White Paper – ESDM Industry

Technology Cluster Manager (TCM)

Technology Centre System Program (TCSP)

Office of DC MSME, Ministry of MSME

December 2020

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Contents

List of Figures

1. Introduction

Technology Centre Systems Programme (TCSP) is a national programme undertaken by the Ministry of Micro, Small and Medium Enterprises with the assistance of the World Bank. The programme seeks to enhance the technological and skill base of MSMEs in certain manufacturing sectors to improve the competitiveness of MSMEs, via upgraded and new Technology Centers (TCs). The objective of the programme is to enhance the productivity of selected MSME clusters by improving their access to manufacturing technology, establishing a strong focus in providing business & technical advisory services, and improving availability & employability of skilled workforce through TCs[1].

As part of the programme, KPMG has been appointed as the Technology Cluster Manager (TCM) to support TCs and undertake technology and cluster development activities. The objective of TCM is to increase business opportunities for MSMEs through market linkages, enhance competitiveness of the cluster business environment, increase the number of MSMEs utilizing the services of TCs, develop a financially self-sustainable business model for cluster related services provided by TCs, identify technologies (Industry 4.0) of the selected sector for TCs, evaluate existing training programs & develop new training programs for rollout at TCs, conduct a gap analysis of TCs, strengthen the capabilities of TCs to provide technical advises to their clients, increase awareness amongst stakeholders on Environmental, Health, and Safety (EHS) requirements[2].

As part of the project, White Papers in different sectors are being prepared to help identify the future roadmap for the sector in general and the TCs in specific. This White Paper focuses on the ESDM sector. ESDM Industry globally is one of the largest industries and is a key driver of the economy.

1.1 Importance of the electronics sector globally

The electronics sector is one of the largest industrial sectors in the world and in the last decade the global electronics market has experienced considerable growth. The companies in this rapidly evolving sector deal with manufacturing, designing, assembling, and servicing electronic products. The electronics sector is a driver of research, development, and innovation (RDI) productivity, commerce, and investment and has made a huge contribution to economic growth in both developed and developing countries. The sector is an important source of employment opportunities and technological skills development. The importance of the electronics sector also lies in the fact that it provides components and equipment for other industries.

The growth of the electronics sector is largely driven by increased consumer demand, on one hand, and increased competition, on the other hand, which reduce the costs related to electronics production and makes affordable electronics products more available to the wider population. There is a significant increase in demand for mobile phones, automobiles, medical devices, and energy-efficient homes. The emerging of new technologies, such as Internet of Things (IoT) and Artificial Intelligence (AI), and other innovations in the sector are making a huge impact on design and manufacturing techniques and impose new business models. The electronics industry makes a significant contribution to global GDP. According to the statistics, in 2017 a worldwide electronics market valued at $2,000 billion. For the sake of convenience, the white paper uses the following classification of the ESDM sector:

a) Manufacturing Services
b) Design Services
c) Testing & Calibration

The Manufacturing Services are further classified into consumer electronics, electronic components, computer hardware, industrial electronics, strategic electronics (Aerospace and Defence), automotive electronics, and medical electronics.

The most profitable electronics sector is the semiconductors industry which is globally worth more than $400 billion. Moreover, many countries around the world are producing more electronics as a result of increasing demand from emerging market economies, such as China, Brazil, India, Mexico, Russia, and

[1] DC MSME website
[2] DC MSME website

Saudi Arabia. China has been highly positioned as a producer of electronics for a long time and now is also one of the major markets for consumer and industrial electronics. In the next decades, it is estimated that Asia will represent about half of the global electronics market, taking also into consideration that huge amounts of government funds and corporate wealth are being invested into research and innovation related to electronic components and systems (ECS).

1.2 Objective of the white paper

The objective of this white paper is to discuss classification of the ESDM sector in India with respect to the global context in order to successfully highlight key trends and identify major stakeholders contributing to the growth of the sector in India. The paper also focuses on determining the position of India in the global electronics market, identifying challenges, make suitable recommendations on introducing emerging technologies for the benefit of TCs and MSMEs.

The white paper tries to highlight the major ESDM industrial clusters across the globe, their success stories and differentiating parameters which contributed to their growth. The paper also tries to give a detailed account of the key trends existing in the ESDM sector globally. The global narrative of the White Paper is followed by an Indian narrative which tries to convey about the sectoral trends in Indian market and highlight major ESDM industrial clusters in India. The white paper also lists down some of the major challenges being faced by the ESDM sector in the country and gives recommendations for technology adoption and overall transformation of the sector.

