St. Jude and Stryker Corporation, to name a few.

In addition, the following medical device industry trade associations closely follow the industry: Advanced Medical Technology Association (AdvaMed), Dental Trade Alliance (DTA), Medical Device Manufacturers Association (MDMA), Medical Imaging Technology Association (MITA) and the International Association of Medical Equipment Remarketers & Servicers (IAMERS).

iii. Japanese suppliers

Top Japanese medical device companies, in terms of sales, include Terumo, NIPRO, Olympus Medical Systems, Toshiba Medical Systems, Hitachi Medico, Nihon Koden, and Fukuda Denshi.

iv. Medical imaging

This market is very concentrated with three leading manufacturers: GE Healthcare. Siemens and Philips who together represent 2/3 of the global market.

Company	Country	Comment
GE Healthcare	The USA	Now an independent company.....
Siemens Healthineers	Europe (DE)	
Philips	Europe (NL)	
Toshiba	Japan	Operates mainly in Japan
Hitachi	Japan	
Shimadzu	Japan	
Samsung Medison	S Korea	Ultrasound
Carestream Health	The USA	Ex Kodak
Hologic	The USA	
Mindray	China	
Wandong	China	

Source: DECISION Etudes & Conseil

v. Diagnostic and Treatment Equipment

The principal manufactures are Medtronic and Zoll (both US players), and Philips (Europe).

vi. Heart Stimulators (Cardiac Rhythm Management or CRM)

Table - Main players in Heart Simulators

Company	Country	Comment
Medtronic	The USA	45% of the global CRM market
St Jude Medical	The USA	
Boston Scientific	The USA	
LivaNova	Europe (UK)	Sales 1 B €. Merger in 2015 between Cyberonics (US) and Sorin (Italy). Sorin had16% of European pacemaker market. Sold CRM (France) in 2017 to MicroPort (China)
Biotronik	Europe (DE)	Over 5 600 employees
Nihon Kohden	Japan	Active in domestic market
Microport	China	Bought CRM (France mostly) from LivaNova in 2017

Source: DECISION Etudes & Conseil

vii. Hearing aids

Table - Main players in Hearing Aids

Rank	Company	Country	Market share	Employees	Sales B €
1	Sonova (Phonak, Unitron)	Europe (CH)	24%	14 088	2 154
2	William Denant (Oticon)	Europe (DK)		13 280	1 773
3	Amplifon	Europe (IT)	9%	10 000	1 000 (e)
4	Sivantos (ex Siemens) (Signia)	Europe (DE)		>5 000	967
5	Starkey	USA		5 000	
6	Widex	Europe (DK)		3 800	
7	Cochlear	Australia	75% of implant	3 000	842
8	GN Resound	Europe (DK)			
9	MED-EL	Europe (AUS)		1 500	
10	Tondi Elektrooniks	Eirope (EST)			

Source: DECISION Etudes & Conseil

viii. Wearables

Apple (USA) is the leader, the other major players in the connected watch segment are Samsung (S Korea), Pebble (USA) and Motorola (USA). For bracelets the leaders are Fitbit (USA), Jawbone (USA) and the Chinese Xiami. Other connected items are available in footwear, clothing, toothbrushes and sports equipment and sportswear (Adidas, Nike...).

Table - Companies in wearables and other health oriented IoT electronic systems

Segment	Company	Country
Smartwatches	Apple	USA
	Samsung	S. Korea
	Huawei	China
	Lenovo	China
	Xiaomi	China
	Garmin	Switzerland
	Fitbit	USA
	Polar	EU
	Withings (bought by Nokia in 2016 and resold in 2018)	EU
Fitness bands	Fitbit	USA
	Xiaomi	China
	Garmin	Switzerland
	Apple	USA
	Samsung	S. Korea
	Polar	EU
Body cameras	GoPro	USA
	Nikon	Japan
	Polaroid	USA
	Xiaomi	China
	Vievu Safariland	USA
Various		
Health Box	Under Armour	USA
Smart scales	Fitbit	USA
	Polar	EU
	Withings (bought by Nokia in 2016 and resold in 2018)	EU
Smart headset	Sony	Japan
Smart jacket	Project Jaquard (Google-Levi's)	USA
Sportswear & clothing end users	Nike	USA
	Adidas	EU
	Under Armour	USA

Source: DECISION, company reports, studies

1.1.4 Healthcare technological developments

Generally speaking the major developments will be at the upper end the use of artificial intelligence and big data for applications ranging from diagnostics to drug development, and at the individual and the citizen end the multiplication of individual devices (home care, wearables, implantable, ingestible).

in the medical imaging segment, the principal area of innovation in the coming years will be:

- Ultrasound technologies (High Intensity Focused Ultrasounds or HIFU and 3D and 4D ultrasounds);
- X-Ray technologies (new X ray sources using femtosecond laser, cold cathode technology, next generation detection devices and 3D imagery);
- Magnetic field technologies (Pathology-specific MRI machines, multimodal machines linking MRI and ultrasound technologies);
- Use of artificial intelligence for analysis and diagnostic;
- Use of IA for drug delivery control;
- Etc.

New technologies based on light rays are starting to appear, such as multimodal devices for endoscopy, 3D video and enhanced reality devices. Simultaneously, medical imagery continues its conversion from analogue to wholly digital systems. The goal is to allow health and medical institutions to free themselves completely from physical film supports

Partially derived from implantable CRM devices, new stimulators designed to treat other ailments and reduce patient discomfort, neuromodulation is a recent segment of about €2 billion in 2014 and whose anticipated growth is 7% annually in the coming years.

A new domain of promising development is emerging with the advent of nanotechnologies and their electronic applications, lumped together under the heading of nanoelectronics. In the case of medication delivery pumps – for example, new developments for insulin pumps could revolutionise treatment methods for diabetes and provide new levels of comfort for patients. Another application that shows market potential is, for example, intelligent catheters for use in cardiovascular surgery.

Already, many applications are available for smart phones and tablet computers that contribute to personal health and well-being. “Big Data” and Cloud computing will inevitably contribute to this trend. The conjunction of these technologies with those of the medical field will, however, run up against concerns about confidentiality and risk management of the patient.

The use of connected devices for health applications (aside from fitness applications, their primary use today) will ultimately reach 1/3 of all applications used by consumers. The “Quantified Self” allows for the collection and follow-up of a large number of health-related parameters, for the sharing of this data with the related medical environment and for the establishment of predictive and preventive health management thereby reducing health care demands and the need for hospital stays.

It is still difficult to accurately project the future of this booming market that borders on health and well-being and traditional medical care methods. As an example, the Healthcare department of the French Telecoms operator Orange

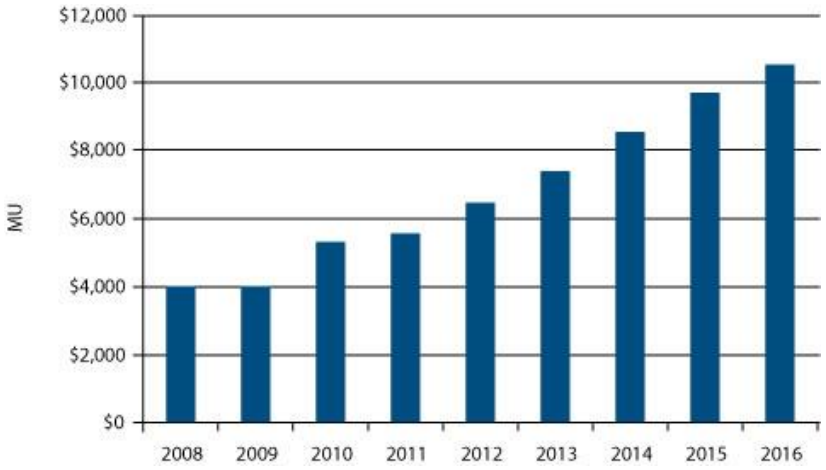
presented the following analysis: in 2014 10 million health care related connected devices were sold representing a market of €1.5 billion. In 2019 the market will grow to €4.5 billion, an increase of 300% in 5 years.

1.1.5 Healthcare MNE interaction

i. MNE use

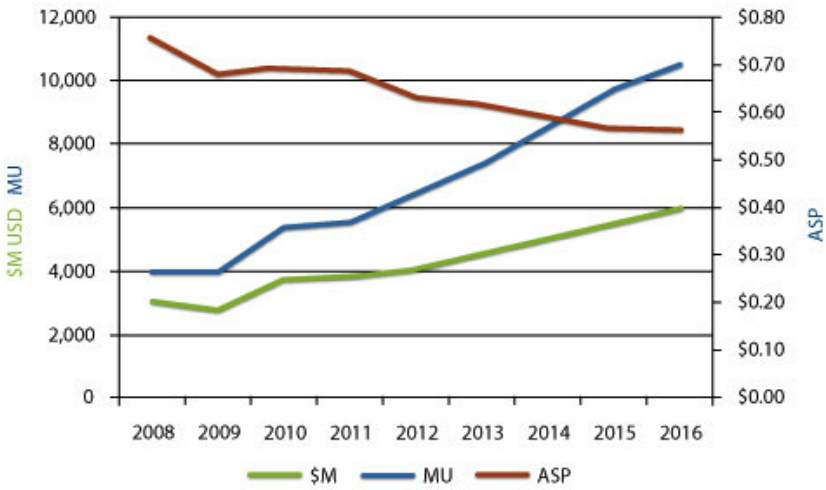
According to Databeans, a market research firm that tracks semiconductor shipments in the medical market, total market revenue will grow from $6 billion to $10 billion by 2016, with unit shipment increasing from 6 billion to 10 billion units in the same time period (Figures 1 and 2). This reflects the demand for medical electronic devices using medical semiconductors. For the most part, the growth will be in FDA Class 2, and to a lesser extent, Class 3 products. Class 2 products are bench-top, portable and wearable devices that are not invasive, while Class 3 devices are implantable units such as defibrillators

Bar chart - Worldwide Medical Semiconductor Shipment Forecast



Source: Databeans Estimates

Graph - Worldwide Medical Semiconductor Market Forecast



Source: Databeans Estimates

ii. MNE suppliers

Overall, semiconductor suppliers have done a good job in integrating the front-end analog-to-digital (A/D) functions in a single piece of silicon. (For a detailed list of product offerings from various semiconductor suppliers, go to www.medsmag.com/sbb). Leading suppliers offer different solutions. Texas Instruments, Freescale and STMicro have the broadest portfolio including digital thermometers, weight scales, ECG/EKD/EEG electrocardiograms, glucose meters, insulin pump, pulse oximeters, blood pressure monitors and ultrasound/scanning devices. Separately, ADI and STMicro offer a MEMS motion detect solution for fall-detection and prevention devices. The innovation of ECG development is moving from portable to wearable. This solution will directly reduce healthcare costs. By wearing an ECG device, a patient with a heart problem can be monitored remotely by the caretaker without being in the hospital. STMicro's battery-powered ECG semiconductor will be a good fit. More and more devices are connected to other devices/ controllers remotely using emerging wireless standards such as ANT+, Bluetooth, ZigBee and near field communication (NFC). Companies like Renesas, TI and Freescale all offer products in these areas under the umbrella of Mobile Health (known as mHealth), or Wireless Health.

Another important segment in medical electronic device design is that of sensors. Now a new term called BAN is emerging. It is the body area network in which the body acts as a network to connect to a medical device. It works by having a sensor connected to the human body and communicating electronic signals to the receiving device much like electrodes are connected to a human body. The sensor can be a passive device (does not require power) or an active device (requires power). A new innovation from STMicro can energize an active sensor without using a battery. The M24LR16ER product is based on RFID technology, which receives power from a remote controller sending RF signals to the sensor.

While all the companies above focus on many homecare devices, Intel is taking a different approach by offering point-of-care stations and hospital bedside entertainment systems based on the Atom processor. These are embedded devices with new applications. The Intel-based Point-of-care system from Kontron is such an application.

Another vision Intel has is to enable developers to build high-end fitness machines where a PC-like display is mounted on a treadmill that would communicate with sensors or devices worn by the users. This provides feedback to the users while they are running on the machine. Additionally, the high-end graphics display can provide personal entertainment making exercising more fun.

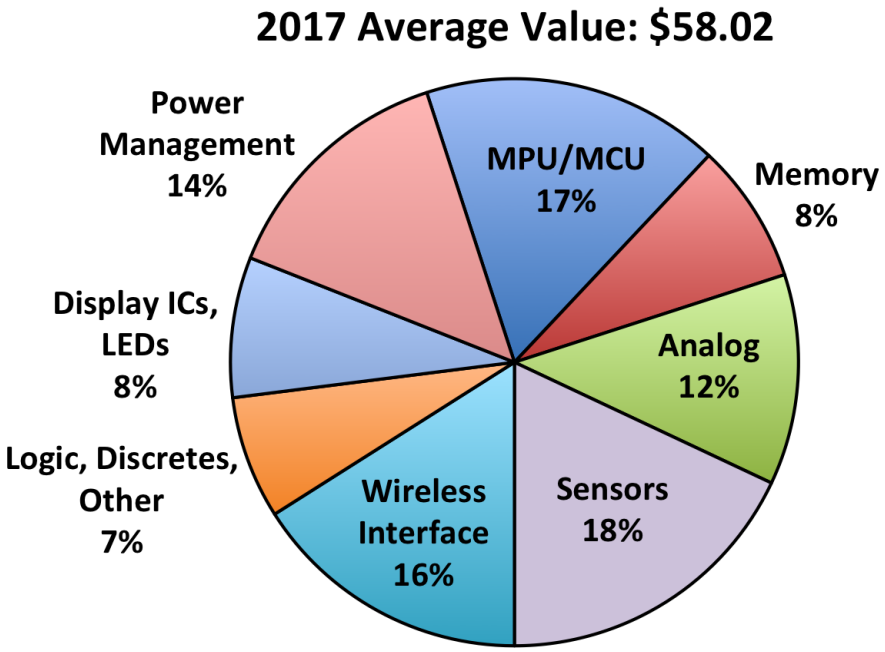
Table - Semiconductor solutions by segments

Product Offerings	Analog Device	Freescale	Infineon	Intel	Renesas	STMicro	Texas Instruments
Cardio exercise machine			■	■			
Digital stethoscopes		■				■	■
Digital thermometer		■				■	■
Digital X-ray	■						
Digital weight scale		■				■	
ECG/EEG/EKG Electrocardiogram devices	■	■	■			■	■
Glucose meter		■	■		■	■	■
Insulin pump		■				■	■
MEMS	■	■				■	■
Point-of-care stations				■			
Pulse oximeter	■	■	■			■	■
Pulse/blood pressure monitor	■	■			■	■	■
Ultrasound and scanning devices	■					■	■

Source: DECISION Etudes & Conseil

iii. Semiconductor content in wireless mobile medical devices

Pie chart – Semiconductor content in wireless mobile medical devices



Source: IC Insights

The pie chart above breaks down the semiconductor content value in a typical wireless mobile medical device. ICs accounted for a little more than three-quarters of the estimated €48.8 semiconductor value in these systems in 2017, with the rest coming from discretes (transistors, diodes, etc.), light- emitting diodes, and sensor chips, such as MEMS-based accelerometers and pressure sensors.

1.1.6 Appendix: NACE, Prodcom, NAICS (USA) codes

NACE

- 26.6 Manufacture of irradiation, electromedical and electrotherapeutic equipment

- 26.60 Manufacture of irradiation, electromedical and electrotherapeutic equipment

Prodcom	**Medical electronics**
	Apparatus based on the use of X-rays, for medical, surgical, dental or veterinary uses (including
26601115	radiography and radiotherapy apparatus)
26601119	Apparatus based on the use of X-rays (excluding for medical, surgical, dental or veterinary use)
	Apparatus based on the use of alpha, beta or gamma radiations, whether or not for medical
26601130	Surgical, dental or veterinary uses, including radiography or radiotherapy apparatus
26601150	X-ray tubes (excluding glass envelopes for X-ray tubes)
26601170	X-ray generators, high tension generators, including parts of HS 9022
26601280	Electro-diagnostic, apparatus (excluding electro-cardiographs), n.e.c.
26601439	Parts and accessories of hearing aids (excluding for headphones, amplifiers and the like)
26601450	Pacemakers for stimulating heart muscles (excluding parts and accessories)

US NAICS codes

- 334510 Electro-medical and Electrotherapeutic Apparatus Manufacturing

  Electro-medical equipment (NAICS 334510) represents the third largest subsector (17 percent of VOS) and accounts for a variety of powered devices, including pacemakers, patient-monitoring systems, MRI machines, diagnostic imaging equipment (including informatics equipment) and ultrasonic scanning devices.

- 334517 Irradiation Apparatus Manufacturing

  Irradiation apparatus (NAICS 334517); about 8 percent of VOS, includes X-ray devices and other diagnostic imaging as well as computed tomography equipment (CT).

Annex 5 - Telecommunications

Overview

- **Market overview**

Telecommunication equipment manufacturers supply hardware, software and services mainly associated to mobile but also fixed networks. Telecommunication infrastructures constitute the backbone of every economy, enabling economic development and innovation.

The telecommunications infrastructure market is highly concentrated and competitive. And this concentration has increased over the past years following the consolidation of telecom services that took place after the liberalization of national telecommunication markets.

With users demanding always more mobility, performance and flexibility, carriers faced increasing competition. In order to win greater agility and flexibility, carriers had no choice but to build more interconnections within large-scale carrier networks. Thus, an ecosystem of services providers and peers is emerging.

Today, Network Functions Virtualizations (NFV) and Software Defined Networking (SDN) help carriers' networks to transform, enabling the telecommunication industry to prepare for 5G and IoT networks.

- ***Market Drivers***

The telecom market has been driven by several factors:

- The expanding demand for mobile communication
- Digital transformation enabling higher data transfer rates
- Semiconductors
- Security
- Power consumption

- ***World Production & Key Players***

Production of communications equipment in Europe has more than halved since 2010, and the same is true of infrastructure equipment. The USA have succeeded in more or less maintaining their production, although all "historic" telecommunications equipment manufacturing countries or regions have been dwarfed by the surge of production in Asia and in particular in China.

Figure – World production of all communications equipment (in billion euros)

	2012	CAGR 2012-2017	2017	% Share 2017
Europe	22,3	-8,3%	14,4	3,6%
USA	29,3	-7,1%	20,3	5%
Japan	24,8	-8,5%	16,0	3,9%
China	170,8	4,0%	208,0	51,3%
Other Asia	67,3	11,2%	114,4	28,2%
Rest of World	23,6	6,4%	32,2	8%
Total World	**338,1**	**3,7%**	**405,2**	**100%**

Sources: Eurostat Prodcom, US Census, JEITA, DECISION estimates

In 2017, infrastructure equipment represented 42% of the total communications equipment production compared to 58% for mobile and other terminal.

Table - Telecom infrastructure and network equipment suppliers (in billion euros)

Company	Country	2012	2016	2017	Growth 2016-2017
Huawei	China	21.2	71.2	77.3	9%
Cisco	USA	35.8	49.3	48.0	-3%
Nokia (including Alcatel-Lucent)	Finland	27.8	21.8	20.5	-6%
ZTE	China	7.2	13.8	14.3	4%
Ericsson	Sweden	26.2	11.3	13.0	15%
Samsung	South Korea	4.0	5.0	5.4	8%
NEC Corporation	Japan	6.9	5.6	4.5	-20%
Juniper Networks	USA	2.5	2.3	2.3	-0.4%
Fujitsu	Japan	2.8	2.1	1.9	-10%

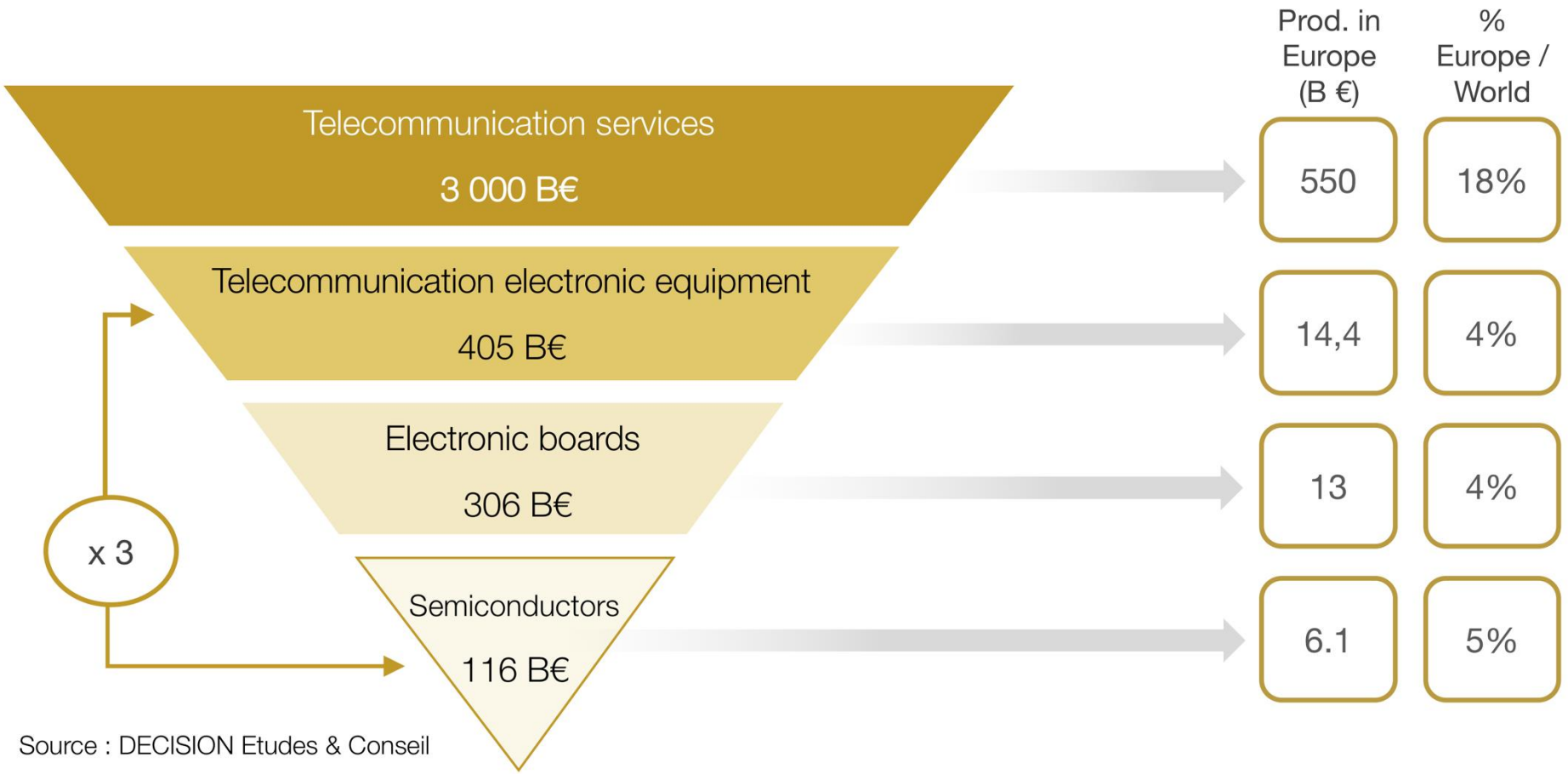
Source: DECISION, from companies' annual reports

The top ten telecommunications infrastructure suppliers are predominantly Asian (China 2, Japan 2, South Korea 1), followed by the Americans (2 companies) and the 2 Europeans in the top 5.

In the Carrier Networks Segment, market leaders are Huawei (#1) followed by the European Nokia (#2) after the acquisition of the equipment manufacturer Alcatel-Lucent in 2016. Ericsson is ranked (#3), before the Japanese NEC (#4) and the Chinese ZTE (#5).

In the Telecoms Software Systems and Services segment, the major suppliers are predominantly US-based with the undisputed market leader Cisco followed by Fujitsu (#2) and Juniper Networks (#3). Ericsson and Huawei are also growing rapidly on this segment.

Diagram - Electronic and SC Industry Value Chain in 2017 - Telecommunication



- ***Telecommunication infrastructure production in Europe***

Production of communications equipment in Europe has more than halved since 2010, and the same is true of infrastructure equipment. The USA have succeeded in more or less maintaining their production, although all "historic" telecommunications equipment manufacturing countries or regions have been dwarfed by the surge of production in Asia and in particular in China.

Table – Communications equipment: European production in value (in billion euros)

	Total	Infrastructure	Handsets	Broadcasting	Parts
2010	**28 813**	12 872	9 009	4 230	2 700
2011	**25 839**	12 915	6 697	3 627	2 600
2012	**23 393**	14 418	3 000	3 269	2 705
2013	**13 208**	6 011	1 700	2 682	2 812
2014	**11 866**	5 862	849	2 392	2 761
2015	**11 896**	6 463	290	2 577	2 564
2016	**12 314**	6 638	342	2 333	3 000

Sources: Eurostat, DECISION Études & Conseil

- ***News***

- In 2017, Nokia started manufacturing "5G-Ready" multiband base stations in a production site in India. AirScale base stations, Nokia's leading technology, convinced several countries. The Finnish company said this is the first triple band radio. 700MHz, 3.6GHz, 26GHz are the three bands that have been selected by Europe in order to launch the 5G network. Nokia and T-Mobile are leading the nationwide 5G networks in the USA. Nokia will provide transport network and future 5G networks in China as well. They also use the beamforming technique and massive MIMO antennas.

- Korea Telecom and Ericsson, during the 2018 Olympic Games, plan to use beamforming technology that will enable mmWaves transmissions to spread optimally in both urban and rural areas.

- Qualcomm has created the 5G modem IC Snapdragonx50, continuing to be a mobile industry leader by reaching mobile Internet speeds of 1GB/s. The Snapdragonx50 chip will be able to reach higher Internet speeds when the 5G network will be rolled out entirely, according to the American company. This modem fits to smartphones equipped with 2 antennas.

- The leading Chinese telecom equipment suppliers Huawei and ZTE are investing heavily in R&D and are developing technologies for 3GPP's Phase 2 release of 5G specifications. They focus on New Radio Network and network architecture solutions leading to massive connections for machines and IoT or autonomous vehicles.

Key messages:

Telecom infrastructure suppliers are facing a similar revolution to the one that affected the computer industry in the 1990s with the generalization of IP-based digital communications. From a supplier perspective, the impact is massive and multi-dimensional:

- *Manufacturing*

On the manufacturing side, the commoditisation of infrastructure equipment combined with the competition of low cost players is pushing to more sub-contracting to EMS by traditional OEMs.
This trend to outsource an increasing share of production to EMS is not new to the telecom industry but will be amplified in the coming years due to the technological shift towards all-IP based network solutions.

Cisco for example, coming from the computer industry, is particularly performing in the telecom market with a fabless industrial model.

- *R&D*

As far as R&D is concerned, the pressure will continue to be strong on new product development and increasingly concentrated on software development rather than hardware.
Due to the higher complexity and heterogeneity of network architecture, OEMs will have to develop innovative eco-systems gathering content producers, start-ups and service companies in order to provide comprehensive solutions responding to market needs.

- *Integration*

In a commoditised telecom equipment industry, the competitive advantage of traditional OEMs no longer relies on their capacity to develop and produce equipment, but on their capacity to integrate equipment from different vendors in order to provide comprehensive solutions to their clients.
In such a context services and applications (security, multimedia, billing, intermediation, network maintenance and upgrade, etc.) take an increasing role in the global value proposition of infrastructure suppliers.

- *Network Virtualization*

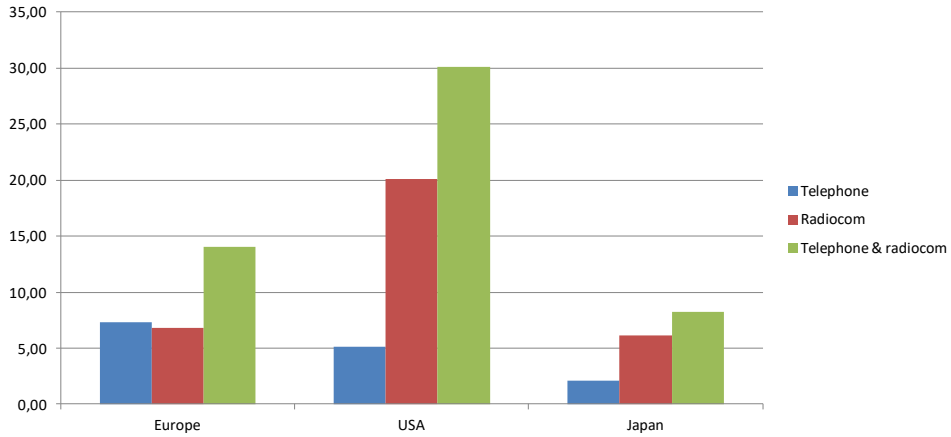
Carriers will also outsource more and more network management operations to their equipment suppliers, which will temporarily put pressure on OEMs to reorganize these operations and increase their productivity.

- This new organisation will open new opportunities for players who could target specific economic or industrial sectors, fulfilling particular needs proper to the industries needs.
- There may be new intermediaries in the value chain, positioned downstream of network operators. They could play the role of bundlers and repackagers for industries or economies. In order to optimize the efficiency of such a new value chain, operators and new entrants will gain at synchronizing their services to enhance connectivity services for specific industries.