2. Global Scenario

In the wake of Liberalization, Privatization, and Globalization across the third world nations, international trade and business activities across the globe have increased immensely. After these reforms in the third world nations came the communication revolution which has revolutionized the electronics market.

In the last few decades, the global electronic market has encountered significant modifications, like the displacement of production from high-cost to low-cost destinations, generating a significant source for the growth and progress of Asian countries. With the reallocation of electronics production, China is holding the position of the market leader. In the last few decades, electronics production in China has increased by approximately 35% (from 2.6% in 1995 to 37% in 2018).

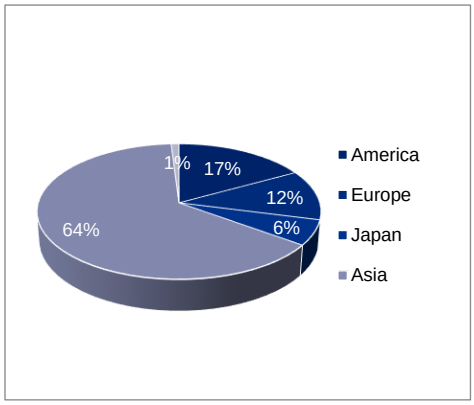

Figure 1: Percentage of Electronics output by Region 2018

In the period from 1995 to 2018, the production of electronics in low-cost countries recorded an increase of about 46%, while a decrease in production in the same percentage was noted in high-cost countries. Figure 1 tries to give a detailed breakup of electronics manufacturing across the globe region-wise.

As stated in the Yearbook of World Electronics data, notwithstanding the movement of production to lower-cost services, a significant dimension of equipment production has remained in Western Europe and the US. Germany leads in electronics production from the perspective of Western Europe, while in Central and Eastern Europe, Poland's electronics production is the maximum. Germany accounted for 32.4% of electronics equipment production in 2019, and its overall percentage is expected to rise more by 2023[3].

With the movement of more distinguished volume production and service trends to lower-cost areas, as well as increased activity by foreign companies, the electronics industries in the US have experienced a significant transformation. In 2004, US electronics exports gave way to Chinese exports. China’s advance as an electronics exporter is just the newest chapter in the transformation of East Asia into the world’s principal electronics production grounds.
Within a decade, the focus of global production for various well-known electronics goods has moved from Japan and East Asian developing markets to China owing to labor and regulatory advantages[4]. The Chinese electronics industry created a total revenue of about 976 billion euros higher than the US industry in 2016. Figure 2 elucidates the leading countries in the electronics industry in 2016, based on market size (in billion euros)

[3] Reed Electronics Research, 2019
[4] Gangnes & Van Assche, 2010

The times are changing now and the communist regime in China is expected to be pro-people now. The everlasting pressure and demand for labor reforms by the activists in China have led to the rising labor costs. These rising labour costs in China can create significant growth potentials for developing countries. One of the beneficiaries of this change is Vietnam. Vietnam is noting significant growth rates due to the relocation of electronics manufacturing from China.

The growing importance of developing countries in the electronics industry has led to stagnation and decline in electronics production in developed countries like the Japan and the US. India, with its immense internal market and "Make in India" ambition, can achieve a new focal place for domestic electronic production dependent upon the political will and shaping of a regulatory regime.

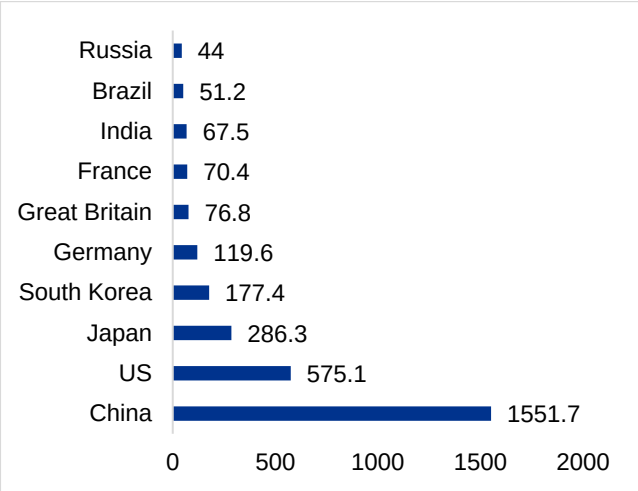

Figure 2: Leading countries in the Electronics Industry in 2016(In billion Euros). Source: Statista Research Department, 2020