- New actors upstream in the value chain could emerge as well for mobile networks. Operators could see an opening in dense urban areas where networks have to support a growing densification of the network. Investing in 5G infrastructures for specific sectors, traditional operators could be in competition with these new entrants.

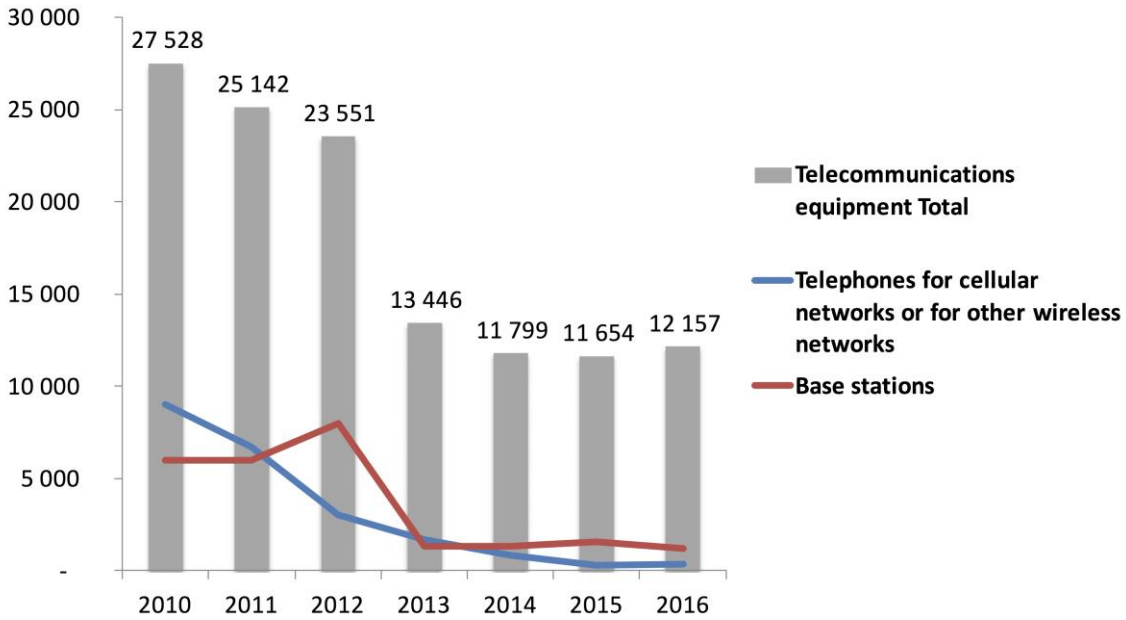
- The overall competition will be led by the orchestration of services and network (NFV and SDN), delivering the most efficient and fast connectivity.

Bar charts – Communications equipment production 2016 (Bn €)



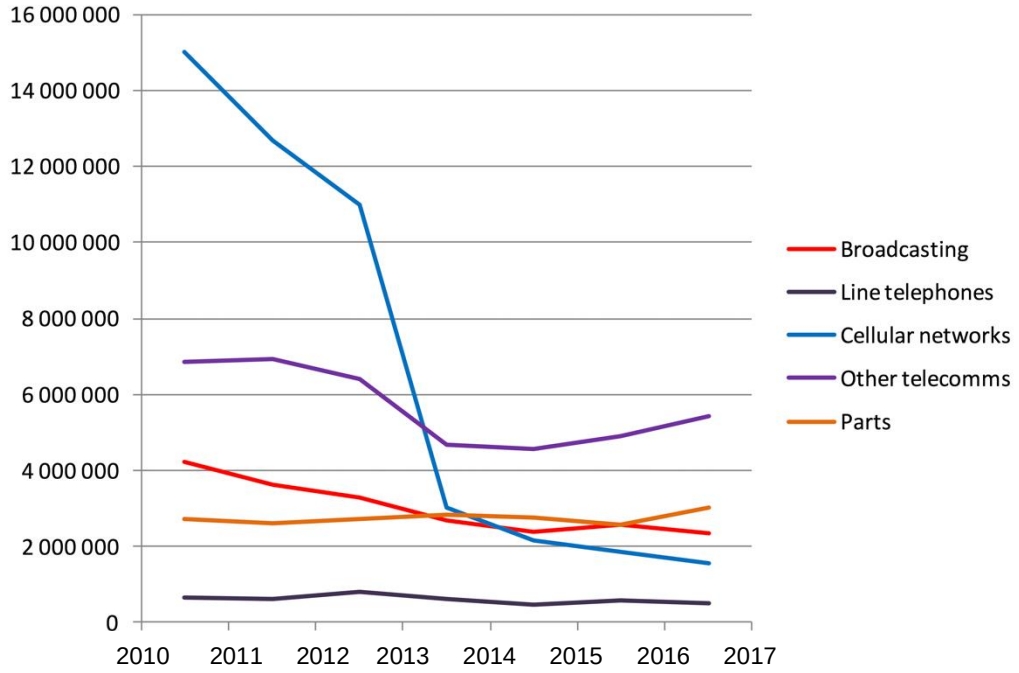
Source: DECISION Études & Conseil, Eurostat, US Census, JEITA

Bar charts – European Telecommunication Equipments Production (Million €)



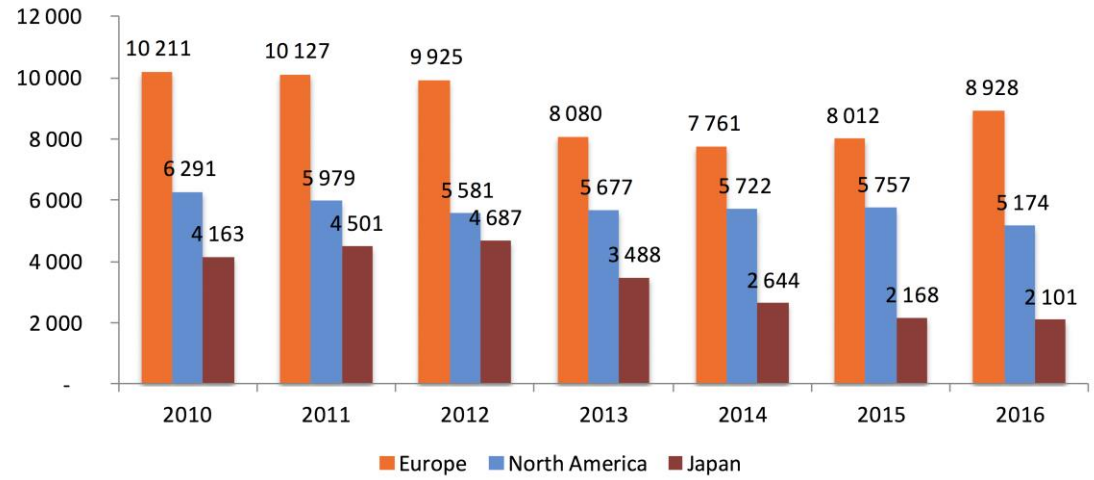
Source: DECISION Études & Conseil, Eurostat

Figure – European Communication Equipments Production (K €)



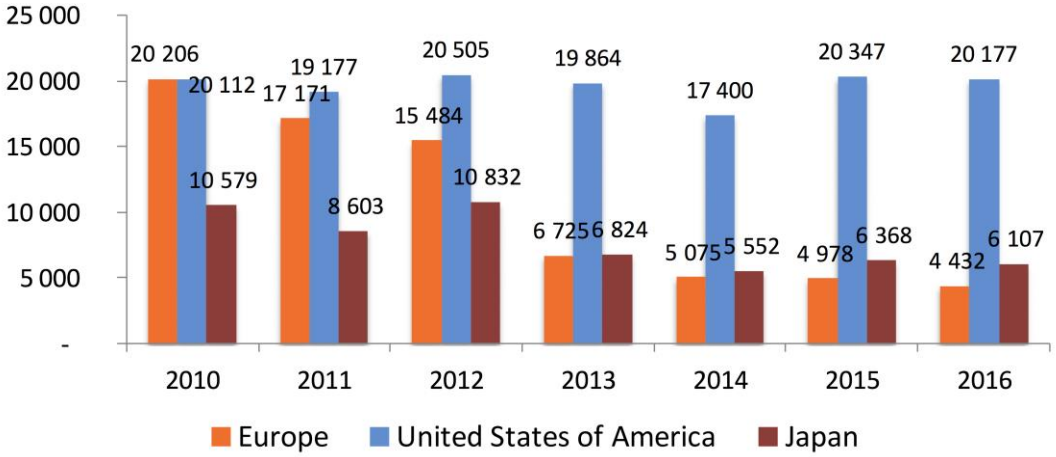
Source: DECISION Études & Conseil, Eurostat

Figure – Line Telephone Equipment Production in Value (Million €)



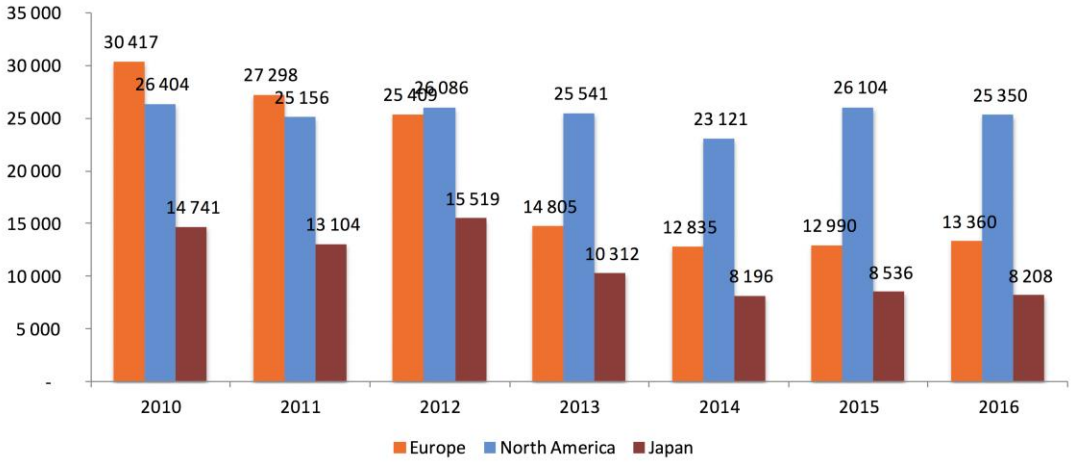
Sources: DECISION Études & Conseil, Eurostat, US Census, JEITA

Figure – Radiocommunication Equipment Production in Value (Million €)



Sources: DECISION Études & Conseil, Eurostat, US Census, JEITA

Figure – All Communication Equipment Production in Value (Million €)



Sources: DECISION Études & Conseil, Eurostat, US Census, JEITA

1.1.1 Telecommunication Infrastructures & Networks

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

Modern communication technology results from the convergence of two industries: voice communications offered by the century-old telecommunications industry, and digital data communications supplied by the younger data network industry. Two categories of products are necessary to realize a communication network: infrastructure and terminals.

- **Communication infrastructures** are made of networks. There are networks addressing the traditional fixed land lines, and now networks addressing the mobile phones, both types comprising three parts: transport, core network, and access network. Coming from the IT environment are also private networks (Local Area Networks). All of these networks are now linked together.
- From an end-user perspective, **telecommunication networks** either address telecom operators (Carriers) offering fixed and more recently mobile telecom services to a large client base, or private companies that require a dedicated and customized telecom network infrastructure tuned to their specific activity (banking, transport operators, retail & logistics etc.)

Historically, these two segments of the telecom infrastructure industry were separated from each other as well by technology and players. Enterprise networks were essentially addressed by the Data Processing industry with market leaders like the Americans Cisco or Juniper while Carriers deployed purely telecom-based technologies using voice switching with leading infrastructure suppliers such as the Europeans Ericsson and Nokia, and the Chinese newcomer Huawei.

Parallel to that convergence, the development of mobile communications has caused a major revolution and reshuffling on the Infrastructure scene, which will continue with the implementation of 5G. Mobile telephony has enabled massive access to the telephone in regions that had few fixed line infrastructures, and where their financing was problematic. The huge development of communications in recent and coming years is solely due to mobile communications, the fixed land line becoming a niche segment.

The telecommunications infrastructure market is highly concentrated and competitive. And this concentration has increased over the past years following the consolidation of telecom services that took place after the liberalization of national telecommunication markets.

With users demanding always more mobility, performance and flexibility, carriers faced increasing competition. In order to win greater agility and flexibility, carriers had no choice but to build more interconnections within large-scale carrier networks. Thus, an ecosystem of services providers and peers is emerging. Today, Network Functions Virtualizations (NFV) and Software Defined Networking (SDN) help carriers' networks to transform, enabling the telecommunication industry to prepare for 5G and IoT.

Telecommunication Infrastructures

The digital transformation is enabling higher data transfer rates. New technologies have an impact on networks construction. The question on which communication technology is the best for most applications is at the heart of telecommunication company strategies. Indeed, each application scenario supposes particular requirements concerning the range, power consumption, throughput, and network topology. Further considerations include cost, ease of integration, and security. Nowadays, cellular networks are technology driven with the evolution of smartphones and the demand for more data transfer. Another trend that impacts networks comes from companies' demands. With the emergence of cloud computing and big data, network infrastructures have to meet the actual needs of the companies.

The choices of the telecommunications companies will have to arbitrate between key network characteristics such as the size of data transfer and the speed required by the company. Security and power consumption also play a significant role in the choice of network infrastructures. Data transfers can be operated via different communication technologies detailed further.

Wired Communication Technologies

Short and Large Range Wired Technologies

Optical Fiber Networks

Optical fiber is used as a medium for telecommunication and computer networking because light propagates through the fiber with little attenuation compared to electrical signals in metal wires. Moreover, optical fiber is flexible and can be bundled as cables. It is especially advantageous for long-distance communications, allowing long distances to be spanned with few repeaters.

Optical fibre technology enables high speed and high-quality data transfers in both short and large ranges. Reliable and fast, this technology presents many advantages compared to antenna-based microwave infrastructures. Security remains the first concern, fibre communication transits through a cable, and the signal cannot be intercepted outside of the tube without degrading the optical signal. The increasing demand for larger data consumption rates stimulates the demand for optical fibres. The cloudification phenomenon amplifies this effect, enabling consumers to access cloud-based stations, audio video-services, gaming and other services, which require a lot of data in the safest way.

The cost for fibre, principally made of glass is decreasing over time, and costs of maintenance are low.

Wireless Communication Technologies

Short Range wireless communication technologies

It exists several types of short distance communication technologies:

Local Area Networks (LAN)

A local area network (LAN) is a computer network that interconnects *computers within a limited area* such as a residence, school, laboratory, university campus or office building. Ethernet and **Wi-Fi** are the two most common technologies in use for local area networks.

Personal Area Networks (PAN)

A personal area network (PAN) is a computer network for *interconnecting devices centered on an individual person's workspace*. A PAN provides data transmission amongst devices such as computers, telephones, tablets and personal digital assistants. PANs can be used for communication amongst the personal devices themselves, or for connecting to a higher-level network and the Internet (an uplink) where one master device takes up the role as gateway. A PAN may be carried over wired computer buses such as USB.
A wireless personal area network (WPAN) is a low-powered PAN carried over a short-distance wireless network technology such as IrDA, Wireless USB, **Bluetooth** and **ZigBee**.

Long Range wireless communication technologies

Wide Areas Networks are preferred to short range technologies when the latter does not suit long-range performance.

Cellular

A cellular network or mobile network is a communication network where the last link is wireless. The network is distributed over land areas called cells, each served by at least one fixed-location transceiver, but more normally three cell sites or base transceiver stations. These base stations provide the cell with the network coverage, which can be used for transmission of voice, data and others.

The most common examples of cellular networks are the mobile phone (cell phone) networks 2G, 3G, 4G. **4G** was launched in 2012 and uses the Long Tern Evolution (LTE) technology.

In 2019, **5G** is expected to be launched. The fifth generation of cellular network (5G) includes high throughput, low latency, high mobility (to be more responsive) and high connection density. The actual 5G-radio system will not be compatible with 4G. Nevertheless, all 5G devices will need 4Gin order to lean on it for making initial connections.

Evolution of Technology generations in terms of services and performance

Generation	Primary Services	Key Differentiator	Weakness (adressed by subsequent generation)
1G	Analogue Phones Calls	Mobility	Poor Spectral efficiency, major security issues
2G	Digital phone calls and messaging	Security, roaming, mass adoption	Limited data rate- difficult to support internet/e-mail demand
3G	Phone calls, messaging data	Better internet experience	Real performance failed to match type, failure of WAP for internet access
3.5G	Phone calls, messaging, broadband data	Broadband Internet, applications	Tied to legacy, mobile specific architecture and protocols
4G	All-IP services (including voice, messaging)	Fast broadband internet, applications	Not optimised for IoT scaling, limited flexibility to support bespoke services accros industry verticals, inadequate for next generation services
5G	All-IP services, new technology sectors, verticals and end-users	Faster and higher - capacity broadband internet, lower (real time) latency, multy access, multy layered	

Source: GSMA

The cellular networks are financed by operator investments, and their annual market is dependent on the economic situation and also of the evolution of the technology.

The landscape of the mobile networks market is today deeply affected by the aggressive competition between operators, and the resulting evolution of their investment strategies.

Low Power Wide Areas (LPWA)

For the Internet of Things (IoT) a Low-Power Wide-Area Network (LPWAN) or Low-Power Wide-Area (LPWA) network or Low-Power Network (LPN) is a type of wireless telecommunication wide area network designed to allow long range communications at a low bit rate among things (connected objects), such as sensors operated on a battery. The low power, low bit rate and intended use distinguish this type of network from a wireless WAN that is designed to connect users or businesses, and carry more data, using more power. Two dominant providers of LPWAN are **LoRa** and **Sigfox**. LPWA is widely used for the Internet of Things.

Satellites

A communications satellite is an artificial satellite that relays and amplifies radio telecommunications signals via a transponder. It creates a communication channel between a source transmitter and a receiver at different locations on Earth. Communications satellites are used for television, telephone, radio, Internet, and military applications. Use of satellites in mobile telephony could be appropriate for certain geographical areas which are difficult to connect to the Internet, because of physical constraints.

Communication Technology' Characteristics

Infrastructure equipment such as antennae, modems or transmitters serve to receive and transmit different types of frequency bands. The effects of frequency on devices coverage mean that there is an optimal frequency use for specific applications.
The quality and the cost of telecommunications will not be the same depending on the technology used. Geographical parameters can also impact the network choice.

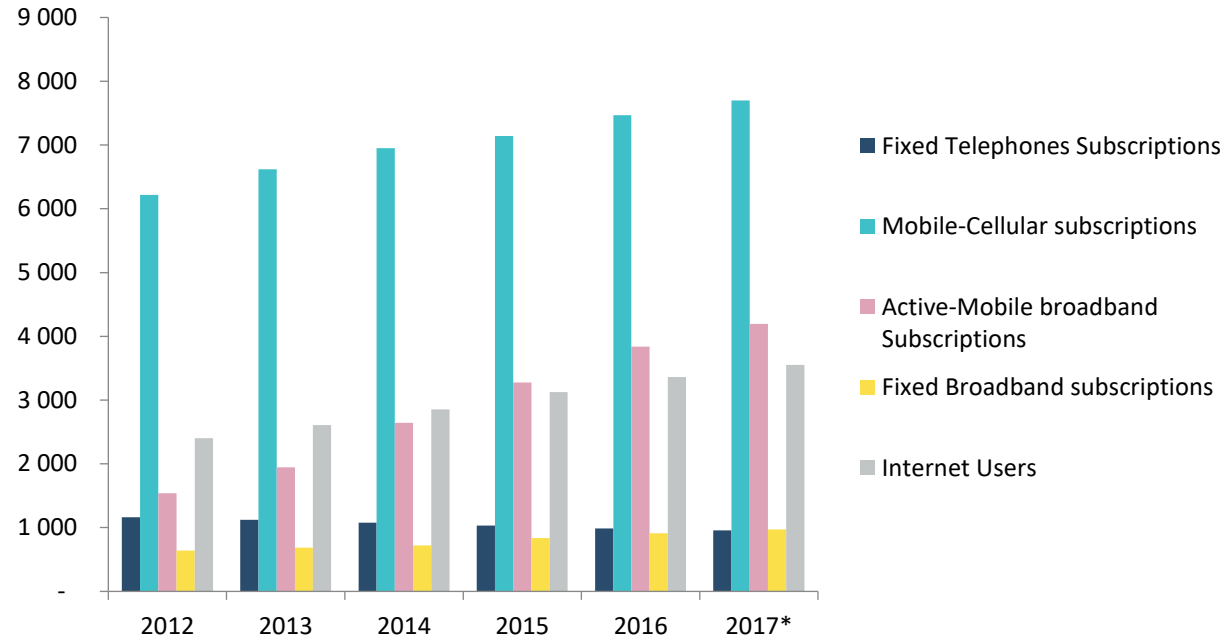
Connectivity Characteristics	Wired Technology	Wireless Communication Technology					
	Optical Fibre Cable	PAN	LAN	Cellular (4G)	Cellular (5G)	LPWA	Satellites
Indoor/Outdoor (1)	Not pertinent	Medium	Medium	High	High	High	Low
Coverage (2)	High	Low	Low	Medium	High	Low	High
Mobility	Low	Low	Low	Medium	High	Medium	High
Throughput (3)	High	Low	Medium	High	High	Low	Low
Security & Reliability	High	Medium	Medium	High	High	Medium	High
Latency (4)	Low	Low	Low	Low	Low	Medium	High
Power Consumption	Low	Medium	Medium	Low	Low	High	Medium
Cost	High	High	High	Medium	High	High	Low
Type of Infrastructure	Optical Fibre Cable	Bluetooth Antennas	Wifi Antennas	4G LTE Antennas	LoRa/Sigfox/LPWA Antennas	LPWA Antennas	Satellites Antennas

Source: London Economics and DECISION
Note: Key connectivity characteristics of communication technologies are summarised in the table, with a RAG rating (red = **weakness** | amber = **medium** | green = **strength**) summarising the overall strengths and weaknesses of these technologies.
(1) Low = No indoor penetration; High = Indoor penetration
(2) Low = only local area coverage (metres); High = Global / regional coverage (1000 km)
(3) Low = < 1Mbps; High = > 1 GBps
(4) Low = > 200ms; High = <10ms

Major Market Characteristics

Most of the world population has now access to mobile telephony, with 7,7 billion mobile subscriptions by the end of 2017. And nearly 3,5 billion people now have access to the Internet. The major market driver today is the access to mobile broadband through the new generations of mobile networks and the corresponding handsets, smartphones and tablets.

Telecom Infrastructure End Users (million units)

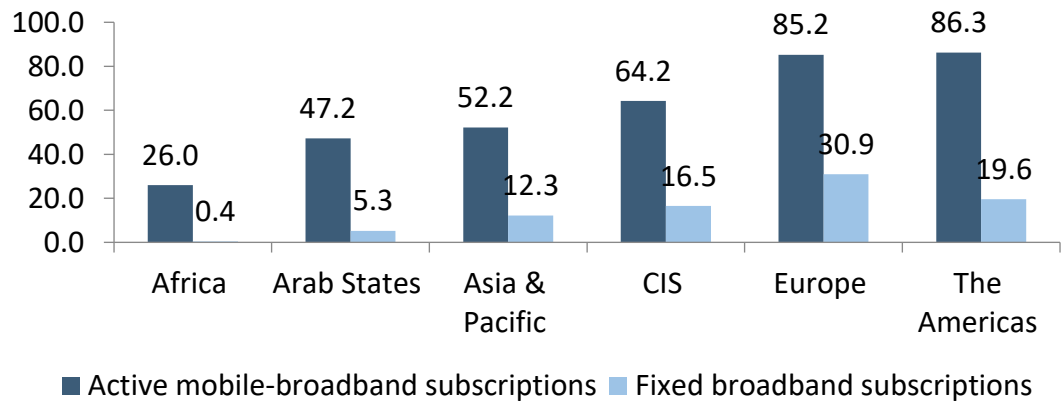


Estimated*
Source: ITU

After the development of the 3G-network coverage (today 75% of the world population), the deployment of 4G networks has started. WiMAX and LTE are the two competing standards released under the 4G names. However, their first versions were not yet fully complying with the IMT advanced requirements on 4G systems, whereas the new versions are or will be. Although mobile penetration is already high, there are still major growth opportunities for mobile infrastructure upgrades.

Access to broadband communications whether fixed or mobile also varies significantly from one region to another, with Europe and the Americas still having the largest penetration per inhabitant. Europe has a penetration rate for fixed broadband that is one and a half times that of the Americas, although its mobile penetration is the same. If this was yo last, it should be an opportunity for European suppliers in this field.

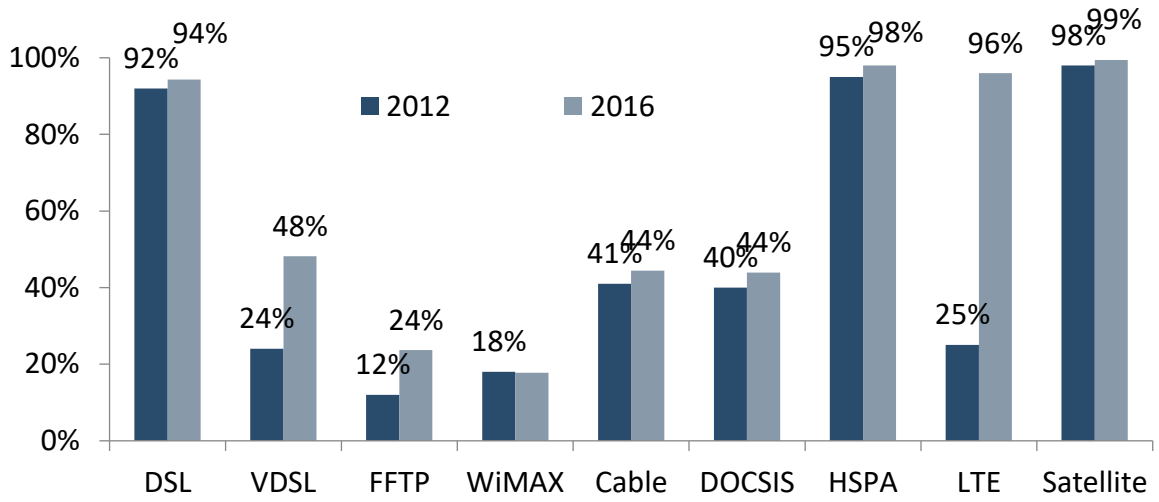
Telecom Infrastructure End Users in 2017* (per 100 inhabitants)



*Estimated
Source: ITU

Driven by the continuous development of broadband access initially through computers and now through smartphones and tablets, new services based on dematerialisation and enriched content are developing at unprecedented pace (Software as a Service, Cloud Computing, Application Platforms, etc.) leading to a massive increase in data traffic worldwide whether fixed or mobile. In Europe, LTE coverage is growing rapidly, reaching about 96% by the end of 2017.

Coverage by Technology in Europe (2012-2016)



Coverage by Technology in Europe (2012-2016)

Technology	2012	2016	CAGR 2012-2016
DSL (Digital Subscriber Line)	92%	94%	1%
VDSL (Very high bit-rate Digital Subscriber Line)	24%	48%	19%
FTTP (Fiber To The Premises)	12%	24%	19%
WiMAX (Worldwide Interoperability for Microwave Access)	18%	18%	0%
Cable (cable TV networks)	41%	44%	2%
DOCSIS (Data Over Cable Service Interface Specification)	40%	44%	2%
HSPA (High Speed Packet Access)	95%	98%	1%
LTE (Long Term Evolution, 4G)	25%	96%	40%
Satellite	98%	99%	0%

Source: Point Topic and European Commission

This is in line with the target fixed by the “Digital Agenda for Europe”: all homes should have access to high-speed broadband of at least 30Mbps by 2020. In North America, the USA have become one of the most advanced LTE markets in the world as CDMA operators have migrated their networks to LTE.

Driven by the fifth mobile generation, and the arrival of 5G cellular networks, data traffic will be on average multiplied by nearly 9 over the next 5 years. Mobile video will be the fastest-growing segment of mobile traffic, encouraged by live video communication adoption.

North-East Asia and Europe are in the lead, before North America, and are expected to remain so during the next five years. However, in the longer-term telecommunications traffic should become proportional to the population and economic activity of the different regions.