The trends in the Global Electronic sector can be enumerated in the two types (i) Electronic Manufacturing Services (ii) Electronic Design Services

2.1 Global Electronic Manufacturing Services

The global EMS market volume in 2019 was $463.2 billion and has the potential to increase by $118.49 billion from 2020 to 2024[5]. In another estimate, it is anticipated to increase at a CAGR of approximately 8% and stand at a whopping $575.69 billion by 2022[6].

The electronics industry is highly competitive, owing to the growing complexity of electronic products and raising tension on OEMs for lowering expenses. The Asia Pacific market size for EMS in 2019 was $ 292.6 billion and China accounted for more than 33% of this market share.

2.1.1 Global Consumer Electronics Industry

The consumer electronics industry is efficient and dynamic involving quick and innovative shifts in technologies, and remarkably competitive. In support of this claim is the fact that reports from 2015 anticipated that the market would reach a size of $838.85 billion by 2020[7] however, 2018 reports note that the market has exceeded the volume of $1.100 billion in 2016, and is awaited to grow at an annual rate of 3% by 2024[8].

[5] Technavio, 2020
[6] BEROE, 2017
[7] Grand View Research, 2015
[8] Wadhwani & Saha, 2018

With a motive to obtain a rival advantage in the market, producers are fabricating discerned exclusive products that are attracting competitors in the industry, with continuing success. Consequently, accelerated commoditization is taking place along with a simultaneous drop in prices.

During 2020, the consumer electronics market generated a total revenue of $368.573 million, of which the largest revenue originated from China i.e. $153.804 million (Statista, 2020). In line with these forecasts, revenues in the consumer electronics market are anticipated to grow at a CAGR of 5.5% by 2024. The figure highlights the projected revenue from the consumer electronics industry till 2024.

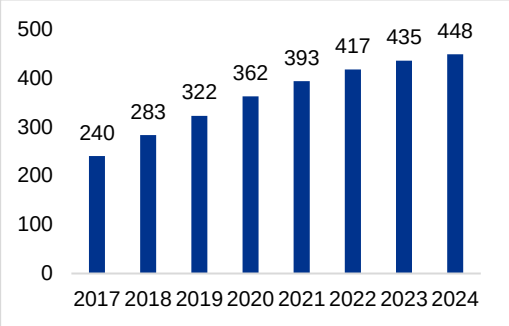

Figure 3: Worldwide Revenue of Consumer Electronics (USD Millions)

The Mobile Phone sub-segment is the most dominant in the global consumer electronics market. In 2018, it accounted for 48% of the global revenue in the consumer electronics sector, and about 21% of global sales. Globally, most revenue is generated in China. The Chinese revenue was $120,503 million in 2020[9]. The competition is fierce, and the number of companies are constantly on the rise. However, the global leaders are the Manufacturers from China i.e. Xiaomi. The global household appliances market is expected to reach $763,451 million by 2025, progressing at a CAGR of 5.4% by 2025[10]. Key trends of some of the major constituents of the household appliances are as follows:

- Revenue in the Washing Machines segment amounts to $58,688 million in 2020. The market is expected to grow annually by 3.1% CAGR (2020-2025)[11]. The global trend is seen in the demand for smart connected washing machines, such as managing and controlling machines using smartphones.
- The air conditioner market is estimated to expand at CAGR of 14% in the period 2019-2024[12]. China is the largest market for air conditioner systems in the world. It is predicted that technologically advanced air conditioners, such as air conditioners with inverter and air purification technologies, to have a positive impact on market growth.
- The global household refrigerators and freezers market size is predicted to reach $125.68 billion by 2025, growing at a CAGR of 6.8% during the forecast period. The decline in product prices, raising income, innovations and investment devices are some of the key trends stimulating the market growth.
- The Global Wearable Electronics market is foreseen to attain $98.24 billion by 2026 and will grow with a CAGR of 24.9%[13]. The key determinants of the market growth are increasing medium lifetime expectancy, increasing interest of customers towards communication, and networking. On the other hand, data privacy problems, shortage of design features, a high initial investment, and higher power usage, limitate the market to reach its full potential[14].