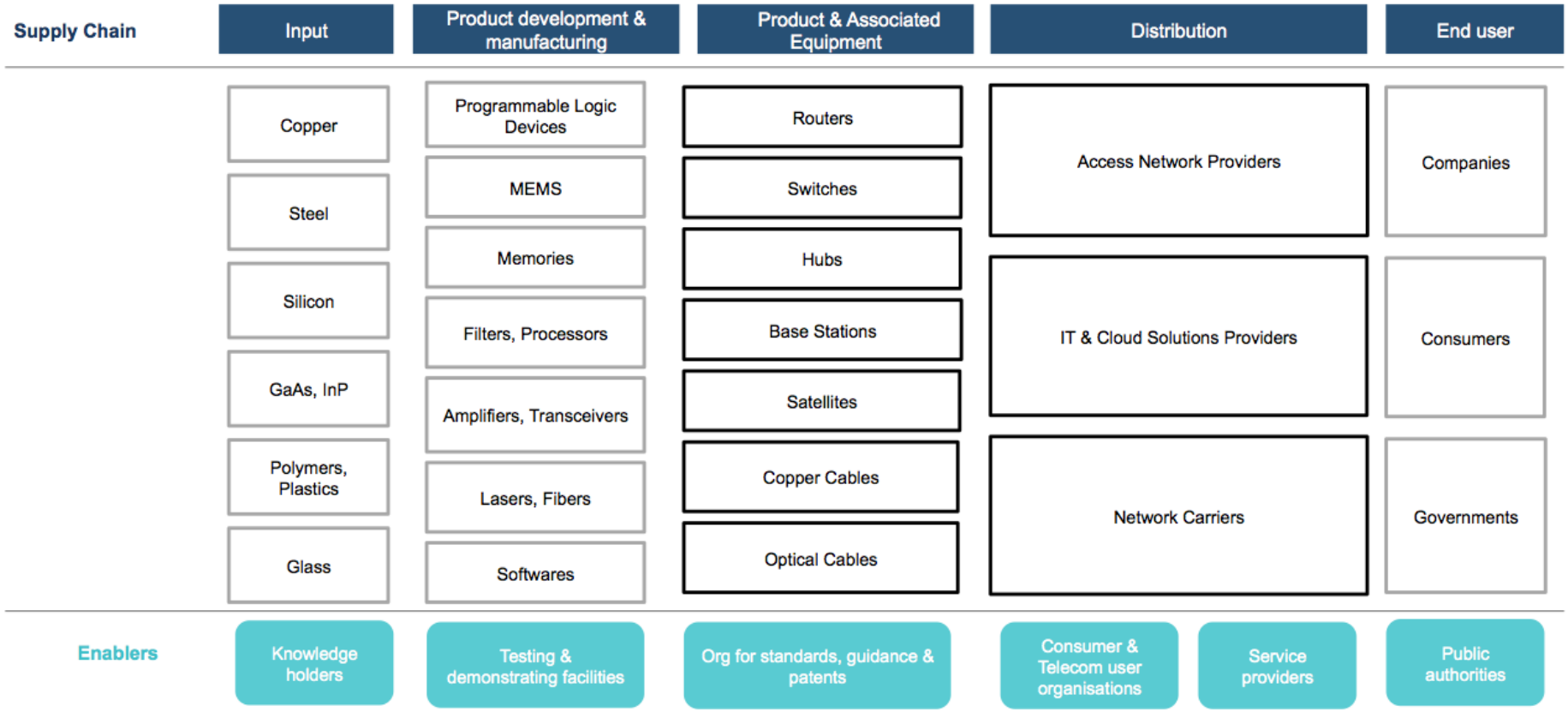
Mobile Data Traffic by region in EB/month*

Region	2016	2017	2023 Forecast***	CAGR 2017-2023**	Multiplier 2016-23
North East Asia	1,9	3,2	21.0	37%	7
Europe	2.0	3.0	21.3	39%	7
North America	1,8	2,6	18.0	39%	7
China (1)	1.0	1,8	15.0	41%	8
South East Asia and Oceania	0,8	1,3	12.0	45%	9
India, Nepal and Bhutan	1.0	1,3	14.0	48%	11
Middle East and Africa	0,7	1,3	14.0	48%	11
Latin America	0,7	1,1	8,9	42%	8
Sub-Saharan Africa (2)	0,3	0,4	4,6	50%	11

Source: Ericsson
* Active devices
** CAGR is calculated on unrounded figures
*** Figures are rounded (see methodology) and therefore summing up of rounded data may result in slight differences from the actual total
(1) These figures are also included in the figures for North East Asia
(2) These figures are also included in the figures for Middle East and Africa

For telecom equipment suppliers, this results in a continuous development of new technologies to provide additional connection bandwidth and new connectivity features both at the core and access network layers, but also in fast growing markets for devices, equipment and software.

Table – Telecommunications infrastructures value chain in 2017



Source: DECISION Études & Conseil

ii. Telecommunication infrastructures in figures 2010 – 2016

A. Methodology notes

European production is measured by Eurostat, who gathers and analyses figures from the national statistical offices across Europe, and publishes them in two distinct sources, the SBS NACE 2 statistics, which give turnover, employees, and other indicators, and the Prodcom statistics, which give production in value and quantity, as well as imports and exports.

There are differences between the Prodcom and the SBS NACE industry database:

- The SBS NACE industry statistics are “activity” statistics, i.e. they measure the activity of “statistical units” (which may be companies or subdivisions of companies) located in the EU. Units are assigned one NACE 4 digits code according to their “principal activity”, i.e. the activity accounting for the most value added (which may be less than 50% when there are more than 2 secondary activities). The whole of the activity of the unit (including secondary activities) is classified under the principal activity code. The database presents various indicators, among which turnover, value added, employees and investment;

- Prodcom data presents the value (in euros) and quantity (in units) produced in the EU in a more detailed 8 digits code (where the four first digits are the same as the NACE code), as well as import-export data. Prodcom.

Therefore, there are 3 different figures that exist and that are supposed to measure the Telecoms Infrastructure production in Europe:

1. **Eurostat SBS Industry database figure: Not presented in this study because considered as irrelevant;**

2. **Eurostat Prodcom database figure: Presented in this study. Europe’s production is estimated at 12.3 B € in 2016;**

3. **DECISION’s figure (that is the final figure retained, highly based on the Prodcom figure with marginal adaptations): Europe’s production is estimated at 13.3 B € in 2016. In the figures presented by DECISION in the pyramids/overview and used to undertake comparisons with the other end-user electronic segments, this figure has been selected and is supposed to provide a precise measure of the production level and location.**

B. Comparison with the other end-user segments

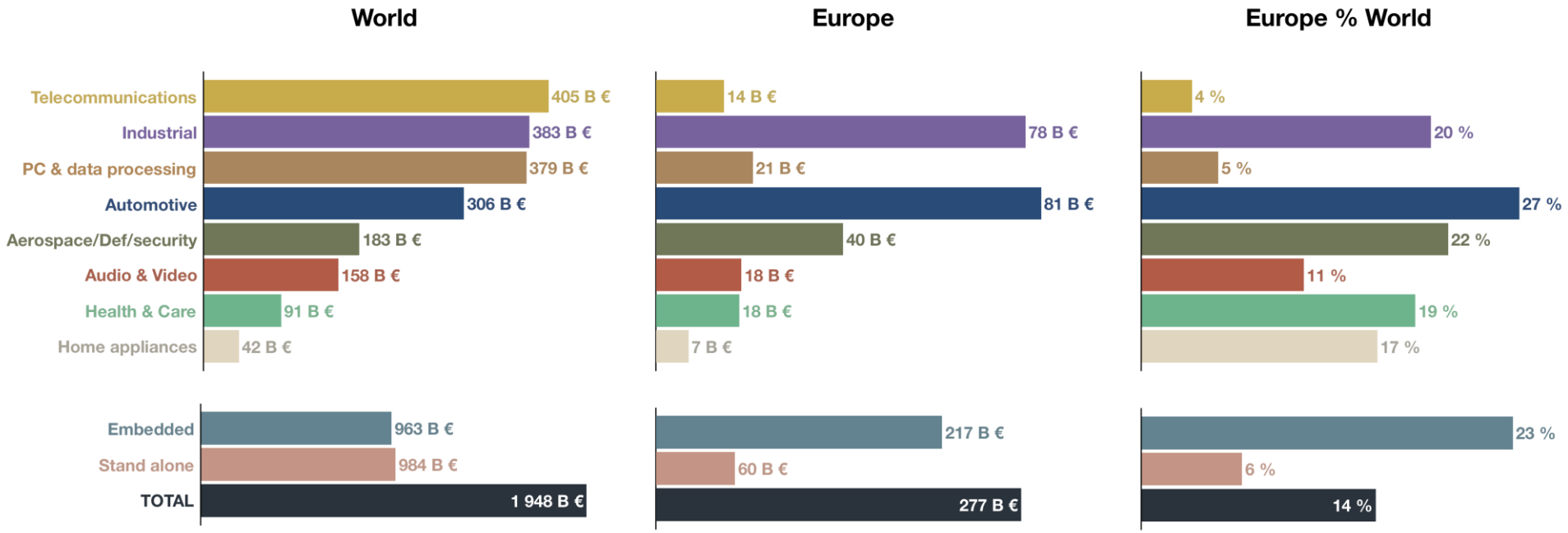
In 2017, the production of electronic equipments dedicated to telecommunication infrastructures accounted for 13.25 B € in Europe and 170.66 B € in the World. In other words, 7.8% of the global production of electronic equipment dedicated to telecommunication infrastructures were taking place in Europe.

As shown in the diagrams above, the total production of telecommunication electronic equipments (including electronics dedicated to telecommunication infrastructures, but also mobile phones and terminals), accounted for 405 B € in 2017. The European production accounted for 14 B € out of this global amount of 405 B €. In other words, Europe represented 3.5% of the global production of telecommunication electronic equipments in 2017.

In 2017, electronic equipments dedicated to telecommunications infrastructures represented 42% of the world production of electronic equipments dedicated to telecommunications (infrastructures, teminals and mobile phones).

On the contrary, in 2017, electronic equipments dedicated to telecommunications infrastructures represented 92% of the European production of electronic equipments dedicated to telecommunications (infrastructure, terminals and mobile phones). Indeed, the European production of mobile phones and terminals fell to 1.1 B € in 2017. The European production of electronic equipments dedicated to telecommunications is therefore now almost completely composed of electronics equipments to telecommunication infrastructures.

Diagrams – Electronic equipment production by segment in 2017 (B€)



Source: DECISION Etudes & Conseil

C. Infrastructures - detailed results

c. Europe’s position in the world

1 - Competitive analysis

Telecommunication equipment manufacturers supply hardware, software and services mainly associated to mobile but also fixed networks. Telecommunication infrastructures constitute the backbone of every economy, enabling economic development and innovation.

The telecommunications market has been driven by increasing demand, due to the explosion of mobile communications, and the succession of generations of mobile and smartphones (4G and 5G). The Internet of Things (IoT) and connected vehicles are major contributors to the growth of demand for telecom infrastructure equipment. Mobile communications require specific equipment (base stations), as well as increased capacity in all the fixed networks.

In Europe, Nokia (Finland, who acquired the Franco-American leader Alcatel-Lucent in 2016) and Ericsson (Sweden) are competing among the major global players. Nevertheless, their revenues are decreasing. The major reasons for this decline are their focus on European and American markets, and the dwindling demand from mobile telecom operators in these regions, as well as the growing price pressure from Chinese and other Asian competitors. Thus, European equipment manufacturers have no choice but to massively engage some restructuring initiatives in order to keep being competitive.

The European telecommunications market is dominated by increasing competition between different equipment manufacturers since the arrival of Huawei in 2004-2005.

Huawei's arrival on the European market has been largely supported by the Chinese government. The China Development Bank has granted an export loan of 20 billion euros to support Huawei's investments abroad. This financial advantage allowed the Chinese equipment manufacturer to challenge its competitors in the European market, winning its first markets in EMEA. Today, the Europe is Huawei's second largest market behind China (with respectively 164 Billion CNY and 305 Billion CNY of revenues those regions in 2017), and the company continues to gain market share. Nokia retains an important position in this market, equipping a large part of the European market. More particularly in France, the company supplies 45% of network equipment.

The telecommunications market is intrinsically linked to the equipment / operator relationship. In Europe, operators have multiplied allowing a fall in subscriber prices for consumers. With 120 operators in Europe against 4 in the US, Europe has a much lower investment capacity and expects the return on investments of the infrastructure they put in place.

For future investments related to 5G, European operators are placing themselves in an observer position, which risks placing them in a position of consumer in this new dynamic of the telecom market.

As for the export market, the issues related to the supply of base stations are at the heart of concerns. In Africa in particular, equipment is fueled by fuel, a resource that attracts lust. It is therefore important for Nokia to develop base stations that operate on solar energy.

Europe should pay attention at the following points:

- Chinese companies have now caught up with or even surpassed the European leaders in telecommunications. For this they benefited from support and protection from the Chinese government, which allowed them to establish a comfortable position in the domestic market and then conquer the European market;
- Europe holds several opportunities in open innovation markets, where R & D can be widely valued. Securing communications remains an added advantage for European equipment manufacturers facing Chinese equipment manufacturers;
- The launch of infrastructure projects via PPPs in Europe has disadvantages in terms of speed. Unlike the United States or Asia where the launch of projects is only a matter of weeks, it can take several years in Europe. This difference in pace could be an advantage for the United States and Asia in this race for connectivity;
- European sovereignty for the management of future networks should be considered with great care. The discussions organized for European decision making are difficult without a representative of Huawei.

2 - Figures

Production of communications equipment in Europe has more than halved since 2010, and the same is true of infrastructure equipment. The USA have succeeded in more or less maintaining their production, although all “historic” telecommunications equipment manufacturing countries or regions have been dwarfed by the surge of production in Asia and in particular in China.

World production of all communications equipment (Bn€)

	2010	CAGR 2010-2016	2016	Share 2016
Europe	30,0	-13,3%	14,2	3,5%
North America	38,5	-9,4%	21,3	5,3%
Japan	34,4	-10,8%	17,3	4,3%
China	130,5	8,2%	210,9	52,2%
Other Asia	48,5	14,4%	108,7	26,9%
Rest of World	12,6	16,6%	31,6	7,8%
Total World	**294,4**	**5,4%**	**403,9**	**100%**

Sources: Eurostat Prodcom, US Census, JEITA, DECISION Études & Conseil

World production of Telecommunications total infrastructure equipment (M€)

	2010	CAGR 2010-2016	2016	Share 2016
Europe	19.7	-6.4%	13.3	8%
North America	20.8	-2.8%	17.6	11%
Japan	18.8	-4.2%	14.5	9%
China	50.2	6.5%	73.4	45%
Other Asia	17.7	8.0%	28.0	17%
Rest of World	8.2	13.0%	17.1	10%
Total World	**135.4**	**3.3%**	**163.9**	**100%**

Sources: Eurostat Prodcom, US Census, JEITA, DECISION Études & Conseil

d. European activity and production statistics

1 - The Eurostat SBS Industry database

Activity statistics are given in the Eurostat SBS (Structural Business Statistics) database for the NACE code 26.30, which includes all handsets as well as infrastructure equipment.

European industrial base in Telecommunications by Member State (%)

Country	Production (%)		Employees (number)	
Year	**2010**	**2015**	**2010**	**2015**
Finland	42.15	33.24	25 586	13 454
Germany	8.07	14.01	25 669	23 411
France	11.67	11.05	24 376	15 018*
United Kingdom	5.00	8.39	:	:
Italy	8.09	7.05	23 910	12 631
Hungary	9.11	6.64	15 961	11 742
Poland	1.64	4.61	11 361	10 971
Spain	1.26	1.81	6 058	4 774
Switzerland	2.18	1.71	:	:
Estonia	0.94	1.60	2 302*	2 302
Others	9.88	1.18	52 932	30 427
Total	100.0	100.0	166 801	124 730

* Break in time series, estimated value
Source: Eurostat, DECISION

Even though Nokia dropped the manufacture of mobile devices, Finland remains first ranked in communications equipment manufacturing. Unlike Ericsson whose main area of activity and investment remains mobile communication networks (both hardware and software), Nokia has a more diversified strategy and is well positioned in fixed network equipment. Representing 13% of the total European communications manufacturing, Finland still invests in ICT. European manufacturers need to invest in innovative products and technologies. Positioning in the 5G standards' leaders, European manufacturers will ensure increasing revenues not before 2019 and the launch of 5G networks. Telecommunication Operators invest proportionally less in GSM/EDGE (2G), WCDMA/HSPA(3G) and more in IoT enabled networks.

European industrial base in Telecommunications by Member State

Country	Value added (M€)		Investment (M€)	
Year	2010	2015	2010	2015
Germany	1 906.9	2 030.0	103.5	150.4
France	1 879.0	1 444	67.2	68.2
Italy	1 568.7	1 746.2	68.6	57.9
United Kingdom	1 436.0	1 746.2	52	94.4
Finland	1 169.3	304.5	200.2	177
Switzerland	607	260.7	6.3	2.6
Belgium	537.9	173.3	17.9	12.8
Sweden	532.1	532.1	29.3	29.3
Hungary	526.1	472.2	53.3	24.1
Spain	367.6	269.4	26.3	30.8
Others	1 407.2	1 581.3	161.7	167.9
Total	11 937.3	9 749.1	786.3	815.4

Source: Eurostat, DECISION Études & Conseil

European industrial base in Telecommunications by Member State

Country	Value added/Production (%)		Production/Employee (k€)	
Year	2010	2015	2010	2015
Germany	0.06%	0.06%	130.40	135.08
France	0.07%	0.06%	112.35	160.21
Finland	9.86%	0.18%	0.46	12.87
Italy	0.08%	0.07%	83.34	112.78
Hungary	0.01%	0.11%	328.45	36.02
Poland	0.25%	0.26%	9.80	12.65
Czech Republic	0.07%	0.06%	46.34	48.54
Romania	0.81%	0.05%	2.13	28.44
Spain	0.12%	0.06%	49.76	89.61
Sweden	2.23%	0.10%	6.64	147.43
Others	0.16%	0.11%	78.10	37.04
Total	0.04%	0.08%	172.74	95.37

Source: Eurostat, DECISION Etudes & Conseil

2 – European Production figures (prodcom database)

European Prodcom figures (2010-2016) (1/2)

Prodcom Definition	2010	2011	2012	2013	2014	2015	2016	CAGR 2010-2016
Broadcasting & media equipment	**4 230 618**	**3 627 712**	**3 269 676**	**2 682 900**	**2 392 872**	**2 577 820**	**2 333 069**	**-9%**
Transmission apparatus for radio-broadcasting and television, with reception apparatus	2 821 114	2 386 121	2 200 726	1 696 875	1 431 645	1 600 000	1 434 393	-11%
Transmission apparatus for radio-broadcasting and television, without reception apparatus	1 076 819	913 210	736 597	634 356	562 794	540 817	446 904	-14%
Television cameras (including closed circuit TV cameras) (excluding camcorders)	332 685	328 381	332 352	351 669	398 433	437 003	451 773	5%
Cellular networks	**15 009 586**	**12 697 267**		**3 023 602**	**2 161 759**	**1 847 573**	**1 536 764**	**-32%**
Telephones for cellular networks or for other wireless networks	9 009 586	6 697 267	3 000 000	1 700 000	849 459	290 402	342 817	-42%
Base stations	6 000 000	6 000 000	8 000 000	1 323 602	1 312 300	1 557 170	1 193 947	-24%
Other telecommunications equipment	**6 872 377**	**6 915 001**	**6 418 556**	**4 688 312**	**4 549 913**	**4 906 198**	**5 444 071**	**-4%**

Source : Eurostat prodcom database

European Prodcom figures (2010-2016) (2/2)

Prodcom Definition	2010	2011	2012	2013	2014	2015	2016	CAGR 2010-2016
Machines for the reception, conversion and transmission or regeneration of voice, images or other data, including switching and routing apparatus	5 684 720	5 840 723	5 368 665	3 557 113	3 270 758	3 428 259	3 778 224	-7%
Other apparatus for the transmission or reception of voice, images or other data, including apparatus for communication in a wired or wireless network (such as a local or wide area network), other than transmission or reception apparatus of HS 8443, 8525, 8527 or 8528	1 187 657	1 074 279	1 049 891	1 131 200	1 279 154	1 477 939	1 665 847	6%
Aerials & parts	2 700 000	2 600 000	2 705 210	2 812 890	2 761 696	2 564 090	3 000 000	2%
Parts of electrical telephonic or telegraphic apparatus	2 700 000	2 600 000	2 705 210	2 812 890	2 761 696	2 564 090	3 000 000	2%
Total Telecommunication Equipments	**28 812 582**	**25 839 980**	**23 393 442**	**13 207 704**	**11 866 239**	**11 895 681**	**12 313 904**	**-13%**

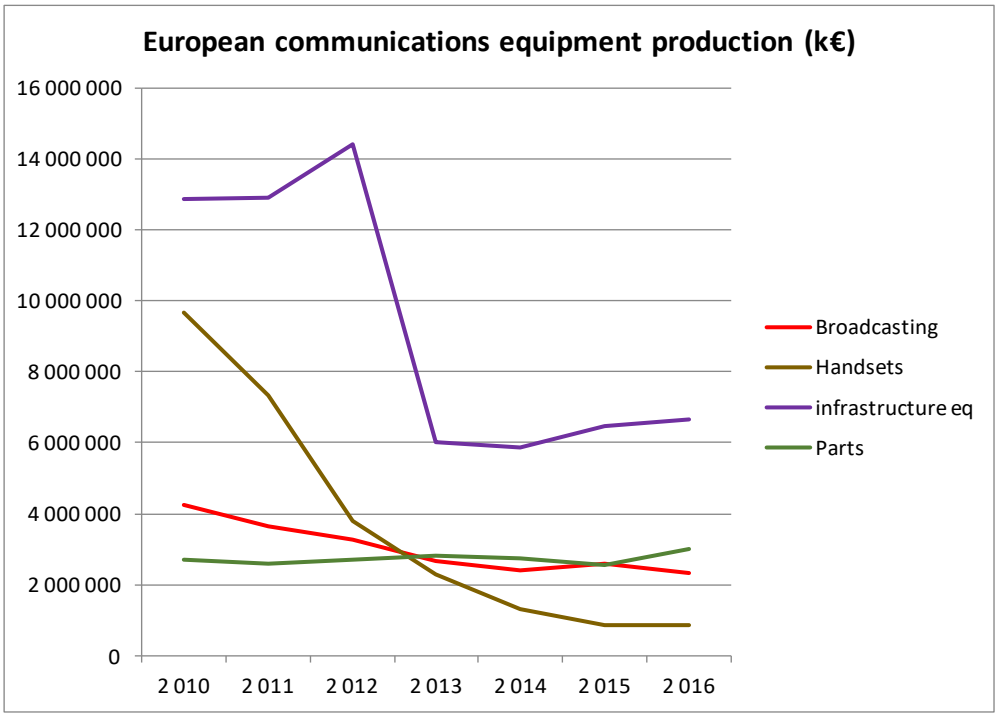
Source : Eurostat prodcom database

The Eurostat Prodcom database provides detailed production figures for the communications sector, and in particular for infrastructures equipment.

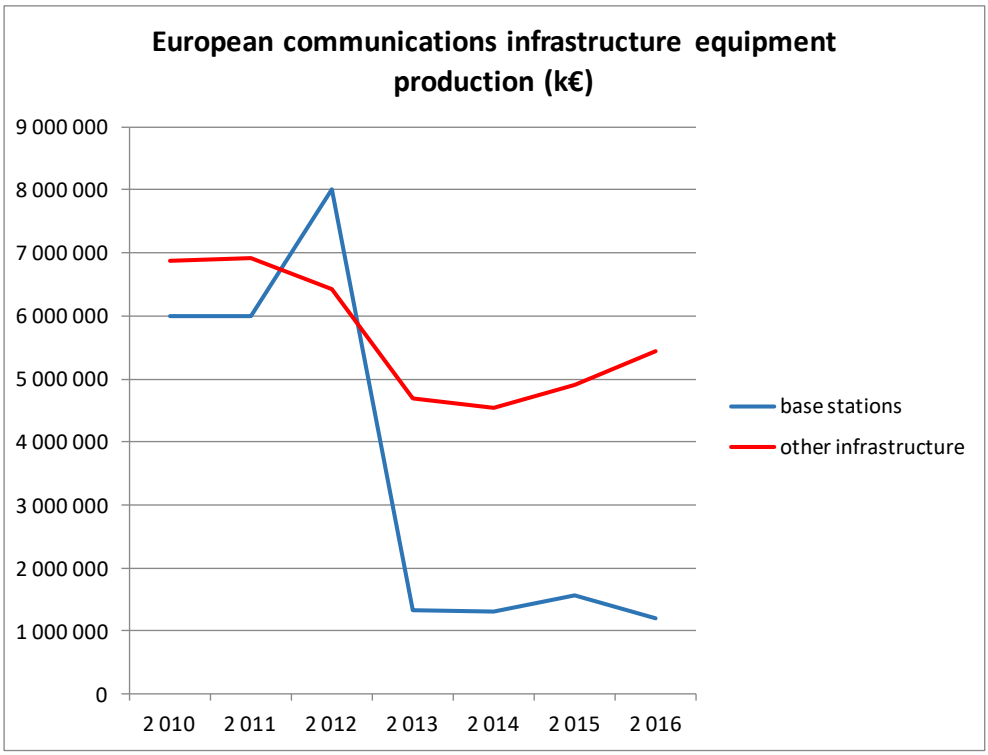
Communications equipment: European Production in Value (M€)

	Total	Infrastructure	Handsets	Broadcasting	Parts
2010	**28 813**	12 872	9 009	4 230	2 700
2011	**25 839**	12 915	6 697	3 627	2 600
2012	**23 393**	14 418	3 000	3 269	2 705
2013	**13 208**	6 011	1 700	2 682	2 812
2014	**11 866**	5 862	849	2 392	2 761
2015	**11 896**	6 463	290	2 577	2 564
2016	**12 314**	6 638	342	2 333	3 000

Source: Eurostat, DECISION Études & Conseil



Source : Eurostat prodcom database



Source : Eurostat prodcom database

iii. Company positioning

Major Telecommunication equipment suppliers by segment in 2017

Market segment	Equipment	Product	Suppliers	
			European	*Other*
Handset	**Terminal**	Smartphones		Apple, Samsung, Huawei, Xiaomi
Carriers Network	**Wireless**	GSM; CDMA; WCDMA; WiMAX; LTE; Base stations	Ericsson, Nokia,	Huawei, Samsung, ZTE
	Fixed Access	Integrated Service Access Platform; DSL	Ericsson, Nokia	Huawei,
	Core Network	Voice Communication, Packet Core, Convergence User Data	Ericsson	Cisco, Huawei
	Bearer	Optical Fibers, Copper Cables, Routers, Switches	Nokia	ZTE, Corning, Huawei
Telecoms Software Systems, Services & Others	**Cloud-Computing & IT**	Cloud Computing Infrastructure, Operating Support Systems, Servers, Storage	Nokia	Oracle, IBM, Cisco, Avaya, Huawei, Ciena
	Services	Maintenance Support Services, IT Integration Services	Orange, BT, DT Nokia	Ventus
	Energy & Infrastructure	Telecoms Power Systems, Telecoms Towers, UPS	Siemens, ABB, Schneider Electric	IBM, GE Industrial Solutions, Huawei

Source: DECISION Etudes & Conseil

Telecom infrastructure suppliers are facing a similar revolution to the one that affected the computer industry in the 1990s with the generalization of IP-based digital communications. From a supplier perspective, the impact is massive and multi-dimensional:

- *Manufacturing*

On the manufacturing side, the commoditisation of infrastructure equipment combined with the competition of low-cost players is pushing to more sub-contracting to EMS by traditional OEMs.

This trend to outsource an increasing share of production to EMS is not new to the telecom industry but will be amplified in the coming years due to the technological shift towards all-IP based network solutions.

Cisco for example, coming from the computer industry, is particularly performing in the telecom market with a fabless industrial model.

- *R&D*

As far as R&D is concerned, the pressure will continue to be strong on new product development and increasingly concentrated on software development rather than hardware.
Due to the higher complexity and heterogeneity of network architecture, OEMs will have to develop innovative eco-systems gathering content producers, start-ups and service companies in order to provide comprehensive solutions responding to market needs.

- *Integration*

In a commoditised telecom equipment industry, the competitive advantage of traditional OEMs no longer relies on their capacity to develop and produce equipment, but on their capacity to integrate equipment from different vendors in order to provide comprehensive solutions to their clients.
In such a context services and applications (security, multimedia, billing, intermediation, network maintenance and upgrade, etc.) take an increasing role in the global value proposition of infrastructure suppliers.

Carriers will also outsource more and more network management operations to their equipment suppliers, which will temporarily put pressure on OEMs to reorganize these operations and increase their productivity.

Top Telecommunication infrastructure equipment suppliers (in billion euros)

Company	Country	2012	2016	2017	Growth 2016-2017
Huawei	China	21.2	71.2	77.3	9%
Cisco	USA	35.8	49.3	48.0	-3%
Nokia (including Alcatel-Lucent)	Finland	27.8	21.8	20.5	-6%
ZTE	China	7.2	13.8	14.3	4%
Ericsson	Sweden	26.2	11.3	13.0	15%
Samsung	South Korea	4.0	5.0	5.4	8%
NEC Corporation	Japan	6.9	5.6	4.5	-20%
Juniper Networks	USA	2.5	2.3	2.3	-0.4%
Fujitsu	Japan	2.8	2.1	1.9	-10%

Source: DECISION Etudes & Conseil, from companies' annual reports

The top ten telecommunications infrastructure suppliers are predominantly Asian (China 2, Japan 2, South Korea 1), followed by the Americans (2 companies) and the 2 Europeans in the top 5.