Some of the other trends in Global consumer electronics are:

- Geographically, Asia-Pacific excluding Japan (APEJ) region is expected to maintain market dominance, with the largest market share and the fastest growth rate, by the end of 2020[15].
- As Europe has developed as a consumer electronics industry and is supported by a high-tech connectivity environment, it is expected to become one of the next major markets for electronic products.
- Growing production and purchases of the product in America will boost the consumer electronic market in the North American region.

[9] Statista, 2020
[10] PRNewswire, 2019
[11] Statista, 2020
[12] Mordor Intelligence, 2019
[13] Research and Market, 2018
[14] Research and Market, 2018
[15] PharmiWeb.com, 2020

- The demand for smart home devices will increase in the future period due to the high interest towards home monitoring from distant places, extensive focus on protection and safety and practicality smart home market. The Smart Homes Market products demand, including Lighting Control, HVAC Control, Home Healthcare, Smart Kitchen, Smart Furniture, will improve thanks to the increase in perception of fitness and healthy lifestyles, the growing demand for smartphones and smart gadgets, rising requirement for energy-saving and low CO2 emission solutions, the presence of market members concentrating on expanding their selection in smart home product portfolios, cost reduction proposals allowed by the market[16].
- The demand for televisions with larger screen sizes and integrated new technologies such as 4K and OLED is growing. The number of companies offering such advanced products is on the rise with key competitors dominating the sector such as LG Electronics, Sony Corporation, and Samsung Electronics. The rising popularity of such devices followed by the falling prices is predicted to be the major driver of consumer electronics.
- The smartphones market is highly competitive and dominated by strong players such as Samsung, Apple, Huawei and Xiaomi. The focus of the leading companies is to be ahead of the competition and to launch technologically improved new models such as camera configuration, processor and battery power. According to the Mordor Intelligence market report, some of the recent developments in the market are[17]:
  - In September 2019, in the middle of the declining sales of Samsung's flagship phone, the company was focusing on foldable to rise the sale. After announcing Galaxy Fold, Samsung was working on a second foldable device that folds down into a compact-sized square.
  - In the same period, Xiaomi launched another 5G handset, Mi 9 5G in China. Only several months after, the company launched new 5G handset - Mi MIX 3 5G. The first 5G smartphone from Xiaomi was launched in February at Mobile World Congress 2019.
- In the field of wearable electronics, top consumer electronics technology trends include smart speakers, automated home, consumer drones and consumer robots.

2.1.2 Global Electronic Components Industry

The global electronic components market was valued at $373.73 billion in 2019. It is anticipated to increase with a CAGR of 8.59% and strike $519.65 billion by 2023[18]. As reported by The Business Research Company (2020), The Asia-Pacific was the dominant market in 2019, with China leading the market with 22.5% of the total market share due to the presence of chipmakers, giant chip designers, and other essential elements that are applied in the IoT applications, smartphones, and laptops.

Electronic components can be categorized into the following types:

i. Active Components: These components are associated with a source of energy and are attributed with the task of introducing energy into the circuit such as transistors and diodes.
ii. Passive Components: These components cannot introduce energy into the circuit and are attributed with the task to amend circuit characteristics such as resistors and capacitors.
iii. Electro-Mechanical Components: These components essentially convert either mechanical action to electrical or electrical action to mechanical such as motor, generator, etc.
iv. Associated Components: Some other components like optical discs, magnets and tuners which serve miscellaneous functions are categorized as associated components.

The active components market holds about 50% of the global market share in electronic components. As pointed in Market Research Future (2018) report, the integrated circuits are the most sought of the product amongst the active components with a revenue of $76.96 billion in 2016 and are awaited to grow at 11.42% CAGR. Furthermore, the consumer electronics fuels the active electronic components market and has contributed $73.5 billion in 2016 and is anticipated to increase at 11.95% CAGR.

[16] Markets and Markets, 2019
[17] Mordor Intelligence, 2019
[18] The Business Research Company, 2020a

In recent years, Asia-Pacific has become a dominant region in the market due to the rapid economic development, digitalization and industrialization. China is in the leading position, with some of the largest companies in the areas of chip manufacturing and design, while North America is at the second place.