In the Carrier Networks Segment, market leaders are Huawei (#1) followed by the European Nokia (#2) after the acquisition of the equipment manufacturer Alcatel-Lucent in 2016. Ericsson is ranked (#3), before the Japanese NEC (#4) and the Chinese ZTE (#5).

In the Telecoms Software Systems and Services segment, the major suppliers are predominantly US-based with the undisputed market leader Cisco followed by Fujitsu (#2) and Juniper Networks (#3). Ericsson and Huawei are also growing rapidly on this segment.

Telecommunication infrastructure key players

Access Provider	Sprint, T-Mobile, Verizon, Deutsche Telecom, Orange, etc.
Network Management & Maintenance	Williams, T-Mobile, Verizon, Deutsche Telecom, Orange, etc.
Network Owner	Level 3, Comcast, Verizon, EarthLink, Spectrum, etc.
Network Constructor & Installator	Ericsson, Nokia, Technip, Avaya, KBR, Fluor, etc.
Network Design	Ericsson, Nokia, Huawei, Avaya, 8x8, etc.
Network Elements	Ericsson, Nokia, Huawei, Cisco, Juniper, Cienna, etc.
Control Software	Ericsson, Nokia, Huawei, Cisco, Juniper, Cienna, etc.
Box Assembly	Ericsson, Flextronics, Pegatron, Foxconn, Jabil Circuits, Celestica, etc.

Source: DECISION Etudes & Conseil

These OEMs can either manufacture their infrastructure equipment themselves or subcontract manufacturing activities to Electronic Manufacturing Services (EMS), while focusing in R&D, integration and services. Subcontracting to EMS and Original Design manufacturers has rapidly increased during the recent years.[1] Flextronics, a major EMS manufacturer captures a large part of this business. Other EMS active in the telecom & networking infrastructures market include the world number one EMS Foxconn, as well as Jabil Circuits.

Since the 2007 economic crisis, value added in communication hardware has fallen in Europe, while it has increased in information and communication services. Average prices of both fixed and mobile broadband access have decreased. The-growing demand for communication devices and services has been offset by global and local competition. Huawei, the Chinese leader in communications equipment, has entered the European Mobile equipment market and is winning market shares. Europe represents for the Chinese brand its first market. The decreasing value added in communications equipment reflects a larger specialization in services rather than in hardware manufacturing or design.

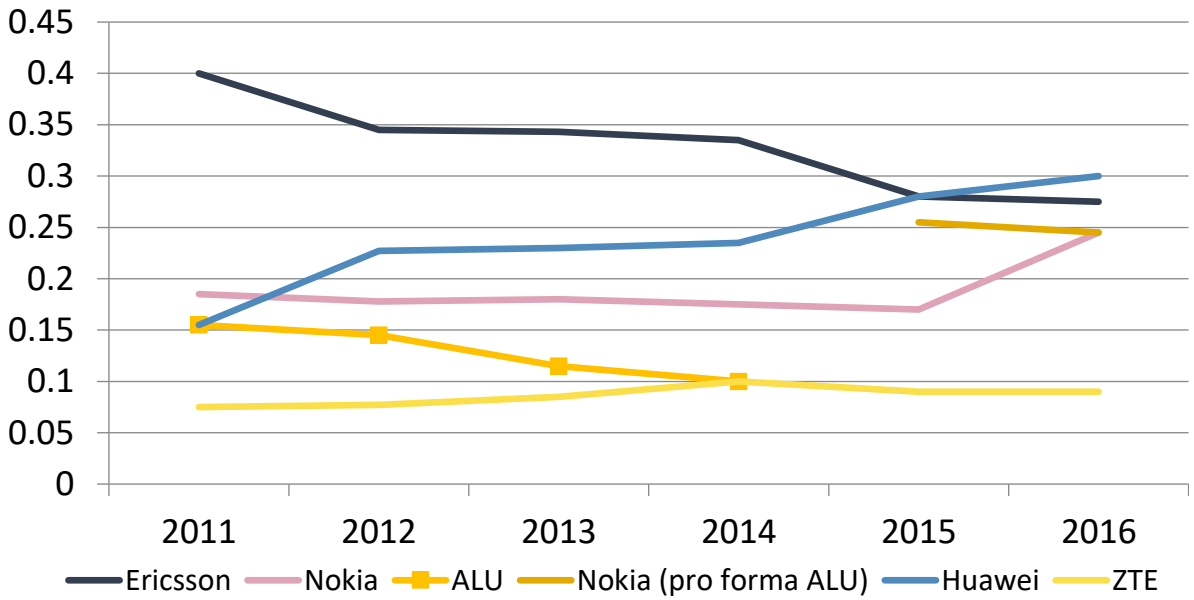
ZTE and Samsung also remain aggressive in the global communication equipment manufacturing market, eroding the European manufacturer's mobile equipment market. Nokia, in advanced to its neighbour Ericsson in restructuration acquired in 2016 Alcatel-Lucent.

The decreasing market share of European manufacturers is explained by a booming Chinese demand for telecommunication infrastructure, where Nokia and Ericsson are not very present. On the other side, Chinese and Asian manufacturers have a limited presence in the US market where LTE has been booming. Even though

[1] https://www.ilo.org/wcmsp5/groups/public/---ed_dialogue/---sector/documents/publication/wcms_161177.pdf

European manufacturers are well positioned in the US market, the LTE spread had no impact on their mobile network manufacturing revenues.

Worldwide telecommunication equipment market by manufacturer market share

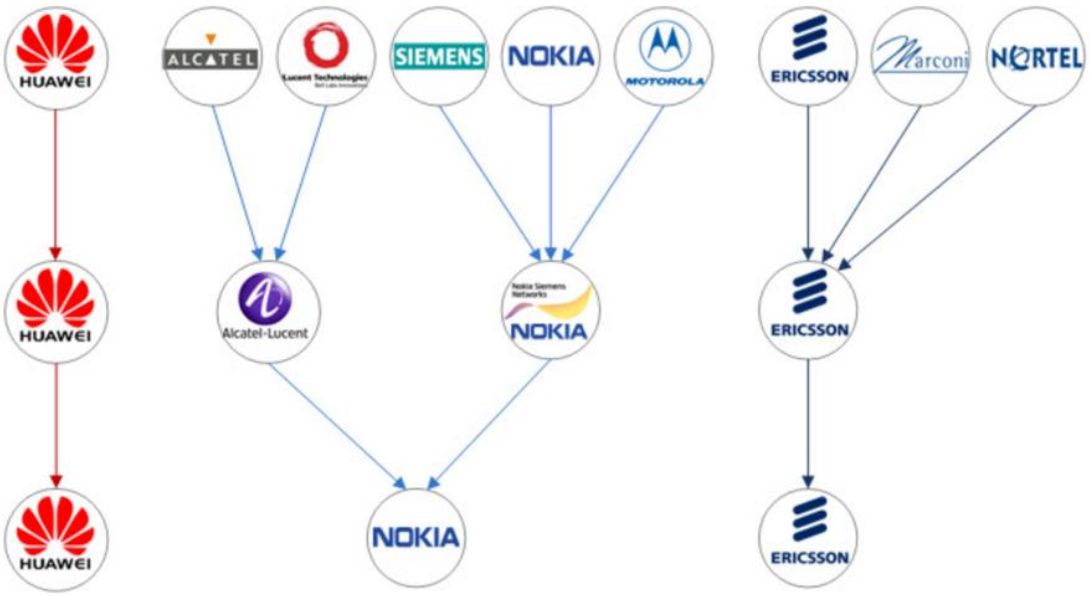


The telecommunication equipment market has a hardware part (cards, base stations, antennas, switches) and software one (software, virtual network, digital switches, clouds, etc.).

Following the decline in its mobile handset sales in 2014, Nokia group decided to sell its terminal and services business to Microsoft for € 7 billion. The company subsequently commits a transfer to favor its network equipment activities.

In November 2016, Nokia acquired Alcatel-Lucent, a company specializing in cloud computing, IP (Internet Protocol) and ultra-fast broadband (THD). The new group will have close to 120,000 employees with a turnover of around 25 billion euros. This strategic acquisition has allowed the group to expand its product portfolio, an essential strategy for dealing with Chinese competition and network virtualization.

Both worldwide leaders are European: Nokia and Ericsson



Huawei, a world leader in telecom equipment, also offered a broader product portfolio than its competitors, positioning itself end-to-end on the value chain. The Chinese equipment manufacturer has detected the convergence between telecom and IT, quickly becoming a leading company in ICT.

Anticipating the convergence of these different markets is at the heart of the reflections on the development of the future 5G network. OTTs (Over the Top Players) like Google or Amazon have also been able to perceive this convergence of markets via the virtualization of network services.

Nokia, Ericsson and Huawei are participating in a race for very high-speed connectivity. The groups must meet the demand of the operators but also that of their future customers. For this, Nokia plans to increase its investment in software in order to regain sales growth, which will reduce its turnover but should increase its margin.

With its millions of lines of code, the software represents the hidden side of telecommunications infrastructure (its development cost represents 70% of the total against about 30% for the hardware part), because always positioned behind the OTTs (Over the Top players) and the Operators.

Nokia is not primarily known for its software business for historical reasons. The knowledge of the IP (Internet Protocol) by the general public comes mainly from the companies that used their services. Cisco was the world leader for the company's IP networks, and owned 70% of the global market for related services. However, Nokia was the world's second largest IP service provider, followed by Juniper.

The American Telecommunication Network Market

The United States has a much higher investment capacity in telecommunications equipment than Europe. The price of an Average Revenue Per User (ARPU) subscription in the United States remained high, which maintained the market power of the four major operators (AT & T, Verizon, Sprint and T-Mobile).

The United States is more inclined than Europe to use outside partners as providers of innovative solutions and strongly utilizes the dynamism of the Internet ecosystem.

For security reasons, the United States does not wish to appeal to Chinese equipment manufacturers for their close ties with the Chinese government. Thus, the United States represent for Nokia and Ericsson, the other leaders in telecom equipment, their first market.

The Chinese Telecommunication Network Market

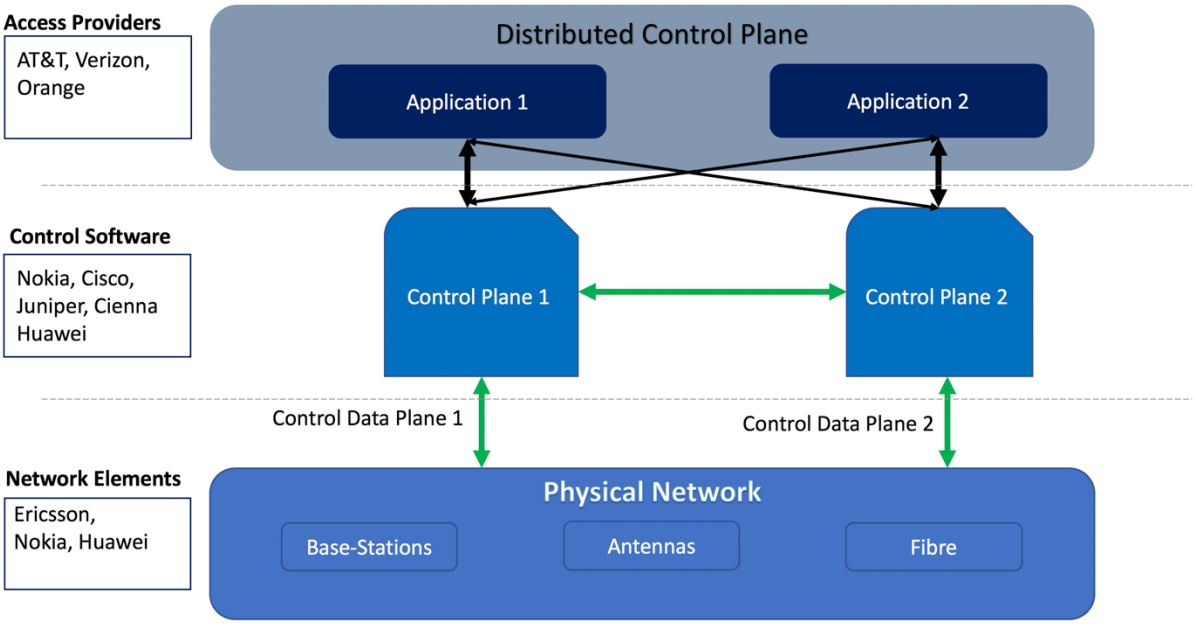
China is one of the leading manufacturers of telecommunication equipment through its two companies Huawei and ZTE. These two firms, in particular Huawei, were able to rely on the growing Chinese domestic market. Despite its openness to foreign manufacturers, the local market remains dominated by Chinese companies. Foreign equipment manufacturers share 20% of the Chinese market.

The various government plans have largely contributed to China becoming a major player in the telecommunications field.

The "China Manufacturing 2025" plan identifies the telecommunications sector as a priority and assigns specific market share objectives: position China as a pioneer country in 5G technology (technologies and standards).

Operator / OEM relationships in Telecommunication

Until now, a telecommunication network had an easy architecture to represent.



Source: DECISION Etudes & Conseil

Telecommunication equipment manufacturers were just behind the operators (Over the Top Players). Each network was managed by Internet Protocol (IP) and the network was vertically distributed by the service providers. OEMs resold operator connection services.

With the arrival of 5G, the relationship between equipment manufacturers and operators could change. Indeed, the digitization of telecommunication networks tends towards a horizontalization of the relations between the different actors. OEMs position themselves end-to-end on the value chain and can claim the position of Access Providers depending on the use of the network (Seen next section for the possible impact of the new 5G network on the value chain).

iv. Technological and market development

Today, carriers have to face three new service classes:

- Enhanced Mobile Broadband;
- Massive Internet of Things;
- Optimised Services.

A particular interest is to allow mobile phones to access the Internet of Things. Indeed, 5G will account for 10 million 5G IoT connections in 2024, which represents one fourth of all 5G connections.[2]

Connectivity revenues will remain the carriers' principal source of revenues from the IoT.

IoT applications depend on device demand for data consumption. Devices will require different data throughput rates, latency, communication frequency, costs and power consumption. Carriers will thus have to make strategic choices for their infrastructure investments.

Two main trends will drive the network industry. First, the expanding smartphone market will stimulate cellular broadband technology, due to the increasing number and types of connections per km^2.

Second, cloud computing and Big Data will foster the cloudification phenomenon in enterprises. Driven by the continuous development of broadband access through computers and smartphones, new services based on dematerialization have emerged. The Telecoms companies will have to face several challenges such as security data transfer, storage, and increasing mobility.

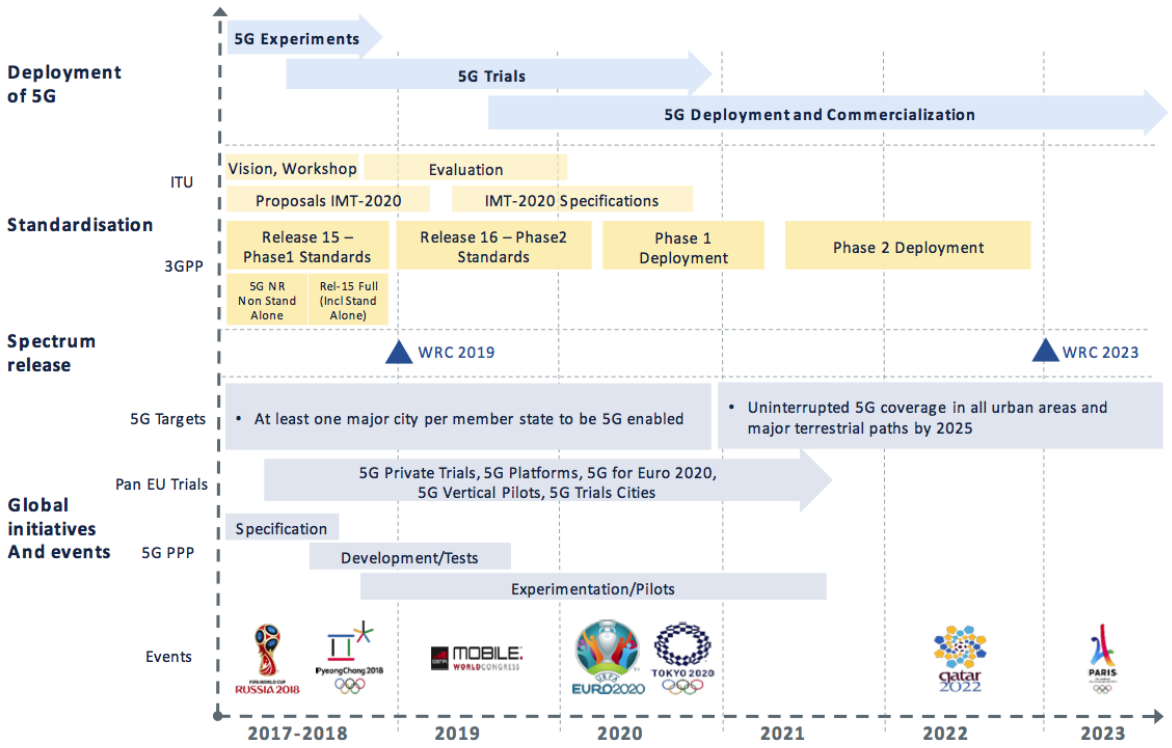
The fierce competition between operators compounded by the increasing demand of data from mobile users has intensified the decrease of margins in the industry. Nevertheless, operators can still count on the valorisation of data consumption. Mobile Video communication constitutes a major interest for major actors, looking for a position in this growing market: Verizon has thus taken position on the video content market, while T-Mobile proposes incentivising tariffs.

Operators have a main role to play on the M2M market segment of IoT networks (LPWA).

[2] Source: Machina Research

5G Networks

Expected roadmap towards 5G



Source: DotEcon and Axon

In partnership with the ITU-R organization, telecom trade associations are being working on synchronizing the implementation of worldwide 5G standards by the 3rd Generation Partnership Project (3GPP). The 3rd Generation Partnership Project met on December 2017 in order to agree on a new architecture network in Europe. This plan is called Non-Standalone 5G New Radio. It aims at easing the share of the future network, using the existing network infrastructure in a first period. Later, the 5G network aims at standing alone with its own infrastructures. On the 14th of June 2018, the 3GPP approved the Release 15 Standalone and agreed on a network based on a virtualised network.[3] This decision opens the way to massive network slicing and allows industries to take the final run towards 5G commercialisation. The principal actors of the NSA and SA 5G New Radio plan were the following:

IC & Equipment Suppliers	Qualcomm, Intel, Ericsson, Huawei, and ZTE
Network Carriers	Sprint, Korea Telecom, SK Telecom, Deutsche Telecom, BT, Telstra, and Vodafone

The 2018 Winter Olympic Games in South Korea will see the first 5G demonstrations. Fans and athletes will enjoy low-latency transmission videos and wireless virtual reality applications. Ericsson, Korea Telecom (KT) and Intel

[3] http://www.3gpp.org/news-events/3gpp-news/1965-rel-15_news

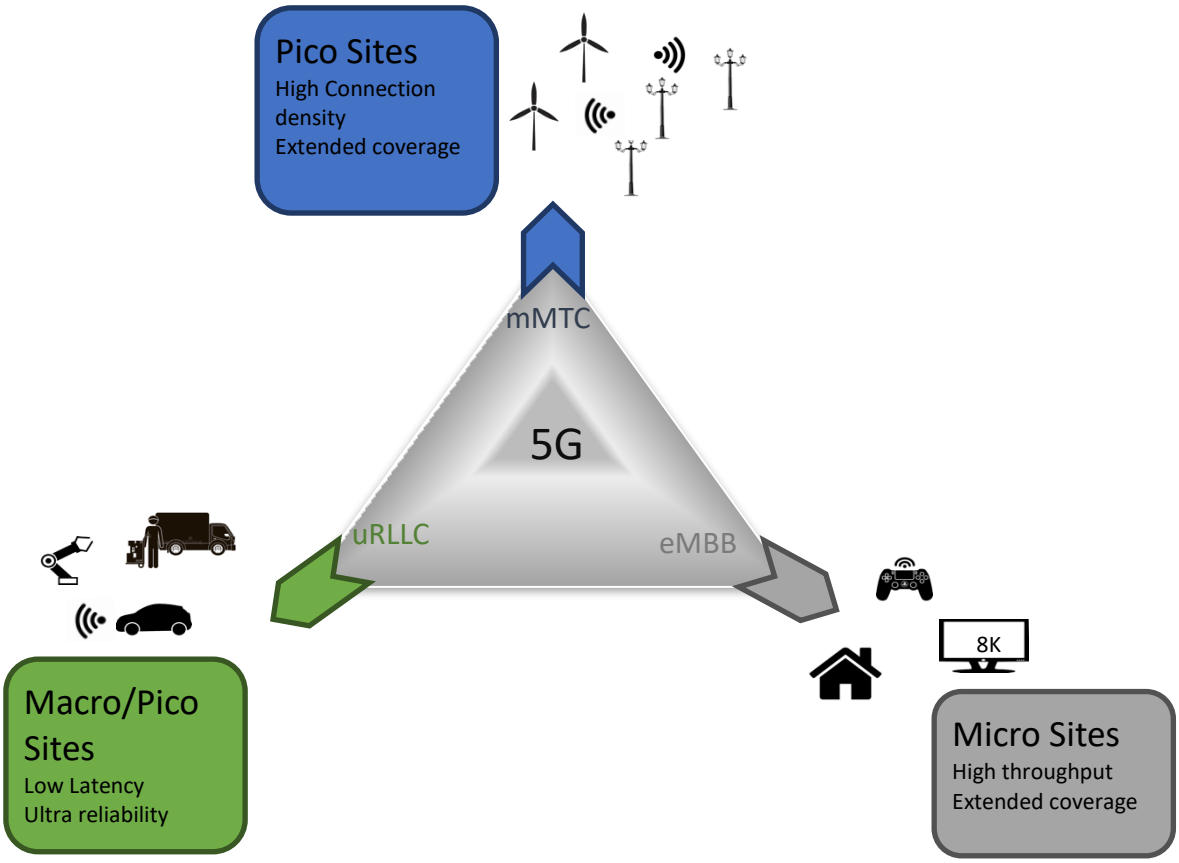
enhanced the Korean network and expect to demonstrate 1GB/s data transmission capacity. KT wants to use this global event as a stepping stone to become the first operator in the world to commercialise 5G services.

The 5G systems will be based on the 5G **New Radio (NR 5G)** and 5G **Core Network**. For unlike 4G and past generations of mobile networks, 5G systems will be based on a service architecture.[4] This architecture will evolve in relationship with virtualisation and software technologies, enabling network to module, reuse and self-contain the diverse network functions.

The 5G New Radio (5G NR)

The 5G NR is a new base station specifically developed for the 5G network. The Air Interface (e.g. radio frequency portion of the circuit between the mobile device and the active base station) is designed to perform the 5G requirements: flexibility, scalability and efficiency. 5G NR will operate from below 1GHz to 100GHz with different deployments. The coverage being inversely proportional to the frequency (e.g. the size, quality and latency of data), the 5G NR will allow these different services to be efficient at the same time.

Telecoms providers have variable interests in 5G Networks. ITU has split 5G network services into three categories: enhanced Mobile Broadband (eMBB) or handsets, Ultra-Reliable Low-Latency Communications (URLLC), which includes industrial applications and autonomous vehicles, and Massive Machine Type Communications (MMTC) or sensors. Initial 5G deployments will focus on eMBB and fixed wireless, which makes use of many of the same capabilities as eMBB.



[4] http://www.3gpp.org/NEWS-EVENTS/3GPP-NEWS/1930-SYS_ARCHITECTURE

5G Network Services	Characteristics	Methodologies	Application
eMBB	Fast connections Wider bandwidths than LTE	Massive MIMO (Multiple-Input Multiple Output)	**Mobile Broadband Access** Communication Media Entertainment
uRLLC	Extreme reactivity Highly resilient communication with redundancy Reliable D2D communications Ultra-low latency transmission		**D2D Communication** Autonomous Vehicles Industrial Control and Automation Telemedecine Public Safety Applications
mMTC	Low energy consumption Low complexity Numerous Connected Devices Battery driven Devices Relative low transmission speed	Ultra-dense small cells-network New waveforms and architectures	**Connect object that are spread out in a very dense fashion** Smart Grids Smart Metering Logistics Field and Body Sensors Smart Cities

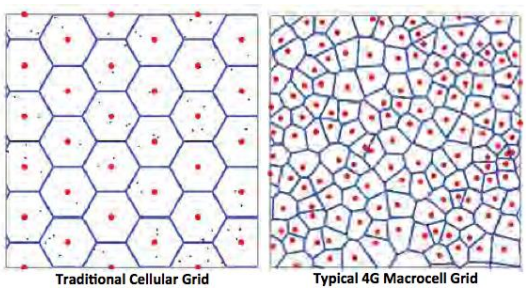
Source: DECISION Etudes & Conseil, Ovum Tmt Intelligence, Ericsson and ITU[5]

Macro sites will cover a larger coverage at lower carrier frequencies.

The major challenge of the mobile network will lie in the difficulty of this growing data traffic, agility and throughput. Traditionally, carriers used to deal with an increasing connectivity by adding more macro-cell base stations.

Nevertheless, the growing number of technologies being gathered into the network is overloading macro-cell base stations and historical cell structures.

Data Traffic Growth changes cell Network Layout



Source: IEEE Communications Society

[5] https://www.ericsson.com/assets/local/publications/ericsson-technology-review/docs/2018/etr_magazine_2018_01.pdf

It is difficult to conclude whether adding more cells will optimize the future mobile network. Most of major actors in infrastructure believe the cellular network should be rebuilt. Thinking about a new architecture network is becoming a major concern to face the increasing data traffic.

Each base station can cover a certain area, and a group of base stations can cover a wider area. The more data needs to be transferred, the shorter the signal will be. Adding small areas and small stations could help in reaching a cell-connection density compatible with the 5G requirements.

However, the more base stations there are, the more interference there is between them (they are closer and use the same bandwidth).

Moreover, the future network will have to account for more mobility, which might intensify the optimisation problem.

The answer is not clear, and both governments and companies are actually working on the best solutions.

Network methodologies that delivers higher speeds and greater capacity [6]

Carrier aggregation: This enables higher bandwidth by aggregating multiple carriers (or channels). The wider the spectrum available, the faster the speed. LTE-A supports up to five carriers while LTE-A pro supports up to 32. LTE-A also enables the use of unlicensed spectrum, including frequencies in the 5GHz range normally used for Wi-Fi. Combining spectrum within licensed and unlicensed spectrum enables faster connections.

MIMO (multiple-input multiple-output): This method enables greater spectral efficiency (more from same amount of frequency) and greater capacity by deploying more than one antenna on the same device. More antennas also offer greater speeds when connecting with a MIMO-equipped access point. LTE-A Pro offers between 8-16 antennas. Evolution of Massive MIMO capability is planned for 5G and likely to be tested in 2017 with 128 antennas.

QAM (quadrature amplitude modulation): This approach also enables improved spectral efficiency. The higher the QAM, more the bits per transmission. This helps achieve higher peak data rates. For example, 256 QAM sends 8 bits per transmission, which is 33 percent more efficient than 64 QAM (6 bits). The latest version of LTE-A introduced 256 QAM.

Relay nodes : These network components (introduced in LTE-A) are low-powered base stations which provide greater coverage and capacity at cell edges and in hot-spots.

Beamforming: This technique, introduced with the first release of LTE, directs a signal from a cellular base station more precisely towards each device. Beamforming is delivered via software application, while LTE uses two-dimensional beamforming; LTE-A pro incorporates 3D-beam forming, enabling higher speeds.

[6] https://www2.deloitte.com/content/dam/Deloitte/in/Documents/technology-media-telecommunications/in-tmt-leap-to-5g-noexp.pdf

- In 2017, Nokia started manufacturing “5G-Ready” multiband base stations in a production site in India. AirScale base stations, Nokia’s leading technology, convinced several countries. The Finnish company said this is the first triple band radio. 700MHz, 3.6GHz, 26GHz are the three bands that have been selected by Europe in order to launch the 5G network. Nokia and T-Mobile are leading the nationwide 5G networks in the USA. Nokia will provide transport network and future 5G networks in China as well. They also use the beamforming technique and massive MIMO antennas.

- Korea Telecom and Ericsson, during the 2018 Olympic Games, plan to use beamforming technology that will enable mmWaves transmissions to spread optimally in both urban and rural areas.

- Qualcomm has created the 5G modem IC Snapdragonx50, continuing to be a mobile industry leader by reaching mobile Internet speeds of 1GB/s. The Snapdragonx50 chip will be able to reach higher Internet speeds when the 5G network will be rolled out entirely, according to the American company. This modem fits to smartphones equipped with 2 antennas.

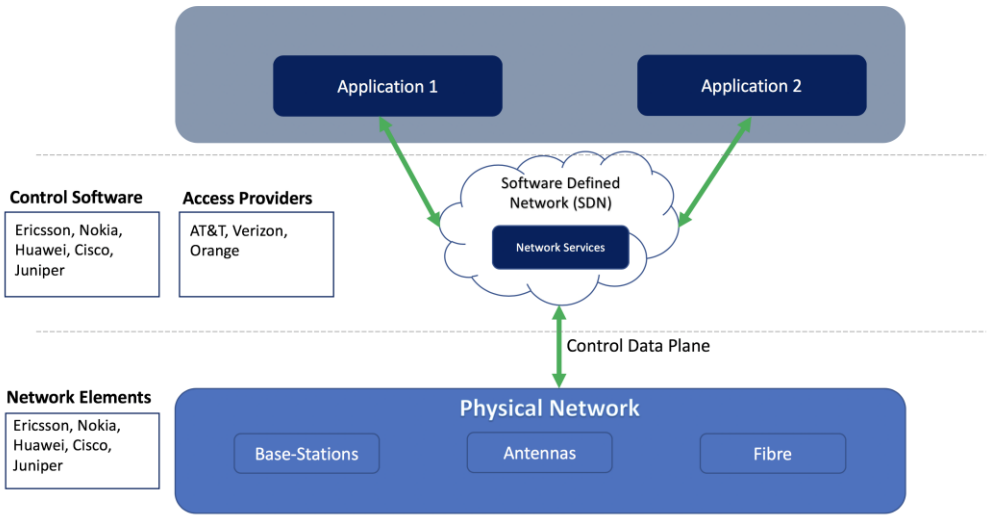
- The leading Chinese telecom equipment suppliers Huawei and ZTE are investing heavily in R&D and are developing technologies for 3GPP’s Phase 2 release of 5G specifications. They focus on New Radio Network and network architecture solutions leading to massive connections for machines and IoT or autonomous vehicles.

The 5G Core Network to Serve Multiple Demands

The cloud 5G core network will enable operators to offer various services on a single network, from the mass market to the vertical industry market.
The 5G Network will no longer be managed from transmission and routing/switching technologies. Needing flexibility and openness, **Network Functions Solutions** (NFV) will enable the virtualisations of common network functions.

This technology is often associated to the **Software Defined Networking** (SDN), which enables the control, centralisation and orchestration of physical equipment from software platforms.

Software Defined Networking Architecture (SDN) – What 5G is going to change



Source: DECISION

The result of these developments will be that networks will be managed virtually in order to provide more mobility, agility and speed.

SDN and NFV will have an economic impact and will transform the global value chain of the actual Telco's landscape. These technologies will introduce more software and IT solutions, which may potentially disrupt the traditional actors, and enable new players to take position in the network market.

Main solution providers for SDN and NFV

Telecom equipment vendors	Cisco, Ericsson, Huawei, NEC, Nokia/Alcatel Lucent, Juniper
IT players	HP, Big Switch Network, IBM, DELL
Pure Players	PLEXXI, Big Switch Network, Cumulus Networks, Metaswitch, Affirmed Networks, PICA-Network

Source: iDate

Privileged relationships with operators might change. Traditional network manufacturers (Cisco, Ericsson, Nokia, Huawei) are particularly sensitive to this trend and will operate changes in their strategy, switching from physical infrastructures to software solutions. Moreover, this could boost the computing and storage industry.

Telecommunication Market Value Chain

Source: Detecon

Upstream the value chain, Huawei, Cisco, Nokia and Ericsson drive equipment manufacturing segment both in hardware (30%) and software (70%) on a global scale. Cisco and Ericsson recently formed a strategic partnership in order to spread costs and keep going competitive on the market. This alliance allows the two companies to complement their product in software and hardware and extend their presence in the value chain.

With the arrival of 5G, equipment manufacturers will be able to develop in two markets:

- Behind the Operators;
- Behind the OTTs who will tell us about their connectivity needs.

The first needs are transportation, energy and defence. These so-called vertical markets are paramount to Nokia's development. Not only in terms of growth but also in terms of design and configuration of technologies.

Nokia now has a role to play in vertical markets. Will this be done behind an operator? Will SNCF directly manage its networks with significant sophistication, and teach equipment manufacturers how to adapt their products to their needs? Today, 85% of Nokia's sales are behind the operators. With the arrival of 5G, the organization of networks could change this distribution of turnover.

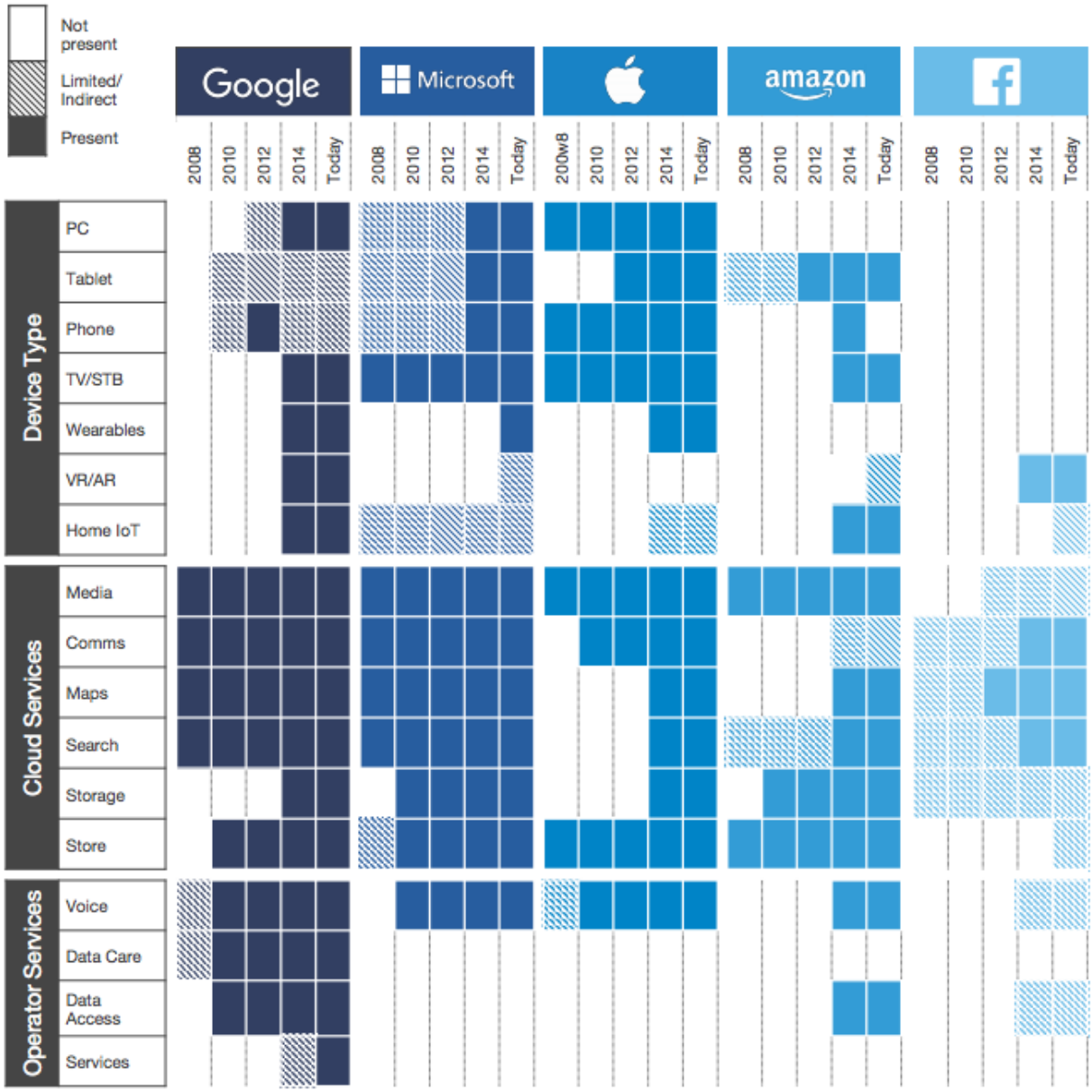
To enable the 5G to be fully efficient, an excellent fibre optic connection is required in order to provide unparalleled connectivity, in terms of security, latency, or speed.

Thanks to France's "very high speed" fibre deployment plan, France is very well positioned in countries capable of quickly launching a 5G network. Downstream the value chain are the Over The Top actors (OTTs): the Ecosystem players which are web-scales companies; the OTT communication providers and the content service providers. Every segment of the value chain is scaling globally except the telecommunication operators. Indeed, Telcos develop separately hardware and software products adapted to each country. This different situation could be explained by the different telecommunication technologies used across countries (might be for historical reasons), diverse regulatory requirements that only telecommunication operators have to comply with.

Because of the virtualization of the global infrastructure network, telecommunication operators will focus on services only, while equipment manufacturers such as Huawei, Nokia and Cisco-Ericsson will diversify their product portfolio.

In Europe, Operators would gain at internationalising to not lose market share on the core network segment in front of the equipment manufacturers.

Web-Scale Companies are no longer just OTT Players



Source: World Economic Forum / Accenture Analysis

What could slow down the launch of 5G in Europe?

France got the bridgehead of the 5G, it means that everything is coordinated from France. This favourite position is largely driven by the important French R & D ecosystem. For the launch of a new network, the most important to be well positioned in the market is to develop the skill. This European asset is essential in this race for high connectivity. Unlike the United States, Europe can count on its internal resources.

Different components delay the launch of 5G in Europe. The first reason is part of a debate on the allocation of frequency bands. The second is more about a problem of European sovereignty.

- **The allocation of frequency bands**

One of the current debates is in the allocation of frequency bands allowing this network access. Telecommunications regulatory entities are in charge of allocating frequency bands.

For the 5G network, the authorities attribute these frequency bands to infrastructure operators and equipment providers such as Nokia. Availability for 5G is a big debate. Especially at the frequency level. It takes at least 100MHZ of frequency band for good 5G service, which must be found available in all countries.

Two difficulties are encountered by the member states of the European Union.

First, each frequency band allocated to this new network service is country-specific for historical reasons. It is too difficult to go back on the use of existing frequency bands and each country must find 100MHz of frequency band available in addition to those already occupied by connected objects, the military, corporate networks, fixed communications and mobile etc.

Secondly, countries that share a border may encounter interference problems. It is therefore essential that neighbouring countries agree on the allocation of frequency bands in these particular geographical areas.

In this debate, the risk in terms of market share for operators would be that they remain national. Operators will more focus on the service segment of the value chain.

- **European sovereignty**

Today, digitalisation poses problems of sovereignty in terms of network management. With 5G, it will be possible to manage network distribution for several types of uses: transport (connected cars), future plants (connected objects), medicine, mobile and fixed terminals, etc. Network virtualization will manage these different types of connections from a cloud platform (software).

Equipping a whole country with a non-European telecom network poses a sovereignty problem that must be rethought. Huawei is now the world leader in network equipment and remains extremely competitive both in terms of price and quality on its products. Europe represents for Huawei its first market.
It has become difficult to make decisions for Europe without them. At each round table are Huawei lobbyists who do not allow to freely discuss the European sovereignty.

Impacts on the Value Chain

Overall, 5G will enable different networks to work together at different speed and performance.
Using a unified infrastructure network, 5G will enable networks industries to diversify their services: they will be able to choose to specialise in a given sector relative to a given market place.

The telecommunications infrastructure market is highly concentrated and competitive. And this concentration has increased over the past years following the consolidation of telecom services.
With users demanding always more mobility, performance and flexibility, carriers faced increasing competition. In order to win greater agility and flexibility, carriers have no choice but to build more interconnections within large-scale carrier networks. Thus, an ecosystem of services providers and peers is emerging. Today, Network Functions Virtualizations (NFV) and Software Defined Networking (SDN) help carriers' network to transform, enabling the telecommunication industry to prepare for 5G and IoT. Network slicing from a physical network to a virtual one will let the operators to offer optimised services to specific sectors or industries.

- This new organisation will open new opportunities for players who could target specific economic or industrial sectors, fulfilling particular needs proper to the industry's needs.

- There may be new intermediaries in the value chain, positioned downstream of network operators. They could play the role of bundlers and repackagers for industries or economies.
  In order to optimize the efficiency of such a new value chain, operators and new entrants will gain at synchronizing their services to enhance connectivity services for specific industries.

- New actors upstream in the value chain could emerge as well for mobile networks.
  Operators could see an opening in dense urban areas where networks have to support a growing densification of the network.
  Investing in 5G infrastructures for specific sectors, traditional operators could be in competition with these new entrants.

- The overall competition will be led by the orchestration of services and network (NFV and SDN), delivering the most efficient and fast connectivity.
  All the business that will emerge from 5G connectivity will try to minimise their risk of 5G connectivity being slow or geographically limited.
  Rural areas and poor connected countries will not wait for 5G network to bring some new products in the market. They will prefer LTE, or NB-IoT, LPWA such as LoRa or Satellite Connections in general.
  Urban areas will be at the earth of synchronisation challenges due to the density of infrastructures and data exchange rates.

- More opportunities as well for the Fibre To The Home (FTTH).

v. Appendix

D. Appendix 1 Europe, USA, Japan statistical correspondence

Line Telephones Equipment systems* M€

	2010	2011	2012	2013	2014	2015	2016
Europe	10 210.9	10 126.6	9 924.5	8 079.6	7 760.8	8 011.6	8 927.8
North America	6 291.1	5 979.1	5 581.4	5 677.0	5 721.6	5 756.9	5 173.6
Japan	NA	NA	NA	NA	NA	NA	NA

Broadcasting M€

	2010	2011	2012	2013	2014	2015	2016
Europe	4 230	3 627	3 269	2 682	2 392	2 577	2 333
North America	3 420.3	3 290.3	2 103.3	1 522.7	1 448.7	1826.9	1 704.5
Japan	NA	NA	NA	NA	NA	NA	NA

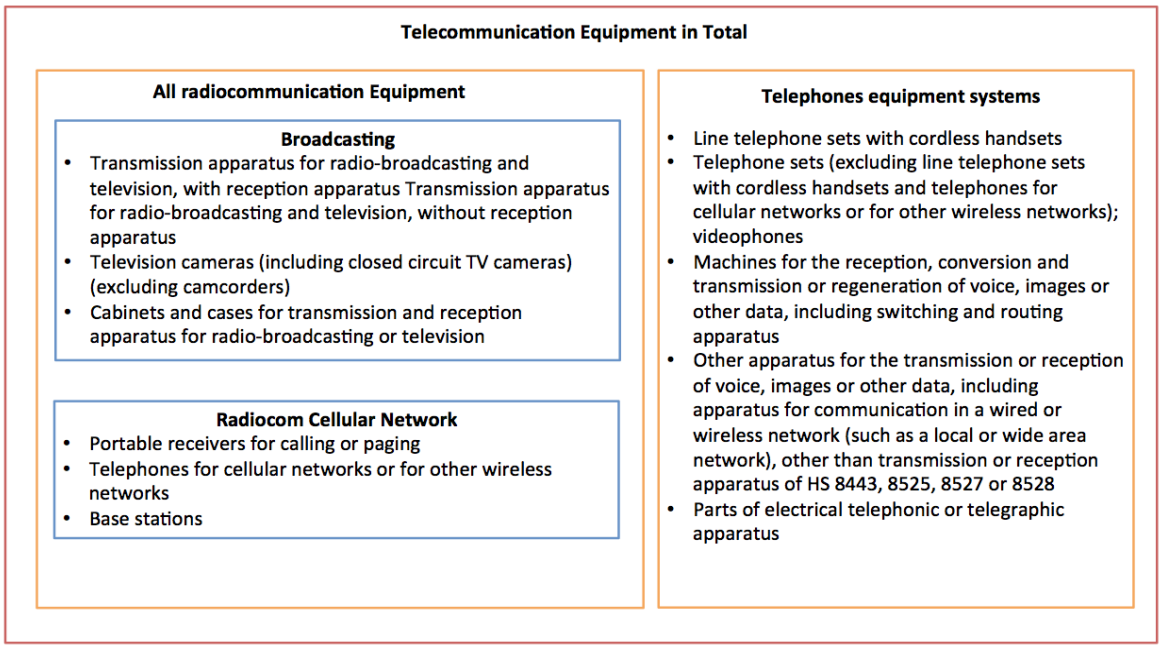
Radiocom Cellular networks M€

	2010	2011	2012	2013	2014	2015	2016
Europe	1 5034.6	1 2713.0	1 1014.7	3 042.0	2 181.7	1 871.9	1 559.3
North America	16 681.0	18 916.0	18 687.6	18 339.0	15 949.7	18 518.4	18 466.1
Japan	NA	NA	NA	NA	NA	NA	NA

Telecommunication in Total M€

	2010	2011	2012	2013	2014	2015	2016
Europe	28 813	25 839	23 393	13 208	11 866	11 896	12 314
North America	33 348.3	31 955.3	36 498.9	30 716.3	28 277.6	31 441.0	30 113.0
Japan	11 808.6	13 103.9	15 519.2	10 321.6	8 194.7	8 995.4	8 216.0

Source: Eurostat, US Census, DECISION
* Carrier line equipment and Wireline voice and data network equipment



Europe

- Public broadcasting Equipment
- Line Telephone Sets
- Cellular networks
- Switching, carrier line, and other telecommunications equipment

North America

- Broadcast studio and related electronic equipment
- Wireless networking equipment
- Radio station equipment
- Telephone apparatus manufacturing
- Other communications systems and equipment including GPS
- Radio and television broadcasting and wireless communications equipment manufacturing nsk total
- Other communications equipment manufacturing

Japan

- Radio communication systems
- Telecommunications systems

Source: DECISION Études & Conseil, Eurostat, US Census

E. Appendix 2 Eurostat Prodcom statistics

Table (1/2) – Eurostat prodcom telecoms statistics

Prodcom Definition	2010	2011	2012	2013	2014	2015	2016	CAGR 2010-2016
Broadcasting & media equipment	**4 230 618**	**3 627 712**	**3 269 676**	**2 682 900**	**2 392 872**	**2 577 820**	**2 333 069**	**-9%**
Transmission apparatus for radio-broadcasting and television, with reception apparatus	2 821 114	2 386 121	2 200 726	1 696 875	1 431 645	1 600 000	1 434 393	-11%
Transmission apparatus for radio-broadcasting and television, without reception apparatus	1 076 819	913 210	736 597	634 356	562 794	540 817	446 904	-14%
Television cameras (including closed circuit TV cameras) (excluding camcorders)	332 685	328 381	332 352	351 669	398 433	437 003	451 773	5%
Cellular networks	**15 009 586**	**12 697 267**	**11 000 000**	**3 023 602**	**2 161 759**	**1 847 573**	**1 536 764**	**-32%**
Telephones for cellular networks or for other wireless networks	9 009 586	6 697 267	3 000 000	1 700 000	849 459	290 402	342 817	-42%
Base stations	6 000 000	6 000 000	8 000 000	1 323 602	1 312 300	1 557 170	1 193 947	-24%
Other telecommunications equipment	**6 872 377**	**6 915 001**	**6 418 556**	**4 688 312**	**4 549 913**	**4 906 198**	**5 444 071**	**-4%**

Source: Eurostat Prodcom database

Table (2/2) – Eurostat prodcom telecoms statistics

Prodcom Definition	2010	2011	2012	2013	2014	2015	2016	CAGR 2010-2016
Machines for the reception, conversion and transmission or regeneration of voice, images or other data, including switching and routing apparatus	5 684 720	5 840 723	5 368 665	3 557 113	3 270 758	3 428 259	3 778 224	-7%
Other apparatus for the transmission or reception of voice, images or other data, including apparatus for communication in a wired or wireless network (such as a local or wide area network), other than transmission or reception apparatus of HS 8443, 8525, 8527 or 8528	1 187 657	1 074 279	1 049 891	1 131 200	1 279 154	1 477 939	1 665 847	6%
Aerials & parts	**2 700 000**	**2 600 000**	**2 705 210**	**2 812 890**	**2 761 696**	**2 564 090**	**3 000 000**	**2%**
Parts of electrical telephonic or telegraphic apparatus	2 700 000	2 600 000	2 705 210	2 812 890	2 761 696	2 564 090	3 000 000	2%
Total Telecommunication Equipments	**28 812 582**	**25 839 980**	**23 393 442**	**13 207 704**	**11 866 239**	**11 895 681**	**12 313 904**	**-13%**

Source: Eurostat Prodcom database

F. Appendix 3 US Census telecom statistics

US production of communications equipment (M€)

US Census Definition	2010	2011	2012	2013	2014	2015	2016	CAGR 2010-2016
Line communications	6 271	5 987	6 460	5 668,5	5 717	5 751	5 155	-3%
Broadcasting	3 420	3 290	2 103	1 522	1 448	1 827	1 705	-11%
Other radio communications	20 047	19 205	23 734	19 834	17 387	20 329	20 104	0%
Other communications	3 610	3 473	4 201	3 691	3 725	3 534	3 149	-2%
Total	**33 348**	**31 955**	**36 499**	**30 716**	**28 278**	**31 441**	**30 113**	**-2%**

Source: US Census

US production of communications equipment (M$)

US Census Definition	2010	2011	2012	2013	2014	2015	2016
Line communications	8 340	8 322	7 171	7 539	7 604	6 384	5 722
Broadcasting	4 549	4 573	2 335	2 025	1 927	2 028	1 892
Other radio communications	26 663	26 695	26 345	26 379	23 124	22 565	22 316
Other communications	4 801	4 827	4 663	4 909	4 954	3 922	3 496
Total	**36 013**	**36 095**	**33 343**	**33 314**	**30 005**	**28 515**	**27 703**

Source: US Census

G. Appendix 4 Japan telecom statistics

Japanese production of communications equipment (M€)

Jeita Definition	2010	2011	2012	2013	2014	2015	2016	CAGR 2010-2016
Line communications	1 230	4 501	4 687	3 491	2 643	2 285	2 103	-9%
Broadcasting	10 579	8 603	10 832	6 830	5 551,4	6 711	6 114	10%
Total	**11 809**	**13 104**	**15 519**	**10 322**	**8 195**	**8 995**	**8 216**	**6%**

Source: JEITA

H. Appendix 4 Geographical distribution of European activity in Telecommunications equipment

Table - Geographical distribution of European activity in Telecommunications equipment 2010-2015 (1/2)

Country	Production		Employees	
	2010	2015	2010	2015
Belgium	135 729	94 334	4 827	1 405
Bulgaria	10 451	32 662	1 155	1 317
Czech Republic	225 290	248 858	4 862	5 127
Denmark	266 385	305 623	1 629	2 099
Germany	3 347 343	3 162 397	25 669	23 411
Estonia	573 912	1 230 282	2 302	2 302
Ireland	-	-	520	520
Greece	18 108	13 587	396	417.9
Spain	301 470	427 791	6 058	4 774
France	2 738 542	2 405 984	24 376	15 018.0
Croatia	64 067	52 211	544	2 561
Italy	1 992 721	1 424 539	23 910	12 631
Cyprus	-	-	-	:
Latvia	-	-	323	423
Lithuania	34 188	27 949	886	461
Luxembourg	-	-	:	:
Hungary	5 242 440	422 914	15 961	11 742
Malta	-	-	:	:

(1) Confidential, estimated by DECISION Etudes & Conseil

(2) the total includes figures not disclosed at country level
Source: Eurostat, SBS industry database, NACE2

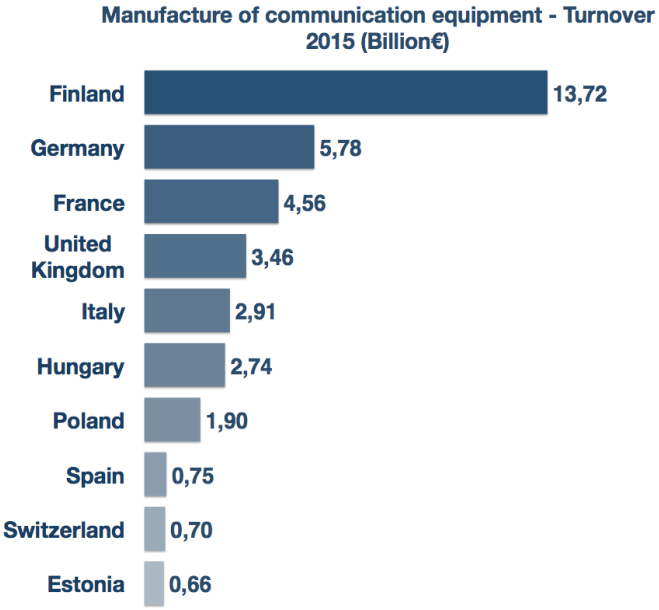
Table - Geographical distribution of European activity in Telecommunications equipment 2010-2015 (2/2)

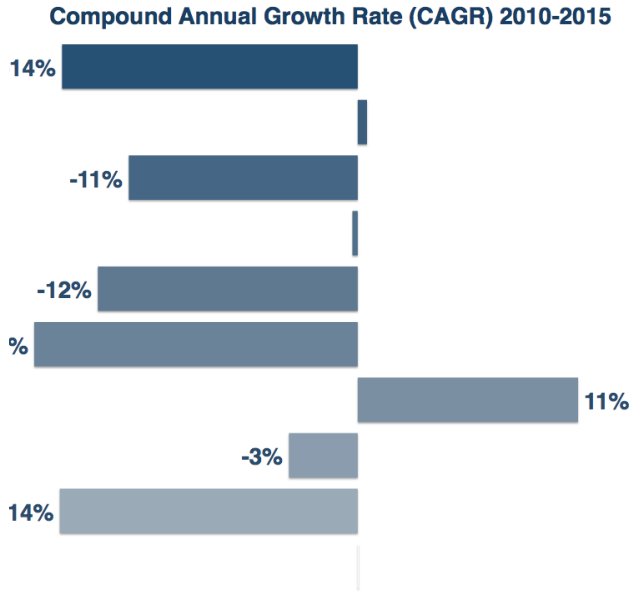
Country	Production		Employees	
	2010	2015	2010	2015
Malta	-	-	:	:
Netherlands	-	43 420	1 343	945
Austria	24 344	21 415	1 876	2 023
Poland	111 297	138 823	11 361	10 971
Portugal	85 201	140 215	1 407	13 93
Romania	8 748	137 824	4 099	4 846
Slovenia	-	-	1 045	787
Slovakia	35 302	1 779	1 586	1 586
Finland	11 862	173 212	25 586	13 454
Sweden	23 808	528 989	3 588	3 588
United Kingdom	1 386 687	1 473 242	NA	NA
Confidential (1)	12 174 686	3 702 183	1 491	928
EU total (2)	28 812 582	11 895 681	166 801	124 730
Norway	35 109	163 746	1 491	928
Switzerland	NA	NA	NA	NA
Turkey	33 792	-	NA	NA

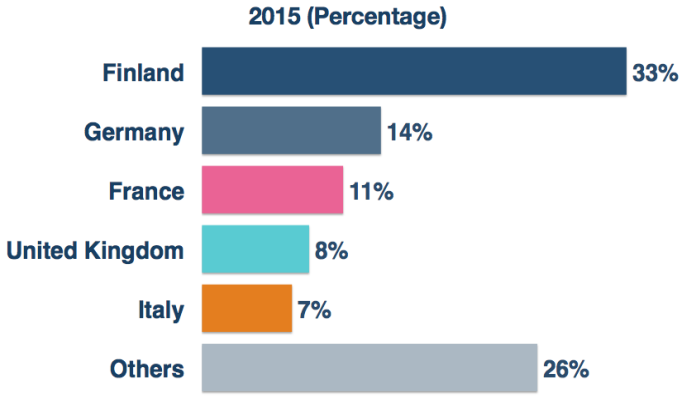
(3) Confidential, estimated by DECISION Etudes & Conseil

(4) the total includes figures not disclosed at country level
Source: Eurostat, SBS industry database, NACE2

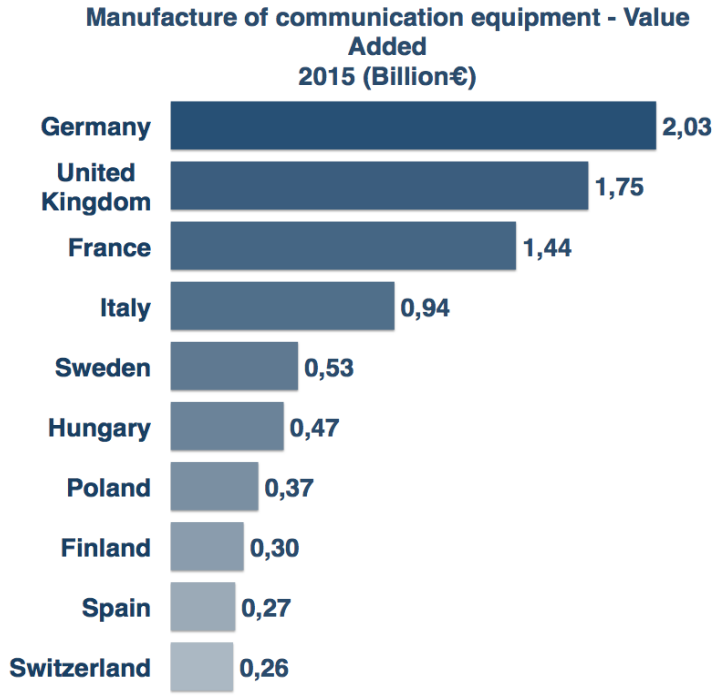
I. Appendix 5 European communications equipment activity graphs