The global passive and interconnecting electronic components market size was estimated at $171.3 billion in 2019 and is expected to increase with a substantial CAGR of 5.3% in the period range from 2020 to 2027. The expansion of digitalization, linked with improved connectivity and mobility demand, is enhancing the complexity of electronics, resulting in the growing demand for passive components[19]. Increase in the adoption of smartphones and laptops in emerging economies, such as India and China, is awaited to stimulate the market for passive and interconnecting electronic components[20].

Internet of Things (IoT) is impacting the electronics sector in general, enabling communication among smart devices. Thus, there is a growing demand for electronic components such as transistors, resistors, capacitors, and diodes that are used in producing sensors and smart devices that can communicate with each other.

The global electronic capacitor market is estimated to register a CAGR of 4.69% to reach $23.477 billion by 2023. Rising demand for consumer and wearable electronics, increasing disposable income, product innovations, and the increasing use of polymer-based capacitors in industrial applications have stimulated the growth of the capacitor market[21]. The global electronic resistors market is estimated to expand at $2.4 billion by 2023. One of the products predicted to have the highest growth rate is semi-fixed variable resistors.

There is a growing demand for active electronic components used in the production of smart home appliances such as air conditioners, washing machines, refrigerators, etc. Wearable devices, such as smartwatches, fitness bands, Virtual Reality headsets, and drones, have emerged as a growing trend among consumers, stimulating the production of active electronic components. There is a need for integration of these components in telecom equipment and networking devices needed for 5G infrastructure development.

The use of advanced electronics in the automotive industry has increased, owing to an increased demand for connected cars. For example, the growing demand for advanced microcontrollers for providing connectivity to autonomous cars is predicted to stimulate the adoption of active electronics components from 2019 to 2025[22]. The recent adoption of the Internet of Things (IoT) and Industry 4.0 for smart manufacturing applications is predicted to encourage wider adoption of active electronic components.

In the area of passive electronic components, there is a growing need for capacitors to be integrated into consumer electronic devices. In addition, with the increasing production of industrial digital devices and consumer electronic goods such as home appliances, transformers are being highly demanded. The increase in the demand can also be attributed to the increase in demand of electricity by the emerging nations along with a considerable growth of the power industry. The Global Transformer Market is estimated to reach $80.1billion by 2025, growing at a CAGR of 6.7% from 2020 to 2025[23].

The growth of the transformer market can be attributed to upsurge in transmission & distribution infrastructure investments, and evolution in renewable energy sector. The growth can also be attributed to transformer systems operations, which act as a highly efficient transmission & distribution equipment.

[19] Mordor Intelligence, 2020
[20] Grand View Research, 2020a
[21] Research and Markets, 2020
[22] Grand View Research, 2019
23 Industry Arc Research,2019

One of the major trends in the electrical resistors market is the production of green products. In the Asia Pacific region, countries such as China, Japan, and India are investing in green resistors with halogen-free insulation. North America is expected to see an increase in the usage of electrical resistors due to the fact that the US government intends to launch eco-friendly energy distribution and transmission control systems[24].

The global electronic manufactruing industry is forever changing with new compliances and regulations to ensure availabiltiy of superior quality products in the market. With rapid growth of technology, many customers are throwing away obsolete equipment in large quantities. This is resulting in landfills being filled with hazardous materials. The high levels of electronic trash and e-waste is leading to mercury and lead poisoning. The RoHS directive was adopted to limit the amount of hazardous materials in the manufacturing equipment. The intention is to reduce the number of heavy metal poisoning incidents, and maybe even e-waste. RoHS is a European Union (EU) directive mainly concerned with the manufacturing of different types of electronic equipment. These can range from household appliances, lighting equipment, electronic tools to control instruments and IT and telecommunications equipment. RoHS restricts the use of the materials like Cadmium, Hexavalent chromium, Lead, Mercury, Polybrominated biphenyls (PBB) and Polybrominated diphenyl ether (PBDE). Also a European Union regulation, REACH addresses the production and use of chemical substances and their potential impact on human health and the environment. The name is an acronym for Registration, Evaluation, Authorization and Restriction of Chemicals. RoHS restricted substances are also on the REACH restricted list. The main difference between RoHS and REACH is that RoHS bans substances that are present in electrical equipment that is within the directive. REACH, however, pertains to all chemicals including those used to make a product. This can include materials, solvents, paints, chemicals, etc.