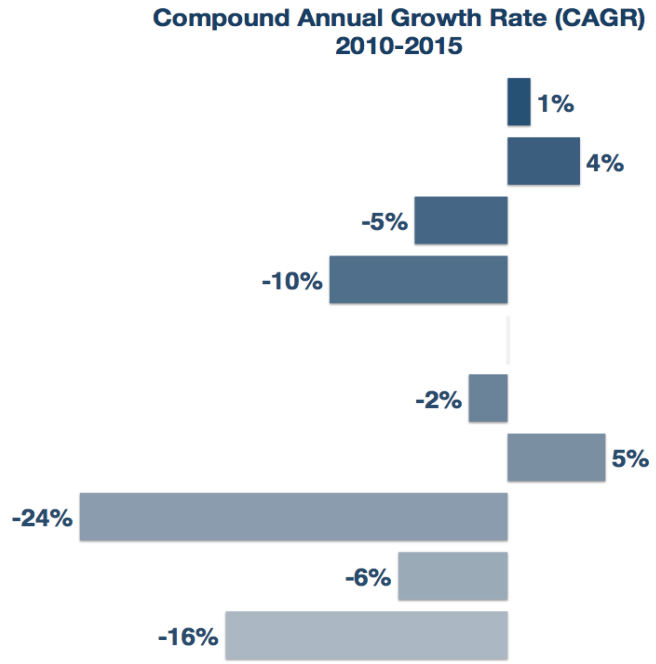


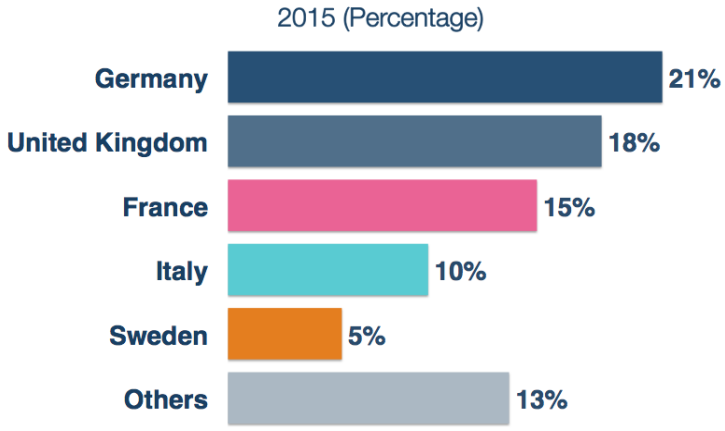




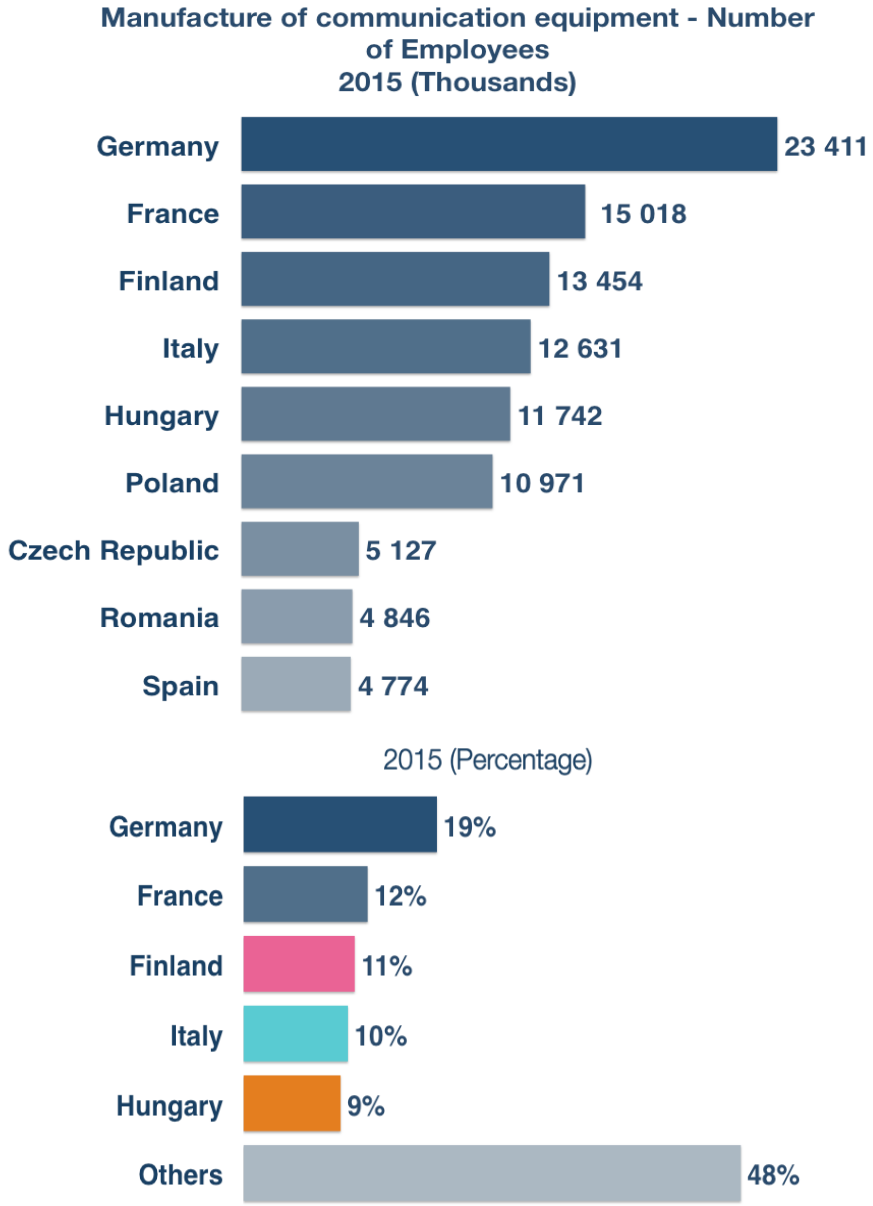
Others : Hungary, Poland, Spain, Switzerland, Estonia, Sweden, Czech Republic, Austria, Denmark, Belgium, Romania, Norway, Portugal, Croatia, Ireland, Slovenia, Slovakia, Bulgaria, Greece, Lithuania, Cyprus, Latvia, Luxembourg, Malta, Netherlands

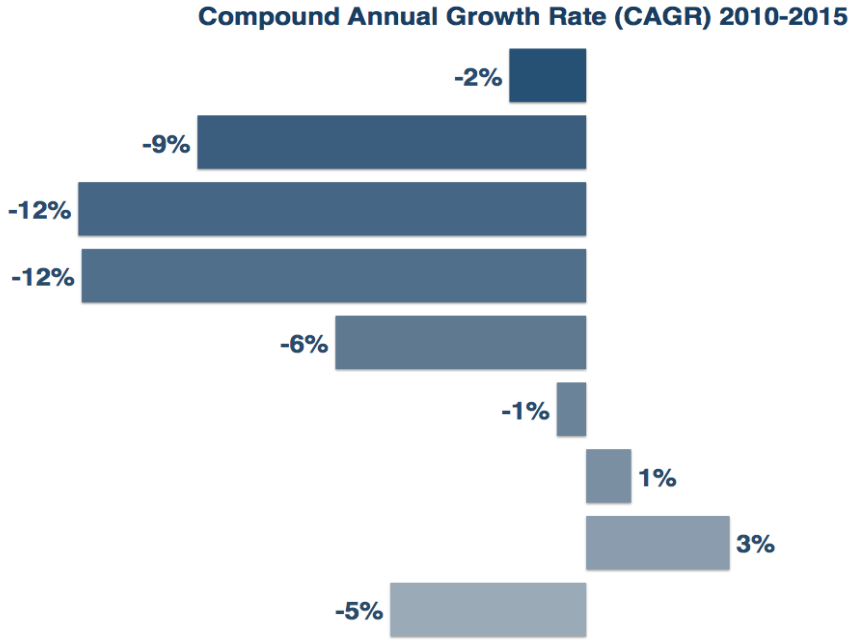




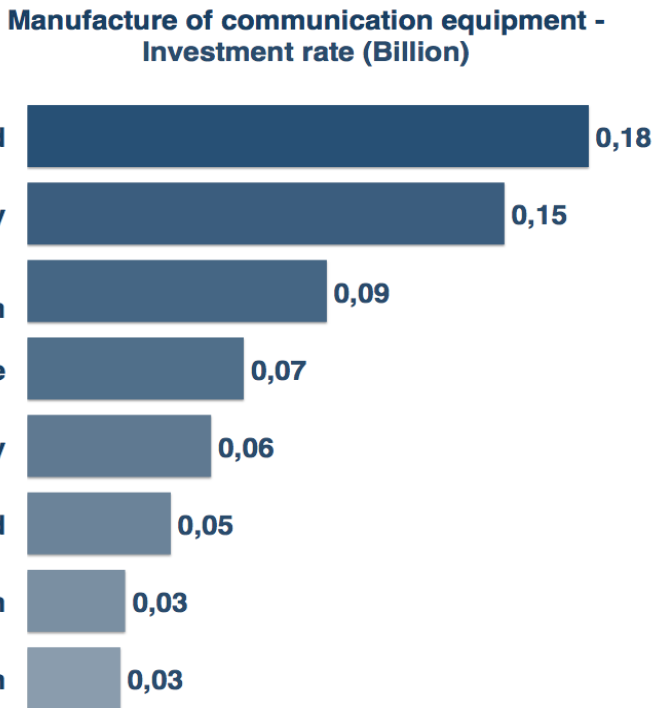


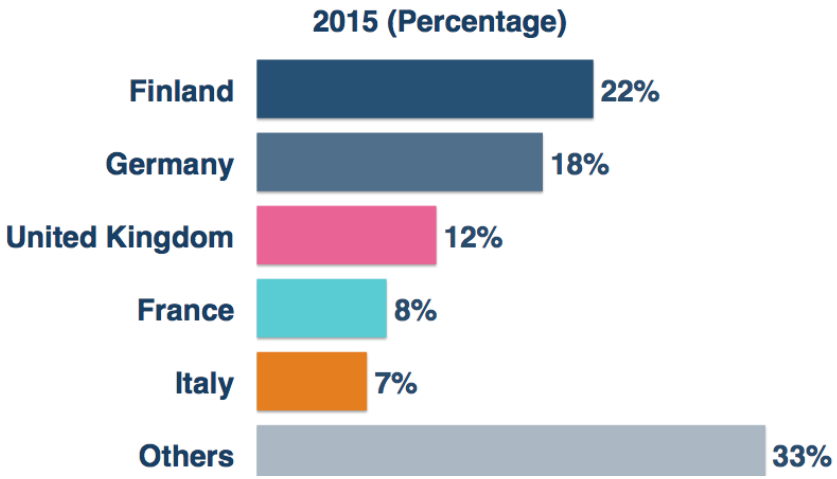
Others: Hungary, Poland, Finland, Spain, Switzerland, Denmark, Belgium, Austria, Czech Republic, ,Norway, Croatia, Netherlands, Ireland, Romania, Estonia, Portugal, Slovenia, Bulgaria, Slovakia, ,Greece, Lithuania, Cyprus, Latvia, Luxembourg, Malta

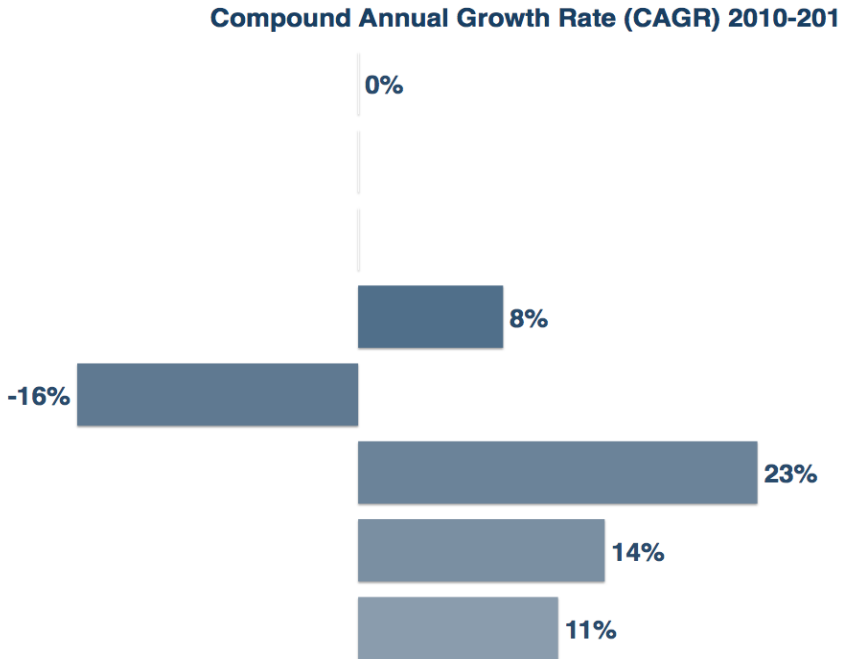




Others: Poland, Czech Republic, Romania, Spain, Sweden, Croatia, Estonia, Denmark, Austria, Slovakia, Belgium, Portugal, Bulgaria, Netherlands, Norway, Slovenia, Ireland, Lithuania, Latvia, Greece, Cyprus, Luxembourg, Malta, United Kingdom, Switzerland







Others: Lithuania, Austria, Bulgaria, Poland, Spain, Portugal, Slovakia, Belgium, Germany, Croatia, Italy, Netherlands, Sweden, Hungary, Greece, France, , Denmark, Switzerland, Norway, Ireland

1.1.2 Mobile & Smartphones

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

J. Product segmentation

Mobile phone market has changed this past decade and became more complex. For the sake of clarity, some definitions need to be set.

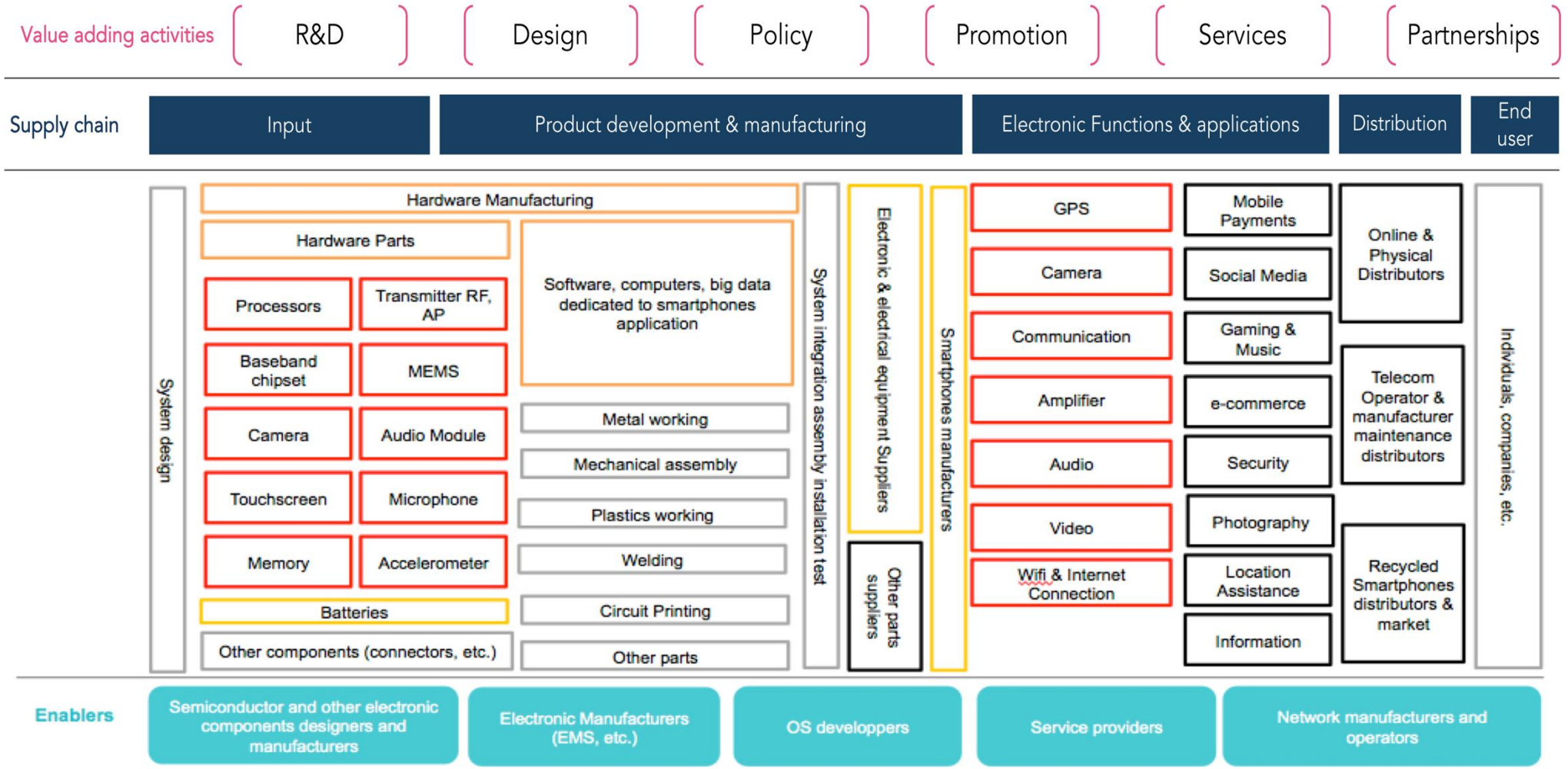
Feature Phone: A mobile phone that incorporates features such as the ability to access the Internet and store and play music but lacks the advanced functionality of a smartphone. Feature phones are basically low-end mobile phones.

Smartphone: A mobile phone that is able to perform many of the functions of a computer, typically having a relatively large screen and an operating system. It will have built-in applications and Internet access turning the once single-minded cell phone into a mobile personal computer which contains features that, in the past, you would have found only on a personal digital assistant or a computer.

In the presentation of our results, feature phones will be treated in the category “Other mobile Phones” category since we will pay attention at what mobile phones can actually do.

K. Value Chain

Smartphone General Value Chain



Source: DECISION Etudes & Conseil

When looking at the value chain of the mobile phone manufacturing industry, most of the established players in the industry were traditionally at some point involved in the manufacture of wireless networks on which the mobile phone run. Since the introduction of the smartphone, traditional PC manufacturers have also entered the market (Apple, Lenovo, etc.)

The mobile phone industry has not only split into components, design, assembly, software and networks, but also into a variety of components and software: more layers of manufacturing and assembly functions are provided by different companies.

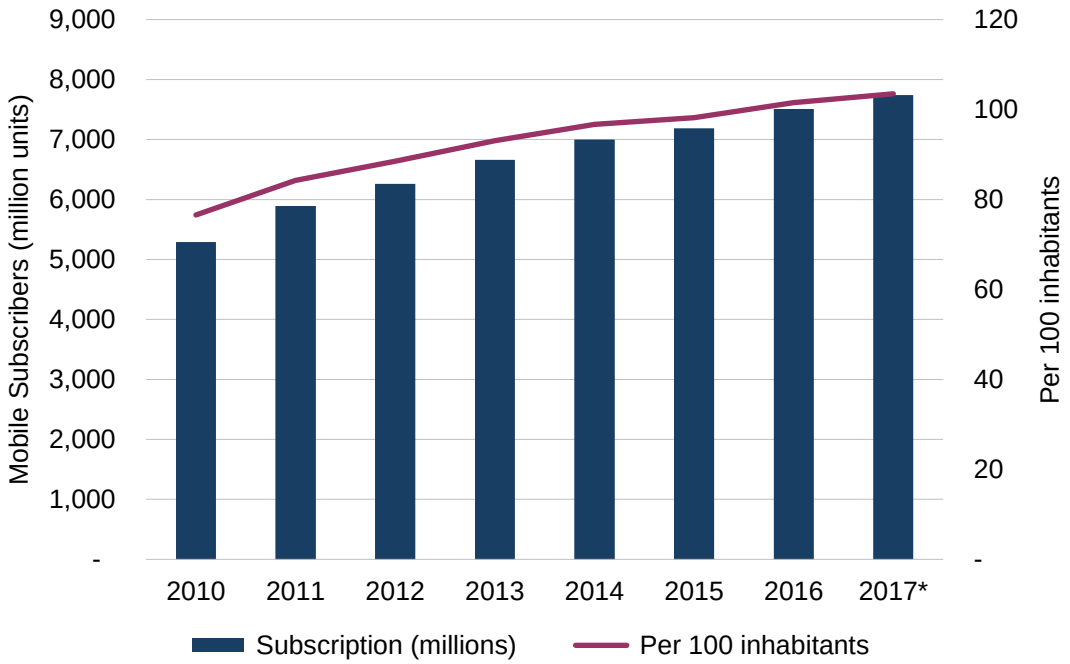
The smartphones market can be split into at least three segments: high-end smartphones, middle-end smartphones and low-end smartphones.

Apple compete only on the high-end smartphones segment whereas Samsung, Huawei, Oppo, LG and other Chinese and Asian brands compete primarily in the low and middle-end smartphones market. In the two latter, competition is driven by production in volume.

L. Global growth drivers & forecasts

In 2017, approximately 78% of the world's population was expected to own a mobile phone. Mobile phone subscription rate increased overtime and global average penetration rate per 100 inhabitants exceeded 100% in 2015. For 2017, mobile phones subscribers per 100 inhabitant growth rate was around 1.9% year-on-year highlighting a maturing mobile market.

World Mobile Subscriber Base Development 2010-2017



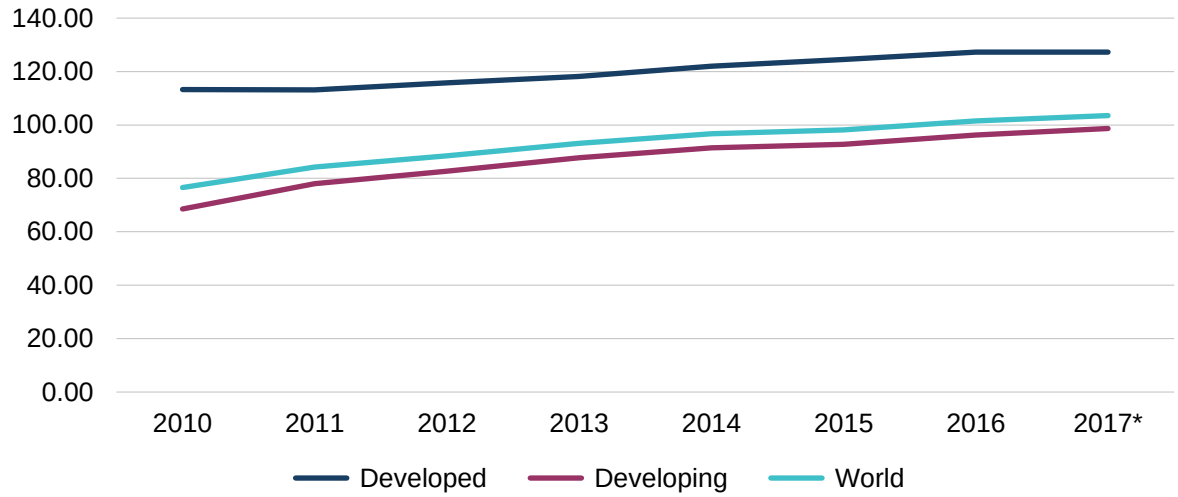
Source: ITU, *Estimate

With a penetration rate of 104 per 100 inhabitants, the number of mobile subscribers is still increasing. Nevertheless, there still exist people who did not subscribe to a mobile phone. The trend comes from a two-sided evolution of the market.

In developed economies, particularly in Europe and the USA, the market is saturating and the penetration rates approach 128 phones per 100 inhabitants. China shows the same trend, with urban citizens owning more than one phone subscription.

On the other hand, there still exist people who do not hold any mobile phone. Mobile market is still growing strongly in Africa and Asia & Pacific, where consumers show a faster adoption of the mobile technology, benefiting from lower average selling prices than the past decade. This rapid adoption has been fostered by the tremendous advantages over fixed communications, particularly in term of deployment cost in developing regions that do not benefit from existing communication infrastructure.

Mobile Phone Penetration Trends

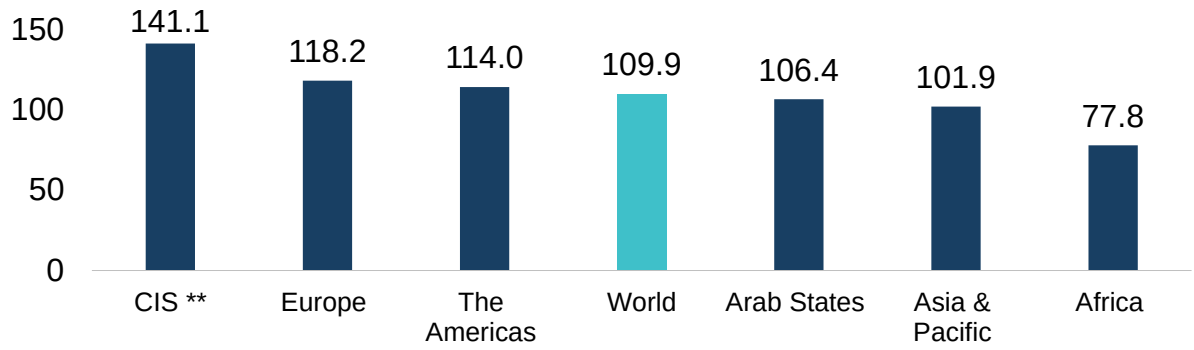


Source: ITU

The Asian market and the Americas exceeded the 100 phones per inhabitant's threshold, whereas Africa has not saturated yet. The main explanation of such a rapid growth is led by younger populations, driven by a high connectivity demand and use.

Developing countries follow a parallel trend with the world average mobile phone penetration curve, reflecting their weight in the global market population.

Number of mobile phones per 100 inhabitants per region in 2017*



Source: ITU
* Estimated
** Commonwealth of Independent States

Today, ICT development is led by the different mobile-broadband services. The growth of 4G services, which reached almost 1,500 million subscribers in 2017 (compared to 336 million in 2015) is a major trend in the mobile phone market. Mobile phone connection to the Internet has an impact on economic growth and social welfare, as well as on many other areas such as education, health, and financial access.

Mobile broadband subscriptions have increased but is still less affordable in developing countries where mobile-broadband prices correspond to 5% of GNI in Least Developed Countries.[7]

The increasing number of emerging countries who have operational 3G and 4G networks is eased by nanosatellites connections, which does not need as much infrastructures as the existent ones.

Developing countries will be the driver of production thanks to high demand for connectivity combined to increasing purchasing power that will foster mobile phones production in unit and in capacity. In developing countries, mobile phones demand is expected to shift from basic mobile phones to less expensive connected smartphones, driven by the Internet penetration and smartphone decreasing prices.

These high-end products were initially reserved to mature economies that had a better access to broadband networks and a larger ability to buy the expensive product. Since 2013, the world sees more equal access to 2G/3G/4G and the democratization of smartphones in many other regions of the world resulting in a booming demand from developing countries. This trend is becoming possible for two main reasons:

- Lower production prices and lower overall cost of ownership for mobile phones, allowing penetration of lower income segments

There is a two-sided effect in the developing countries mobile phones market. First, mobile sales are moving towards lower revenues growth level. With lower production costs of smartphones, manufacturers tend to lower their ASP to furnish the emerging countries growing market.

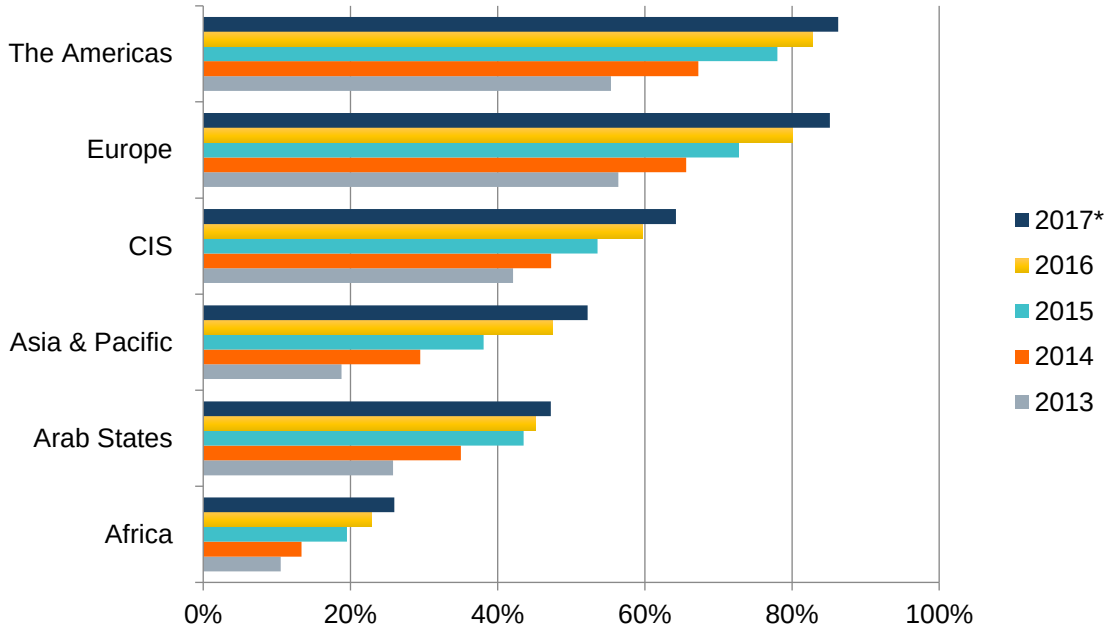
[7] ITU

African countries have on average the fastest growing annual growth rate of mobile subscription.