2.1.3 The Global Computers Hardware Market

As reported by the Business Research Company (2020b), the global computer market expected to shrink by $6 billion in 2020 compared to 2019 i.e. from $364 billion in 2019 to $358.3 billion in 2020 at a CAGR of -1.6%. The drop can be attributed to an economic slowdown across countries due to the COVID-19 outbreak and an increase in demand for other substitute devices like Tablets and mobile phones. However, it is presumed that the market will improve and increase with a CAGR of 8% from 2021 to 2023 i.e. it is expected to reach $449.6 billion in 2023.

In 2018, Western Europe was the largest region in the global market, accounting for about 33% of the market, followed by APAC with a 27% market share, while Africa was the smallest region in the global market[25]. The Business Research Company (2020b) report shows APAC as the region with the largest share of 36% in 2019, followed by the North American share of 28%, while Africa still has the lowest market share. IoT, as a complex multi-player ecosystem, is appearing as the subsequent significant trend in the computer market with the potential to perform influence across the business spectrum[26]. In 2018, the computing segment accounted for 28% of the global revenue and the estimates are that it will reach about $290 billion by 2023. On the global level, most of the revenue is generated in China which stood at $63,523 million in 2020.

The global PC market, comprised of desktops, notebooks, and workstations, has seen a decline of 9.8% in the first quarter of 2020, reaching a total of 53.2 million shipments[27]. After growth in 2019, the outbreak of COVID-19 has interrupted the supply chain. The growth is concentrated with the three main players i.e. Lenovo, HP Inc, and Dell.

The demand in the PC market is encouraged by the progress in technology, disposable profits in the consumer market, and resources and spending of companies. Large companies dominate the market

[24] Transparency Market Research, 2017
[25] Research and Markets, 2019b
[26] Business Research Company, 2020b
[27] International Data Corporation, 2020

thanks to the brand value that has accumulated over the years, while smaller companies compete with innovative products and various discounts for a much-localized gain in the customer base.[28]

The global laptop market is anticipated to grow with a CAGR of 1% in the period range between 2020-2024 and will reach $7.52 billion[29]. Rising urbanization and increasing spending abilities of consumers relating to middle and upper-middle classes, linked with emerging lifestyles, are predicted to boost the global market over the years[30]. Furthermore, expanding internet infrastructure over the globe is positively affecting the growth of the market, state ambitions (such as Made in China 2025, Digital India, and Make in India) are allowing large growth potential to companies working in the market. The growing interest in 2-in-1 laptops is expected to stimulate the growth of the global laptop market. 2-in-1 laptops are transportable computers that have characteristics of both laptops and tablets[31]. Determinants such as the high demand for personal computing devices and massive investment in the R&D sector are heightening the global 2-in1 laptop market[32].

2.1.4 The Global Industrial Electronics Market

Industrial electronics accounts for 18% of the global production amongst electronic goods, making this sector the second largest after consumer electronics[33].The major components of Industrial electronics sector are[34]:

i. Process Control Equipment (PCE)
ii. Test & Measuring Equipment (T&ME)
iii. Power Electronics Equipment (PEE)
iv. Automation and Analytical Instruments (A&AI)

The process automation and instrumentation market are estimated to reach $95.5 billion by 2024 expanding at a CAGR of 6.0%. Major factors influencing the market growth are energy efficiency, cost reduction, application of new technologies such as IoT and increasing adoption of industrial automation[35]. In the process automation and instrumentation market, the manufacturing execution system (MES) segment is predicted to gain dominance. MES applications have many advantages. It helps deliver high performance of production, reduces cycle time, improves productivity, and provides cost savings. Field instrument segments held the largest share within process instrumentation in the market.

The global test and measurement equipment market is expected to grow from $25.7 billion to $32.3 billion by 2024, at a CAGR of 3.90%. Increasing demand by automotive and transportation users is propelling market growth. The market is predicted to have high growth in the healthcare sector due to the development of new healthcare equipment, patient-monitoring systems, and personal emergency reporting systems. In the global test and measurement equipment, there is a growing application of power analyzers for end-of-line (EOL) testing in the automotive industry. Data centers are showing particular demand for high-speed digital test equipment, as they are turning to higher transmission speeds and new standards[36].

The global actuators market is estimated to reach $74.5 billion by 2024, progressing at a CAGR of 8.6 %[37]. The Asia Pacific region is the leader in the market. The market growth is influenced by the development of advanced and cost-effective actuators, as well as the rising demand for industrial robots and process automation. In the global actuators market, the linear actuator segment is expected to have the highest growth from 2019 to 2024. Based on the application, the robotics segment is expected to grow at the highest CAGR in the same period.

[28] Market Research Reports, n.d.
[29] Technavio, 2020a
[30] Grand View Research, 2018
[31] Technavio, 2020b
[32] Market Research Future, 2018b
[33] Advance Market Analytics, 2019
[34] MEITY Annual Report 2018-19
[35] Markets and Markets, 2019
[36] MP Digest, 2018
[37] Markets and Markets, 2019

The industrial sensors market is predicted to reach $21.6 billion by 2023, at a CAGR of 6.16%[38]. It is estimated that the rising adoption of industrial automation and IoT technologies will contribute to the growth of production capability. In the global industrial sensors market, there is an increasing demand for proximity sensors. In the automotive sector, the touch-free user interface is driving the adoption of proximity sensors. The growing deployment of industrial robots is another important factor stimulating the demand for proximity sensors. In the global power electronics market, the greatest share of device types is reserved for power ICs, while it is predicted that the market for SiC and GaN devices will register the high CAGRs. The global transducer market is projected to grow at a CAGR of 3.31% and reach $683.7 million by 2023. The Asia Pacific region is emerging as the largest transducer market. Among the major factors contributing to the market growth are industrial automation, electric vehicles, control and protection systems, and adoption of renewable resources.

The global power electronics market size is expected to grow at a CAGR of 4.7% and reach $44.2 billion by 2025[39]. The Asia Pacific region is predicted to progress at the highest CAGR by 2025. The major factors driving the market are the increasing use of power electronics in electric vehicles and the adoption of renewable energy resources.

2.1.5 The Global Strategic Electronics Market

The global military satellite market is predicted to grow at a CAGR of above 6% during the period 2020 – 2025[40]. Military satellites are an essential part of the advanced tactical communication systems. There is a growing demand for efficient tactical communication systems to be used by military forces around the world in the first place to help prevent and fight terrorist attacks. The Asia-Pacific region is predicted to have the highest growth rate, due to focus on the development of military satellites by countries such as China, India, Japan, and South Korea. As per a market analysis by Indian Electronics and Semiconductor Association (IESA) the share of different nations by value is given in figure 5.

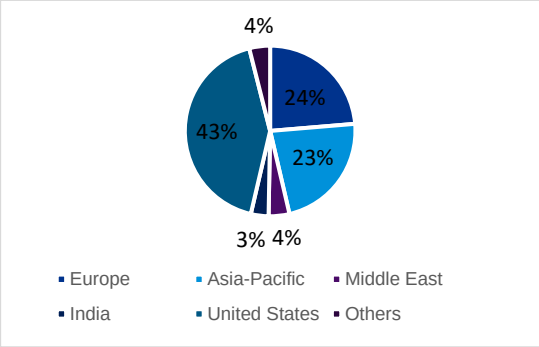

Figure 4: Distribution by Geography; Source: Strategic Electronics Report 2019

The global avionics market is anticipated to grow from $68.5 billion in 2019 to $86.9 billion by 2024, registering a CAGR of 4.86%[41]. Major factors driving the growth of the market are the integration of new technologies within aircraft, growth in the retrofit aircraft market, and scheduled maintenance operations of aircraft. North America is reported to be the largest market for avionics during the forecast period. The hardware segment is projected to be the major segment driving the avionics market during the forecast period.

The global aerospace and defence business landscape is experiencing a notable gap, hit by a strong focus on innovation and digital transformation, as well as geopolitical circumstances such as the unexplored implications