- Better, wider and cheaper network coverage: Increasing data connectivity will lead future smartphones sales

Every part of the world has seen great progress in broadband connectivity and Internet connection. Nevertheless, developing countries do not evolve at the same rhythm than developed economies due to a lack of infrastructures. In developing countries, infrastructures face a lack of financial sources and are more prone to natural disasters and climate change than in developed economies.

Proportion of individual with mobile broadband subscription, 2017*



Source: ITU, Estimated*

Africa, Arab States and Asia & Pacific, due to the increasing rate of mobile penetration, attracted more investors in telecommunications, targeting the huge and growing middle class of the continents. The increasing numbers of investors in infrastructures predicts better, wider and cheaper network coverage for smartphones' users in developing countries[8].

[8] Deloitte

vii. Figures, Europe 2010-2016, world and main countries

M. Methodology notes

The figure of Mobile phones production indicated by DECISION in this report is the figure from the Eurostat Prodcom database. In 2016, the estimated European production of mobile phones was therefore 343 M €.

There are differences between the Prodcom and the SBS NACE industry database:

- The SBS NACE industry statistics are “activity” statistics, i.e. they measure the activity of “statistical units” (which may be companies or subdivisions of companies) located in the EU. Units are assigned one NACE 4 digits code according to their “principal activity”, i.e. the activity accounting for the most value added (which may be less than 50% when there are more than 2 secondary activities). The whole of the activity of the unit (including secondary activities) is classified under the principal activity code. The database presents various indicators, among which turnover, value added, employees and investment;

- Prodcom data presents the value (in euros) and quantity (in units) produced in the EU in a more detailed 8 digits code (where the four first digits are the same as the NACE code), as well as import-export data. Prodcom.

N. Comparison with the other end-user segments

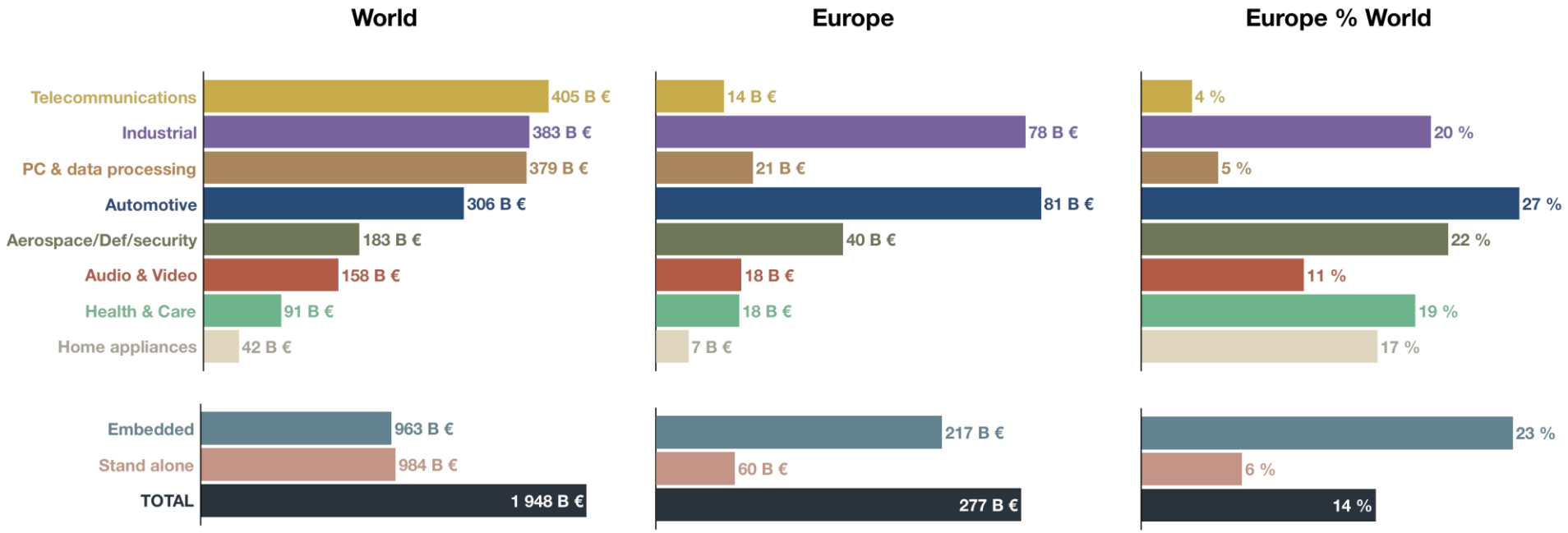
In 2017, the production of mobile phones and terminals accounted for 1.1 B € in Europe and 234.5 B € in the World. In other words, 0.5% of the global production of mobile phones and terminals were taking place in Europe in 2017.

As shown in the diagrams above, the total production of telecommunication electronic equipments (including mobile phones and terminals, but also electronics dedicated to telecommunication infrastructures), accounted for 405 B € in 2017. The European production accounted for 14 B € out of this global amount of 405 B €. In other words, Europe represented 3.5% of the global production of telecommunication electronic equipments in 2017.

In 2017, mobile phones and terminals represented 58% of the world production of electronic equipments dedicated to telecommunications (including infrastructures, terminals and mobile phones).

On the contrary, in 2017, electronic equipments dedicated to telecommunications infrastructures represented 8% of the European production of electronic equipments dedicated to telecommunications (infrastructure, terminals and mobile phones). Indeed, the European production of mobile phones and terminals fell to 1.1 B € in 2017. The European production of electronic equipments dedicated to telecommunications is therefore now almost completely composed of electronics equipments to telecommunication infrastructures (92%).

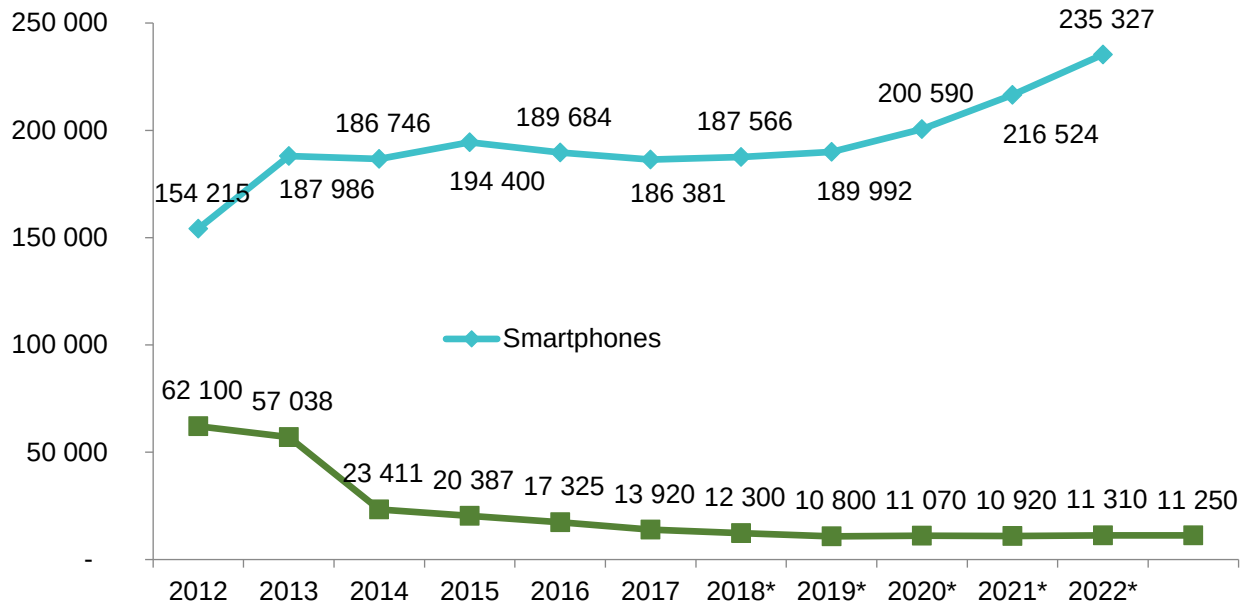
Diagrams – Electronic equipment production by segment in 2017 (B€)



Source: DECISION Etudes & Conseil

O. Europe positioning in the world

World Mobile Phone Production (Feature phones and Smartphones) in Value (million euros) from 2012 to 2027 with forecasts till 2022



* Forecasts
Source: DECISION Etudes & Conseil

At the end of the forecast period, we expect smartphones production in value to increase due to the launch of the 5G cellular networks in 2020. In the saturating mobile phone markets of Europe, China and US, the market is expected to reach a steady state level of growth in term of volume. Most of cellular mobiles will support IoT and M2M services and will guarantee lower latency and higher mobile range. In term of prices, high-end smartphones are expected to be more expensive. On the other side, the lower cost of production of low-end smartphones will decrease and reach low-revenue populations.

The mobile phone manufacturing industry is related to the production and assembly of devices upstream the value chain, including components suppliers and research and development stages. Network operators and retailers are located downstream the value chain. They are in charge of the distribution and sale of end products.

Our production forecast anticipates that the Asian share of mobile production will grow thanks to smartphones:

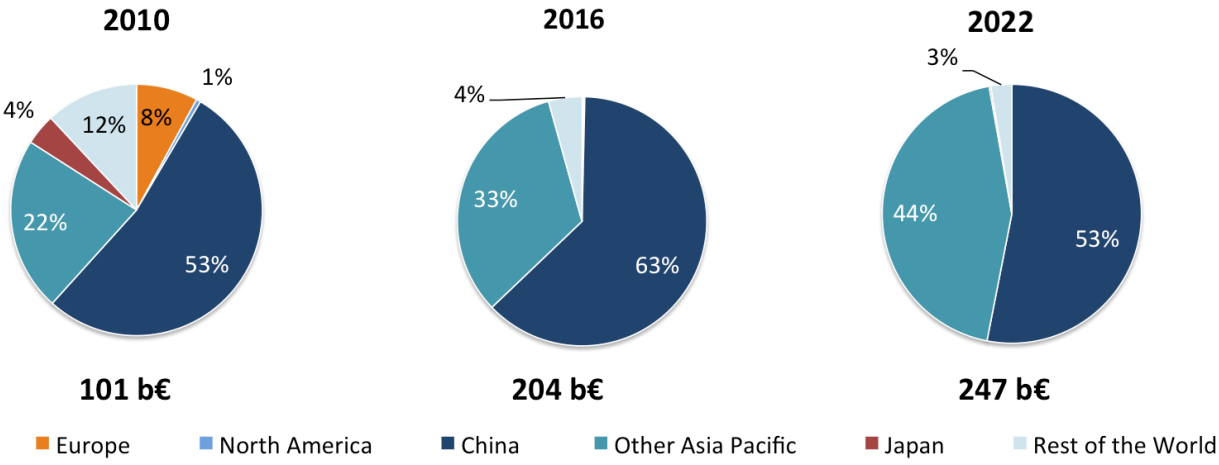
- China will continue to benefit from the success of Apple devices and from the company's fabless strategy to sub-contract 100% of its production in this country.
- The Other Asia-Pacific (OAP) region will benefit from the increasing demand in Chinese stars smartphone manufacturers (Huawei, Xiaomi, Oppo, Vivo), which are the main challengers to Samsung and Apple. The smartphone output from OAP grew from 22% production share in 2010 to 33% in 2016 and should reach 44% in 2022. The smartphone output from OAP was of 67.3 billion Euro in 2016 and is expected to reach 113 billion euro in 2022.

For low-cost mobile handsets, our production scenario by region is the following:

- The production in value should decrease because of steady sales in units with decreasing prices.
- Low-cost mobile phone manufacturers should outsource their production from China to Other Asia Pacific countries because of the explosion of smartphone production and the rising wage costs in China.

Overall, we expect the mobile phone production share to increase in value.

Mobile Phones Production Share per Region (% Value Share)

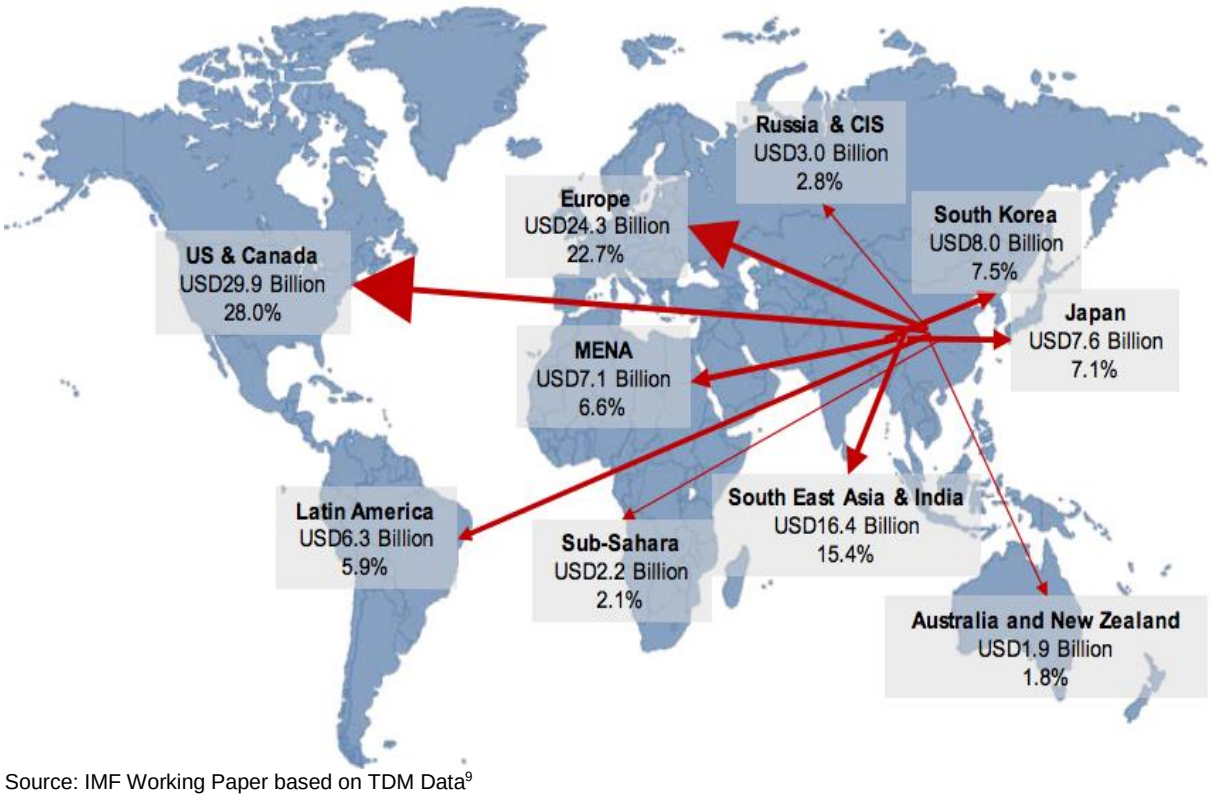


Source: DECISION Études & Conseil

The smartphone market is mature and almost saturated in Europe, USA and China. On the other side, emerging countries market is driven by an increasing demand. The global market is expected to push its growth through two main drivers:

- Continuous replacements in the mature markets of developed countries of existing smartphones by more sophisticated ones;
- Increasing penetration rates in emerging markets like India, African countries and others.

China: Exports of Smartphones - Value and Share of Total Smartphone Annual Exports, 2016



Source: IMF Working Paper based on TDM Data[9]

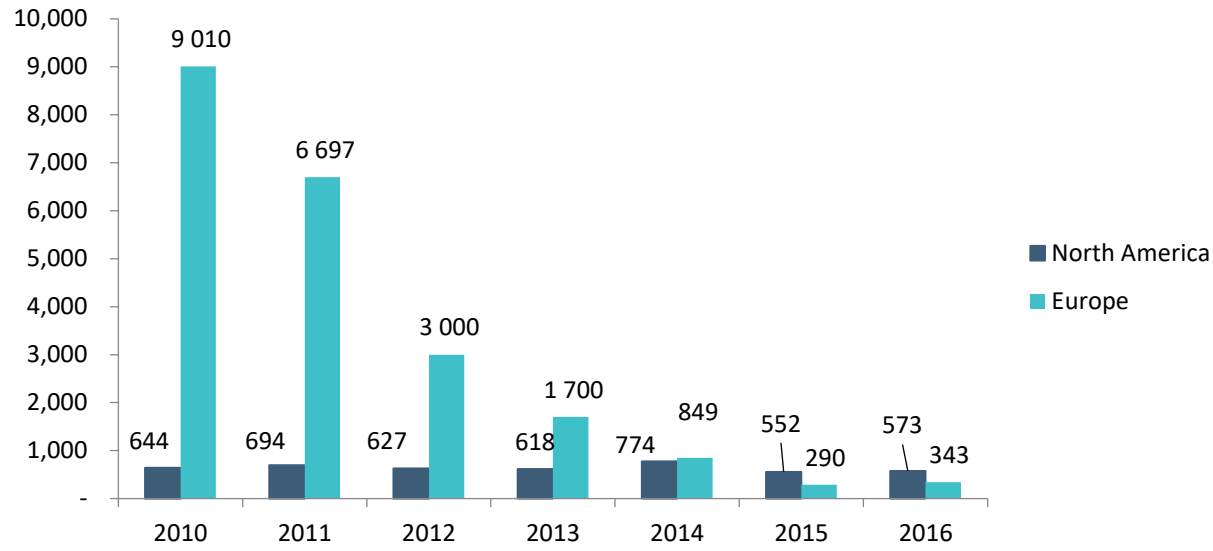
P. Europe - Focus on the factory production

Historically, European mobile phones manufacturers performed well with leading brands like Nokia (Finland) and Ericsson (Sweden) who used to capture around half of the global market in 2005 but also Sagem (Fra) and Alcatel (Fra), which were in the top-ten ranking at that time. The European Original Equipment Manufacturers (OEMs) benefited from a competitive advantage during the 2G and 3G standard developments. The European companies claimed around two thirds of the patents for technology supporting standards.[10] Moreover, Siemens, Alcatel, Nokia and Ericsson generated high entry cost barriers for new competitors by using cross-licensing patents between them. Nevertheless, having to pay lower royalty rates through offsetting licenses did not enable European manufacturers to survive.

[9] See note 7

[10] Study on internationalization and fragmentation of value chains and security of supply, Danish Technological Institute in cooperation with Ecorys and Cambridge Econometrics

Mobile Phones Production in value (million Euros) from 2010 to 2016 (Prodcom)



Source: DECISION Études & Conseil, Eurostat, US Census

Back in 2007, Nokia was the indisputable leader in unit and value of the mobile phone industry, equipping two-thirds of the market and shipping more than 60 million smartphones produced in large volumes by its European plants. But after 2010, the Finnish-based manufacturer passed up the chance to launch a new innovative product as it had done with its GSM handsets in the early 1990's. Nokia stopped producing smartphones in Europe and impacted the remaining semiconductors manufacturers. European and American supply chains practically completely relocated in China and Asia.

viii. Company positioning, Europe, World

From 2017 to 2022, the mobile phone production is expected to grow in units from 1,843 million units to 2,147million devices and in value from 198,7 to 214,9 billion euros.

- Samsung's sales are expected to decrease, facing a fierce competition with the Chinese rising stars, for both feature phones and smartphones;
- Apple's success is largely explained by the popularity of its iPhone 7, iPhone 8, iPhone 8 Plus, and iPhone X and its strategy on how it differentiates thanks to its in-house developed OS compared to the Android-based smartphone manufacturers;
- The Chinese brands are expected to increase their sales in volume, winning some market shares in India and Africa in the two mobile phones markets;
- From 2019, we expect smartphones sales to increase due to the launch of the 5G cellular networks in 2020 and the fifth generation of smartphones embedding 5G chipsets;
- The smartphone market is not expected to grow before 2019. The populations who do not own any mobile phones are still constrained by network coverage, located most of the time in rural areas. 5G will first be launched in dense areas. In parallel, LTE and 4G network coverage will still be spread in the other parts of the globe;
- Tax barriers could affect the price of imported and exported goods. In the long run, one could think smartphone manufacturers will have incentives to product manufactured goods in other countries than China.

Smartphones Production (Volume in million units) by Major Manufacturer

	2016	Growth 2016	2017	Growth 2017
Samsung	306	-4%	321	5%
Apple	215	-7%	216	0%
Huawei	133	28%	153	15%
Oppo	85	116%	112	31%
Vivo	72	107%	95	38%
Xiaomi	71	0%	92	31%
ZTE	60	34%	45	-25%
LG Electronics	55	-8%	56	2%
Lenovo and Motorola	51	-31%	50	-2%
Nokia/HMD Global/Microsoft	14	-63%	19	34%
Other	433		373	
World Market	**1495**	**4.9%**	**1537**	**2.8%**

Source: DECISION based on Gartner

Over the past decades, mobile phone technology has considerably improved, reaching unprecedented adoption and penetration rates. The use of smartphones has been driven by data consumption, demanding always more connectivity.

The mobile broadband networks market is growing steadily across the world. The fourth-generation mobile network was put in the market in 2012 and allowed larger and faster data transfer. If in 2016, more than half of the world did not have access to the Internet, 84% of the global population was covered by a mobile broadband network (3G and more).

Driven by the fifth mobile generation, and the arrival of 5G cellular network, data traffic will be on average multiplied by 8,7 from 2017 to 2023. Mobile video will be the fastest-growing segment of mobile traffic encouraged by live video communication adoption.

Mobile Data Traffic by region in EB/month*

Region	2016	2017	2023 Forecast***	CAGR Forecast**	Multiplier 2016-23
North America	1,8	2,6	18	39%	7
Latin America	0,7	1,1	8,9	42%	8
Western Europe	1,2	1,8	12	37%	7
Central and Eastern Europe	0,76	1,2	9,3	41%	8
North East Asia	1,9	3,2	21	37%	7
China (1)	1	1,8	15	41%	8
South East Asia and Oceania	0,79	1,3	12	45%	9
India, Nepal and Bhutan	1	1,3	14	48%	11
Middle East and Africa	0,71	1,3	14	48%	11
Sub-Saharan Africa (2)	0,25	0,41	4,6	50%	11

Source: Ericsson
* Active devices
** CAGR is calculated on unrounded figures
*** Figures are rounded (see methodology) and therefore summing up of rounded data may result in slight differences from the actual total
(1) These figures are also included in the figures for North East Asia
(2) These figures are also included in the figures for Middle East and Africa

Korean giant Samsung remains the leader in volume with 321 millions smartphones sold compared to 215 million by its US competitor Apple in 2017. Samsung has reached this position thanks to a broader range of smartphones sold at lower prices. This achievement was made possible because Samsung is vertically integrated and is sourcing internally an important portion of its key components, having a cost control, which its competitors did not have. Furthermore, Samsung has adopted the Android Operating System, the most popular open source platform, which reduced its OS R&D expenses compared to Apple that controls both software and hardware development of its phones.

Nevertheless, in terms of revenue and profit, Apple's strategy is still the most successful one. Indeed, Apple has managed to maintain its brand image as driver of the innovation in the smartphone segment allowing the company to sell its products at higher prices and to make more than twice more profit than its Korean competitor.

Indeed, Apple is the leader in term of profitability, while the market polarization becomes more aggressive. Only 10 out of 300 percent of the mobile manufacturers make profit.

Operating Profit Ratios in 2016

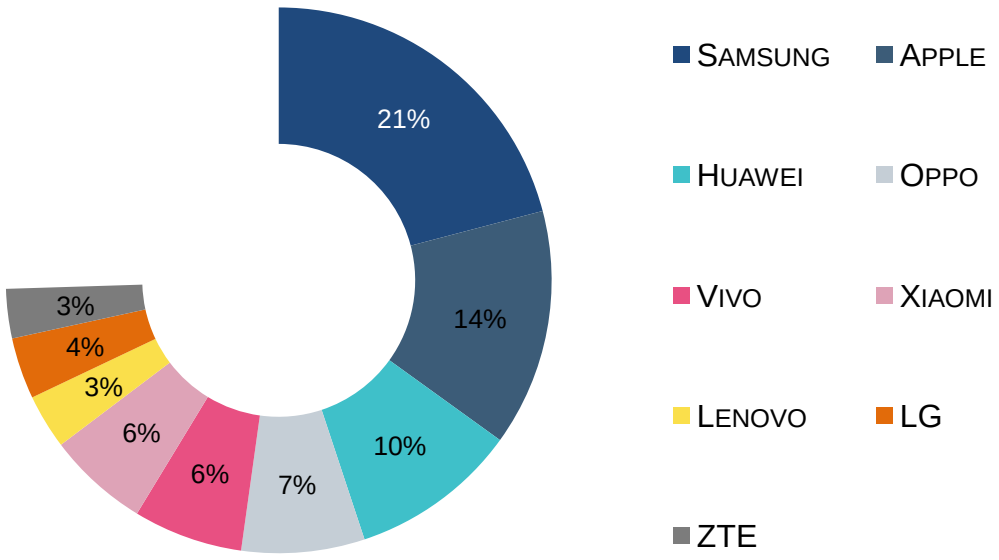
Apple	30%
Samsung	12%
Huawei	4%
OPPO	5%
Vivo	5%

Source: Business Korea

New comers are claiming their ambition to challenge this domination: the Chinese manufacturers. Huawei, having released its first smartphones in 2009, is tapping the market by the bottom thanks to its affordable products designed for emerging countries and was ranked n°3 during the last years. Oppo and Vivo, two other Chinese companies, are following the same path on the Chinese and Indian market, gaining some market share as well. Focusing on the design, audio and photography, the two manufacturers emerged, occupying respectively the 4th and 5th position in the worldwide market in term of mobile shipments. Both of them offer a higher trade margin than Xiaomi, their concurrent, offering only 5% of their margin to retailers against an average of 8%.

To face these two Chinese stars, Xiaomi announced it would not generate more than 5% margin this year on its smartphones production, targeting an average selling price to end-users at 117€. Known as a price-cutting manufacturer, Xiaomi is facing the higher growth rate. In India, it succeeded in overtaking some market shares to Samsung, becoming the first smartphones manufacturer in the country.

Mobile Phone Market Share in Volume in 2017



Source: DECISION Etudes & Conseil

The competition is also increasing in the high-end smartphone market segment. Low and middle-end smartphones manufacturers are progressively moving up to high-end smartphones manufacturing. The mobile phone industry has fragmented overtime through a divided production of components among different manufacturers.

Bill of Materials and Major Manufacturers

Display

Apple	Samsung
SAMSUNG DISPLAY	SAMSUNG DISPLAY
NISHHA CO	
STMIelectronics	

Apps Processor/Baseband

Apple	Samsung
DIALOG SEMICONDUCTOR GMBH	SAMSUNG SEMICONDUCTOR
DIALOG SEMICONDUCTOR GMBH	MAXIMUM INTEGRATED PRODUCT
ST MICROELECTRONICS	INTEGRATED DEVICES TECHNOLOGY
BROADCOM LTD	

Memory

Apple	Samsung
TOSHIBA	TOSHIBA
SK HYNIX INC	SAMSUNG

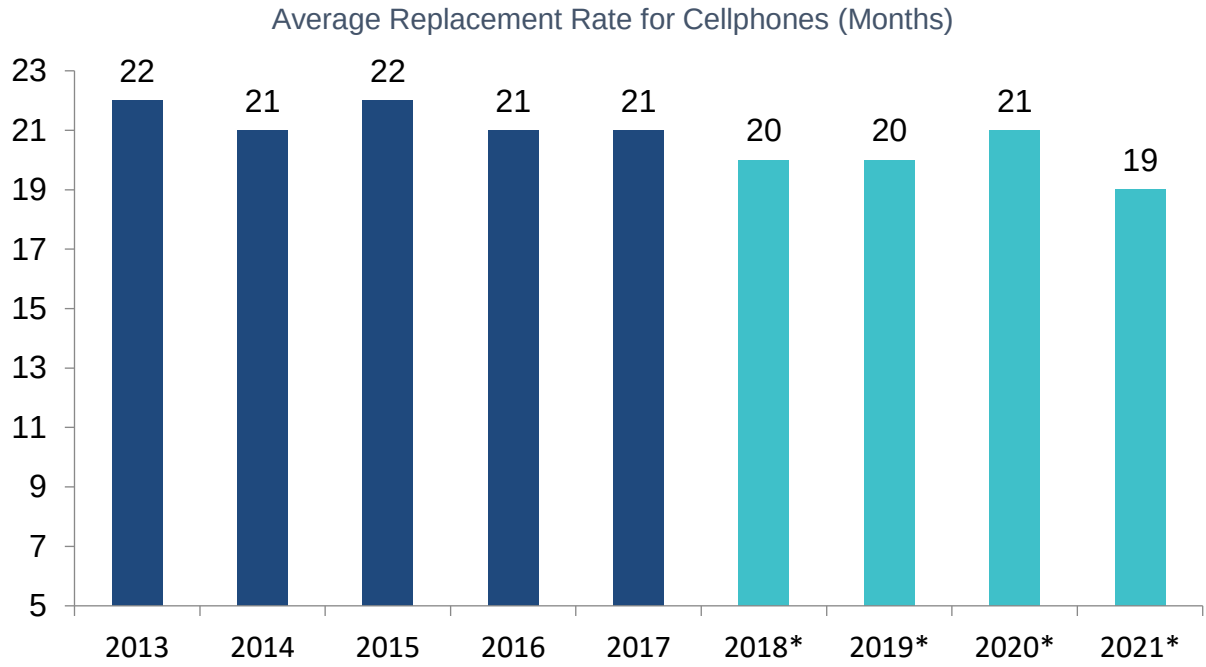
User Interface

Apple	Samsung
CIRRUS LOGIC	QUALCOMM
CIRRUS LOGIC	CIRRUS LOGIC
	SAMSUNG SEMICONDUCTOR INC
NXP Semiconductors	

Function	Apple iPhone X	Samsung Galaxy S9+
Display/Touchscreen Module	31%	22%
Major Mechanical/ Electro Mechanical	17%	20%
Apps processors/baseband	13%	18%
Memory	9%	16%
Cameras	10%	6%
True Depth Sensing Suits	5%	5%
RF/PA Section	4%	5%
Sensors	1%	2%
User Interface IC Contents	3%	2%
WLAN/Bluetooth Modules/4G/ LTE	2%	2%
Battery	2%	1%
Others	4%	2%
ASP	370$	375$
Starting Selling Price	999$	840$

Source: DECISION calculations, based on IHS Market

Splintering of components manufacturing has enabled economies of scales in the manufacture of basic components such as radio frequency chips, displays, batteries and MEMS.
Given the hypercompetitive smartphones market characterized by the frequent introduction of new products, consumers tend to often replace their smartphones.
The average replacement rates are expected to be flat before the launch of the 5G networks, highly helped by many U.S. and European service providers who recently cancelled the 2-years subscription contracts.



* Forecasted
Source: IC Insights

In 2020, where the 5G is expected to be launched in several countries, we expect the replacement rates to increase again, and convincing consumers to frequently changing a smartphone is going to represent one of the main challenges for smartphones manufacturers. Our main intuition is that smartphones manufacturers will focus on producing low and middle end smartphones in order to boost individuals' consumption over time. This will lead manufacturers to increase their production in volume.

In this way, the Chinese brand Xiaomi who started to sell its smartphones only via Internet has known unprecedented growth rates in volume. In the first semester of 2018, the brand registered a 124,3% growth YoY in million units, ranking 4th in the global smartphones market this semester. Led by Oppo and Vivo in term of unit shipment, two other Chinese Stars, these companies are expected to be led by Xiaomi in term of production units in 2022.

Major Smartphones manufacturers, in million units, forecasts till 2022

Company	2016	2017	2018*	2022**	CAGR
Samsung	306	321	315	275	-3%
Apple	215	216	219	250	3%
Huawei	133	153	160	200	6%
Oppo	85	112	121	135	4%
Vivo	72	95	110	125	6%
Xiaomi	71	92	125	158	11%
Total Smartphones	**1 437**	**1 434**	**1 454**	**1 693**	**3%**

* Estimated

** Forecasted

Source: DECISION Etudes & Conseil

On the other hand, the launch of 5G networks will represent a turning point for high-end smartphones manufacturers. We expect Apple and other brands to compete on high-end smartphones on the development of high-end smartphones application processors.

Samsung's overall smartphones unit sales are expected to be down by 3% to 275 million units in 2022, a slowing trend explained by the increasing market shares of the Chinese manufacturers who increase their sales in volume overtime.

ix. Technological and market development

Over its infinite set of possibilities, we decided to focus on several major innovations that could impact the mobile market industry.

The future development of smartphone capabilities will take three directions: the 5G networks launching and the smartphones capability to connect to the Internet of Things, Augmented and Virtual Reality, and cloud Computing.

Technological Roadmap – Impact on the global smartphone value chain in terms of competitive advantage and perspective of volume production

	Short-term impact (2017-2022)	Long-term impact (2022-2030)
Electronic Components Equipment		
Graphene: Sensors/batteries	No Significant impact	Significant impact
Graphene: Displays	No Significant impact	Significant impact
Infra-Red Sensors	No Significant impact	Significant impact
Others		
Graphene: Physical Structure	No Significant impact	Significant impact
Big Data in smartphones value chair	No Significant impact	Significant impact
3D Imaging	No Significant impact	Critic impact
Edge Computing	No Significant impact	Critic impact

Source: DECISION Études & Conseil

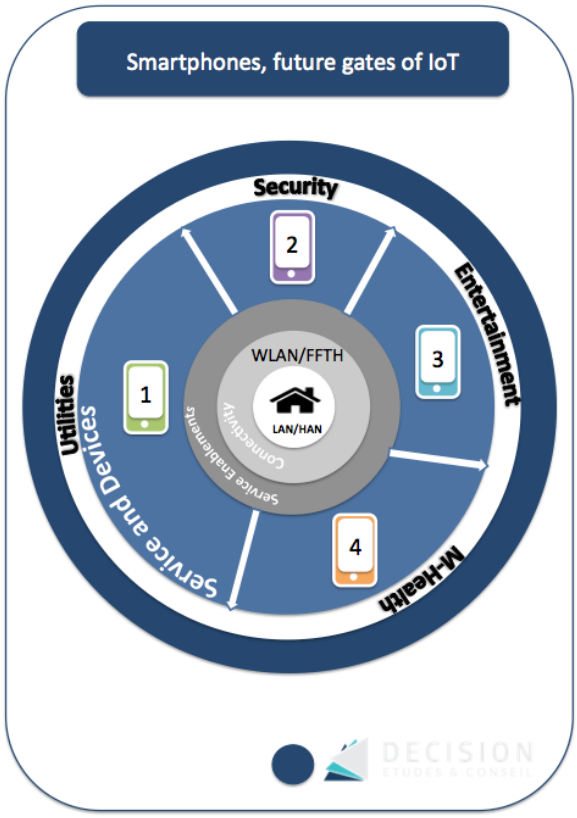
Technological Roadmap – Main actors involved in the development of every technology

	Indicative List of European Actors	Indicative List of Other significant Players
Electronic Components Equipments		
Graphene: Sensors/baterries		Samsung (South Korea), Huawei (China)
Graphene: Displays		
Leds	STMicroelectronics (France), OSRAM (Germany), Philips (Netherlands)	Qualcomm (USA), LG (South Korea)
Others		
Graphene: Physical Structure		Samsung (South Korea)
Big Data in smartphones value chain		
3D Market		T-Mobile (USA), LF Optimus (South Korea)
Edge Computing		

Source: DECISION Études & Conseil

Q. Mobile Phones, the future gates of the Internet of Things?

With the emergence of the 5G networks, people will be able to manage connected-objects from everywhere and smartphones will be the device, which allow everyone to access storage and computing services. The monitoring applications directly accessible from smartphones will represent a low cost and flexible home control. Smartphones (or any mobile device) may gather the application logic, data storage and communicate with the Internet of things that are connected to it. Things don't have to be as Smart, because smartphones will provide these capacities.



Source: DECISION Études & Conseil and GSMA

	Application	Company
1	Traditional Home Appliance	Miele, Liebhner, Kenmore
	Smart Home Appliance	Samsung, Google, Amazon, Philips, Apple
	Home Energy Management	Alert Me, Pulse Energy, GridpointHonywell, iControl, Tendril
	Home Automation and Monitoring	
2	Traditional Security Systems	ABB, ADT, Schneider
	Smart Home Security Systems	
3	Audio & Videos devices and services	Netflix, Apple, Samsung, LG, Sony
4	Daily Living devices	Airtrip, Apple, Qualcomm, Google, GE

Connected Mobile - Smart Homes

Consumers are now able to manage a large range of home appliances from their smartphones. Philips, through Interact, will launch an IoT ecosystem of LED lighting for Smart Homes. Its platform aims at collecting and analyzing data on light consumptions in cities in order to better forecast the needs in energy of a home consumption. Amazon and Google already launched smart home devices such as TVs, Cameras, Lighting and outlets.

The increasing connectivity of mobile phone devices will challenge smartphones' battery capacity.

Mobile Health

Rapid Growth of IoT and smart sensors on mobile devices will drive the healthcare innovations. Smartphones already helps people in managing their health through applications that help measuring blood pressure, heart rates etc. Mobile devices are also able to detect whether an individual is prone to a heart attack or not. Data collected on smartphones or cloud platforms could ease health professionals to understand patients' medical antecedents. Digital access to medical records will be one of the advantages of using such medical applications.

Apple turned iPhones into mHealth devices by proposing sharable and personalized medical records, and sleep tracking recorders. Google followed the same ambitions with DeepMind Health, oriented towards professional usage. Driven by an increasing mobile devices penetration and an increasing health consciousness among seniors, global mHealth market is expected to grow from 25,4 million revenues in 2017 to 58,8 billion dollars in 2020.[11] The success of the iWatch in healthcare questions the legitimacy of smartphone usage for such smartphone's applications.

Major part of mobile manufacturers opted for a Flash LED that enables to shine blood vessels in order to take the consumer's pulse. The device consists of two parts: a photo plethysmography (PPG) sensor. It refers to the technology commonly used by a pulse oximeter to capture blood volume change based on a light-emitting diode (flash of the smartphone's camera) and a thin-filmed force transducer. The PPG sensor measures changes in blood volume by shining tissue and measuring changes in light absorption, which can determine pulse rate. More, it can measure blood oxygen concentration. Shipments of smartwatches and smart bands together will total 170 million units by 2020, and all of them are expected to incorporate optical sensor components.[12]

Philips has drawn on its extensive in-house expertise in optics, video, and signal processing to create a VittalSigns Camera Technology. Through any standard video camera, it simultaneously measures pulse and breathing rate using PPG sensors.

R. Augmented and Virtual Reality

Intelligent Analytics

Samsung announced during the 2018 World Mobile Congress that next features will use visual analytics to analyze in real time information about what the camera see. For example, it will be possible to know the energetic value of a plate served in a restaurant.

[11] Allied Market Research; Markets and Markets; Transparency Market Research; BCC Research; Roland Berger
[12] Trend Force

Iris, fingerprints and facial recognition will be leading the 3D sensing market. Most of Smartphones companies have built 3D sensor equipped-smartphones after Apple launched the iPhoneX. Qualcomm as well will bring in 2018 iris recognition in cell phones. One of the key products driving facial recognition will be the IR LED. Iris recognition has been continuously incorporated in Samsung smartphones.

In the future, smartphone will have an increasing cannibalization effect on keys and other ways of usual ways of identification such as office entry-cards and transport cards.

3D Imaging

Ultra-thin hologram technology could soon be launched by smartphones manufacturers. The holo-phones will be boosted by the development of 5G that will increase the connectivity and data transfer rates. Amazon offers a Fire Phone, LG Optimus, RED and many other players will enter this new market that could help improving medicines in the visualization of organs for example. When practicing sports, it will be possible to kit sporting equipment with holographic Imaging items in order to better manage the individual's performances. T-Mobile, the American Company, is seen as a leading company in the hologram technology development.

S. Entertainments: Movies, Games and Music

Mobile technology was initially developed for voice services. With more durable batteries, 4K videos and larger touchscreens, videos consumption through smartphones is expected to increase as well. Mobile video will be the fastest-growing segment of mobile traffic encouraged by live video communication adoption. Netflix, Apple, Amazon and Sony are the main leaders of this segment.

Thanks to high-speed computing and the development of Internet connectivity, gaming-industry increased. Growth in this industry is driven by several phenomenon. First, the emergence of mobile gaming (smartphones and tablets) thanks to the success of itinerant platforms located in Asia and other emerging countries. Secondly, the arrival of a new market sector: virtual reality games. Traditional video games will be exposed to a fierce concurrence.

Audio services on streaming platforms emerged as well. Edited by Apple Music, Google Play Music or Spotify, digital albums are expected to win some market shares at the expense of physical sales, which tend to disappear.

After the launch of AR headsets, HTC, Samsung, Google, Sony, Facebook, Steam and other companies enlisted in AR since 2016.The emergence of the VR headsets, with an integrated smartphone into it. More than screens resolution, the players' location recognition is at the heart of the technology. Realized thanks to cameras that can broadcast the reality into the headset, mobile phones might have an advantage on this market.

LEDinside expects that the price of global InfraRed laser projector market for mobile 3D sensing is estimated to increase exponentially. Infrared laser projector has three major components, including infrared laser (Vertical Cavity Surface Emitting Laser or Edge-Emitting Laser), WLO (Wafer Level Optics), and DOE (Diffractive Optical Elements). Current costs of infrared laser projector are around US$3.5 to 6 but is anticipated to decrease in the next years due to a rising demand.

T. Artificial Intelligence and the Cloudification Phenomenon

Machine-Learning

In order to make mobile devices fitting always more its users, machines learning is thoroughly developed among smartphones manufacturers. Apple already designed and built a neural engine for iPhone X, in order to handle the phone's images and speech processing. Google does something similar with its Pixel 2 smartphone. Amazon and Huawei might follow soon with increasing R&D spending's in AI. They use AI to better understand users' behaviour for better allocating resources and improving energy efficiency.

Security

Cyber security is probably one of the biggest next step markets of smartphones industry. Companies and smartphones users recognize that one of the first source of error can be found in clumsiness and careless mistakes. AI could be used in order to learn how smartphones users behave, and thus detect rapidly a contradiction in habits that could alert for possible cyber-attacks or others.

Edge Computing

From now, Smartphones manufacturers focused on incorporating wider physical capacity storages in devices.
Cloud emergence combined with IA and higher connectivity opens to future scenarii, which could change the way mobile devices are built.
If some actors have already started to propose some cloud services in order to save files from smartphones to clouds, mobile phones still integers semi-conductors in order to store Applications etc.

One possible outlook could include the shift of storage solutions from physical components which used to be integrated in the smartphones to cloud spaces, where files, applications, videos will be stored.
Moreover, because of limited computing capacity of smartphones devices, computing could be realized from computers that would treat, run the calls and run the applications directly from cloud platforms.

The revolution of IoT and VR will amplify this cloudification phenomenon.
Every actor, particularly in the smartphone industry looks for investing in cloud platforms in order to win the loyalty of their clients. The lock-In of files like photos or videos taken through smartphones might be the dominant strategy of smartphones manufacturers.

Mobile phone production will be directly impacted through the components used for storage. The demand for micro memory components should decrease with the arrival of 5G network.

U. Graphene

Batteries

Smartphones manufacturers may use such a material in some decades in order to develop Long-Lifespan graphene composed batteries. With extraordinary thermic properties, graphene may enable to conduct electricity around ten thousand time faster than silver. Manufacturers like Huawei are trying to develop graphene to build batteries with

longer life expectancy and lower battery load time. Samsung is also trying to develop battery-boosting technologies that may allow 12 minutes. Nevertheless, this technology is still in R&D stage and is not expected to enter the market before several years.

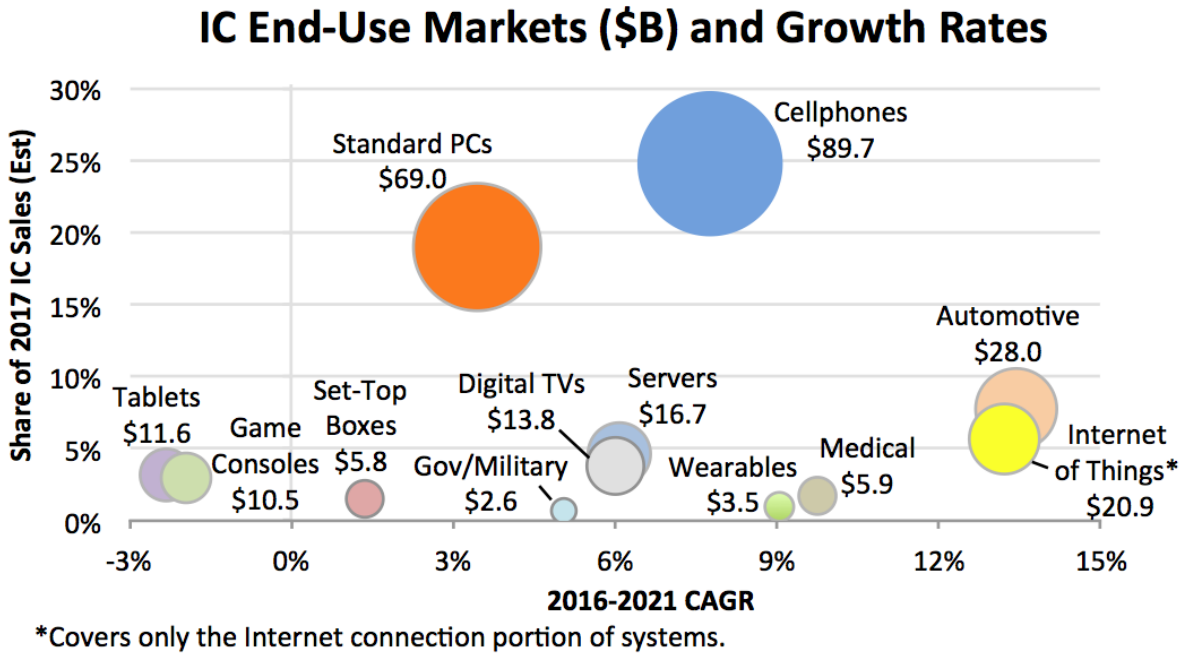
Foldable Phones

Two hundred times more resistant than steel, and foldable as a paper sheet, graphene could be used coupled with OLED screen technologies to build the future smartphones, to the extent that glass would not be used anymore for the smartphone's screens. Like the batteries, foldable screens will not be produced now, graphene applications still being studied and explored.

x. MNE interactions

V. Comparison between smartphone and other IC end-use market

The smartphone segment is currently the first IC end-use market and also the one with the highest forecast growth rate within the 2016-2021 period.



Source: IC Insights

W. Smartphones' ASP evolution

Becoming more and more useful and vital for most of the global population, the fifth generation of smartphones will allow completing more and more functions. Thus, production cost is expected to rise. Several brands are now building their own chipset and Huawei already announced the creation of its integrated 64-bit CPU chipsets, fostering high performance computing tasks and lower energy consumption. The table below compares high-end smartphones processors being shipped in 2016 and 2017 by 5 market leaders.

Comparison of High-End 64-bit Cellphone Application Processors

	Apple A11 Bionic	Qualcomm Snapdragon 835	Samsung Exynos 8 Octa 8895	MediaTek Helio X30	HiSilicon Kirin 970
Introduced	Sept. 2017	Nov. 2016	Feb. 2017	Aug. 2016	Sept. 2017
Status	In iPhone 8 models and iPnone X	In phones appearing in 1Q17	Released for phones in 2017	Entered volume production in 1Q17	First used in Huawei's Mate 10 Pro (4Q17)
64-bit CPU Architecture	Custom ARMv8-A CPUs ("Monsoon" and "Mistral")	Semi-Custom CPUs usingARM Cortex Core* ("Kryo 280")	Four Custom ARMv8-A ("M2") and Four ARM Cortex-A53	Two ARM Cortex-A73, four Cortex-A53 and four Cortex-A35	Four ARM Cortex-A73 and Four Cortex-A53
# of CPUs	6	8	8	10**	8
Graphics Processing Unit	Apple-designed three-core GPU	Qualcomm's Adreno 540	ARM's Mali-G71 MP20	Imagination Tech's PowerVR 7XTP-MT4	ARM's Mali G72 MP12
Clock Speed	2.53GHz (fast CPUs), 1.42GHz (low-power CPUs)	2.45GHz (fast CPUs), 1.9GHz (low-power CPUs)	2.3GHz M1, 1.7GHz Cortex-A53	2.6GHz Cortex-A73, 2.2GHz Cortex-A53, 1.9GHz Cortex-A35	2.4GHz Cortex-A73, 1.8GHz Cortex-A53
4G Modem	None	LTE modem (Category 16/13)	LTE modem (Category 16/13)	LTE modem (Category 10/13)	LTE" 4.5G" modem (Category 18)
Memory Controller	LPDDR4X	LPDDR4X	LPDDR4X	LPDDR4X	LPDDR4X
Fab Process	10nm (TSMC) 3D FinFETs	10nm (Samsung) 3D FinFETs	10nm (Samsung) 3D FinFETs	10nm (TSMC) 3D FinFETs	10nm (TSMC) 3D FinFETs

*Developed under ARM's new "Build on ARM Cortext Technology" (BoC) licensing model versus a full-custom CPU design based on the 64-bit ARMv8-A instruction set.

**Groups ten 64-bit CPUs into a tri-cluster configuration (two high-performance Cortex-A73 cores, four mid-range Cortex-A53 cores, and four low-power Cortex-A35 cores).

Source: IC insights

The A11 Bionic microprocessor has been used in the iPhone 8, iPhone 8 Plus, iPhone X that ranked in the best-selling smartphones in the first semester of 2018. Integrating more 3D graphics, high definition video, these new processors support AI and hardware acceleration engines for enhanced VR/AR, high quality video communications, extend battery life through intelligent power management, facial recognition and many other functions.

Huawei and Samsung, like Apple, develop internally their own processors for smartphones.

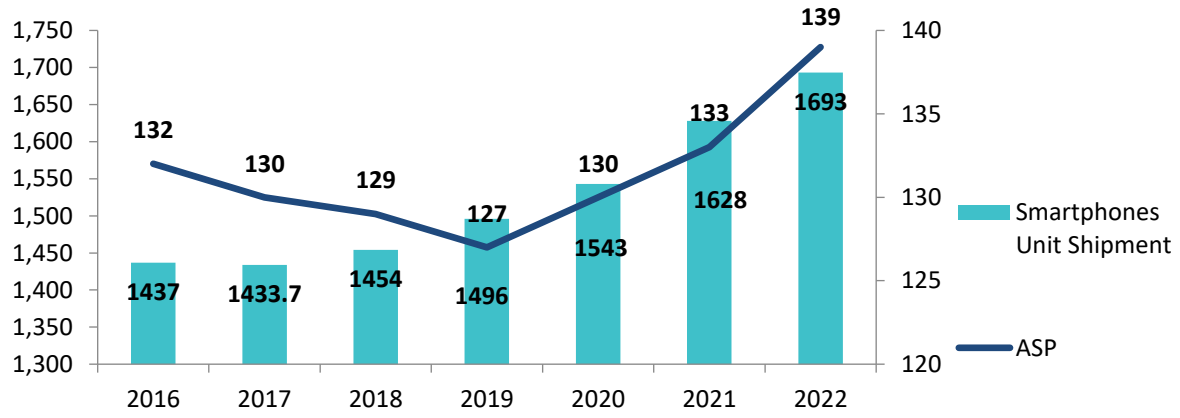
In 2017, Xiaomi announced its first internally developed processor in handsets, the Surge S1-based Mi5C handset, manufactured by Taiwan Semiconductor Manufacturing Company. Developing internally processors in handsets allow smartphones manufacturers to cut the cost of the handsets**.** Buying application processors from Samsung, MediaTek or Qualcomm result in a comparatively higher selling price.

2017 – Average Production Cost per Smartphone in €

Components	Average Production Cost per Smartphone (€)	Percentage of Total Value
Display/ Touchscreen Module	40,3	31%
Major Mechanical/Electro Mechanical	22,1	17%
Apps Processors/Baseband	16,9	13%
Memory	11,7	9%
Cameras	13	10%
True Depth Sensing Suits	6,5	5%
RF/PA Section	5,2	4%
Sensors	1,3	1%
User Interface IC Contents	3,9	3%
WLAN/BT Module/4G/LTE	2,6	2%
Battery	2,6	2%
Others	5,2	4%
Average Cost	**130**	**100%**

Source: DECISION Études & Conseil

Global Smartphone unit Shipment Evolution



Source: DECISION Études & Conseil

ASPs for smartphones are expected to rise after 2019 for two reasons.

- First, the hyper competitiveness of the market will naturally force the weaker suppliers to leave the market, giving more market power to the principal suppliers and smartphones manufacturers;
- In addition, smartphones will be equipped with more numerous 4G and 5G features and applications that will push the global Average Selling Price upside.

Even though newly Chinese manufacturers entered the market and proposed lower ASP, this trend should be reversed with the arrival of the 5G networks. Indeed, this new network will allow mobile phones to perform more tasks if connected to this network. Smartphones manufacturers will not have other options but to fit mobile phones to these new opportunities with additional functionalities and features (e.g. 4,5G/5G, HD Cameras, Bluetooth, GPS, mobile TVs etc.).

On average, a high-end smartphone includes wider amount of DRAM and NAND flash that low-end smartphones, both of which rose in price in 2017.

Average IC Content in Cellular handsets (2017E)

Product Family	Basic Phone	Enhanced Phone	Low-End Smartphone*	High-End Smartphone**
Memory	$1.30	$4.10	$9.90	$33.70
RF/analog/mixed signal	$2.05	$2.55	$4.25	$12.65
Applications processor	—	$2.80	$6.95	$17.80
Misc. logic	—	$1.10	$1.70	$3.65
Camera chip	—	$1.60	$1.85	$3.70
Digital baseband	$1.90	$2.00	$2.10	$3.25
Multimedia processor	—	$1.20	$1.50	$3.20
Bluetooth module	—	$1.55	$1.55	$1.55
Total ICs	$5.25	$16.90	$29.80	$79.50
			*<$200	**≥$200

Source: IC Insights

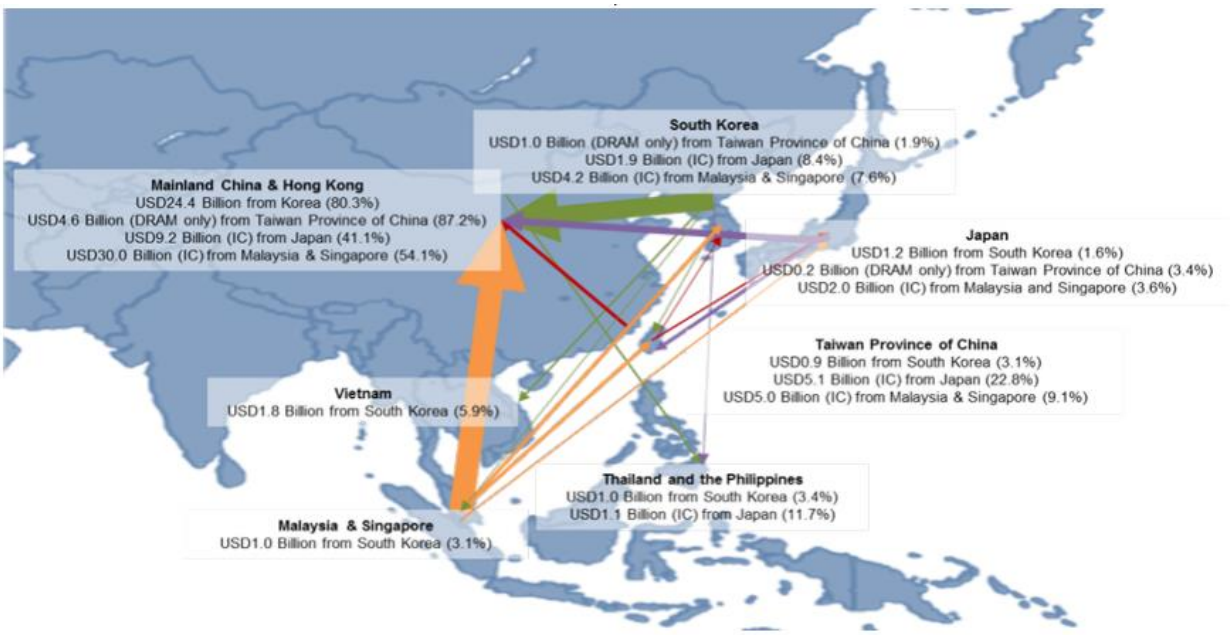
In addition, both low-end and high-end smartphones are intended to increase their use of NAND Flash Memory and DRAM usage, due to higher connectivity and data transfer rates. Going forward, smartphones producers will be directly impacted by the increasing prices of these two main features that will be driving the ASPs.

Main components used in smartphones production are manufactured in Asia. DRAM and flash memories are mainly manufactured in South Korea and Vietnam (Samsung Electronics Corporation). Japan, Malaysia, Singapore, South Korea and China are specialized in system chips (CPU and processors). Finally, displays are also mostly manufactured in South Korea and Japan.

The supply chain of smartphones' manufacturing has become more and more fragmented and the figure below summarize the geography of the Integrated Circuits exports in Asia.

X. Geographical repartition

Annual exports of Integrated Circuits, Value and Percentage of Total Component Exports, 2016



Source: IMF Working paper[13] based on KITA; Ministry of Economic Affairs, Taiwan Province of China; TDM Data; and UN Comtrade Database.

The global smartphone value chain involves several regions and the launching of iPhone products has had significant impacts on Asian countries exports and imports. If China is historically the main country shipping the finished smartphones to the rest of the world, Asian countries continues to gain some importance in the global mobile phones' manufacturer ecosystem.

[13] A New Smartphone for Every Fifth Person on Earth: Quantifying the New Tech Cycle by Benjamin Carton, Joannes Mongardini, and Yiqun Li

European Commission

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