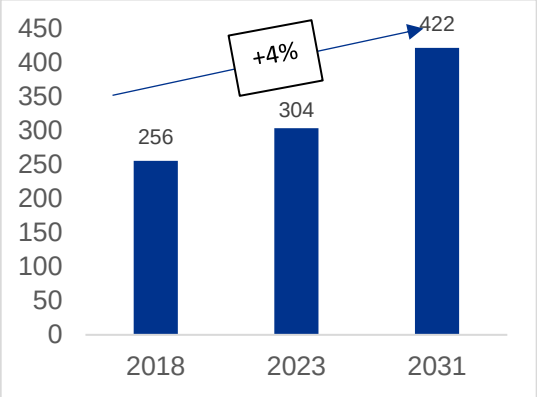

Figure 5: Global Defence Electronics Market by Value

[38] Markets and Markets, 2018
[39] Markets and Markets, 2020
[40] Mordor Intelligence, 2019
[41] Markets and Markets, 2019

of Brexit and COVID-19. The aerospace and defence industry is one of the most complex and specific parts for electronics manufacturing. As FINN (2019) pointed out, while end-users in the air and on the battlefield may inquire more numerous modifications, the essence of the industry will be driven by a more risk-averse strategy and a moderate selection of the concept of connected factories which is correlated with the Industry 4.0. Deeper infiltration into the aerospace and defence markets may provide an opportunity for electronics manufacturing services **(**EMS) providers to increase profit margins. Most of those possibilities will arise from the Far East and Latin America.

2.1.6 The Global Automotive Electronics Market

The automotive electronics market size evaluated at $285 billion in 2018 and is predicted to progress with a CAGR of 7% in the period range between 2019 to 2030[42]. Key market drivers that impact the sector are growing demand for safety and comfort characteristics, the rigorous regulatory framework in North America and Europe, rising purchases of electric vehicles in China, and expanding vehicle production activities in South Africa.

Asia Pacific market is expected to maintain its dominance over the forthcoming period, due to the growing purchasing power of consumers, the improvement of living standards, and the fast-growing automotive industry.[43] North America is predicted to increase with the second-highest CAGR of 9.2% over the period from 2020 to 2027[44], while Europe's automotive electronics market is awaited to expand at a moderate rate due to the increasing requirement for passenger cars in the region[45]. In 2019, the Asia Pacific region took a dominant revenue part and was evaluated at $101.74 billion[46]. According to the Global Market Insights report, the automotive electronics market was valued at $285 billion in 2018 and is predicted to grow at a compound annual growth rate of 7 per cent by 2030.

The growth of the market, both in terms of value and quantity, is mostly influenced by the faster growth of the average number of software applications and electronics components per vehicle[47]. The body electronics, entertainment, and safety systems are forms of integration of automotive electronics in vehicles. Components that directly or indirectly depend on the electronic systems in cars are engine management, in-car entertainment systems, computers, ignition. The growing automotive sector is flourishing the demand for these components, tenfold every year[48]. Furthermore, expanding consumer transfer towards automation and notable demand for luxury cars will increase the growth of the market in the forthcoming years.

On the other hand, high prices of advanced driver-assistance systems (ADAS), rising automobile system complexities, and diminishing automotive production in the U.S. are the key challenges of the market in the following period[49]. ADAS automotive electronics market income is forecasted to manifest a growth with a CAGR of about 9.5% by 2030 due to the safety and advantages given by the system. The highest share of the automotive electronics market, by vehicle type, has the passenger car segment with $87.39 billion in 2019 and is anticipated to growing with a CAGR of 5.6% by 2026[50]. ACES trends (Autonomous driving, Connectivity, Electrification of vehicles and Shared mobility) have a major role in changing the automotive value chain. Today, automobiles are equipped with many electronic components. Together with other trends such as miniaturization and use of lightweight materials, the auto electronics market is rapidly developing. There are embedded systems in almost all parts of automobile's architecture – safety airbags, engine management, telematics, parking ability, auto control steering, transmission, etc. The need for electric active suspension for fuel economy and better ride will increase electronics content within vehicles. Moreover, electronic systems have become a significant part of the cost of an automobile. For example, they accounted for about 30% of the vehicle value in 2010. In 2030, it is estimated that electronic systems will make half of the total vehicle cost.

[42] Bhutani & Yadav, 2019
[43] MarketResearch.biz, 2018
[44] Grand View Research, 2020b
[45] MarketResearch.biz, 2018
[46] Grand View Research, 2020b
[47] Market Research Future, 2020b
[48] The Market Watch, 2020
[49] Bhutani & Yadav, 2019
[50] Allied Market Research, 2018

The Automotive Electronics market is composed of the following:

i. Power electronics (16%)
ii. Safety Controls (32%)
iii. Communication and Entertainment (22%)
iv. Body Electronics (30%)

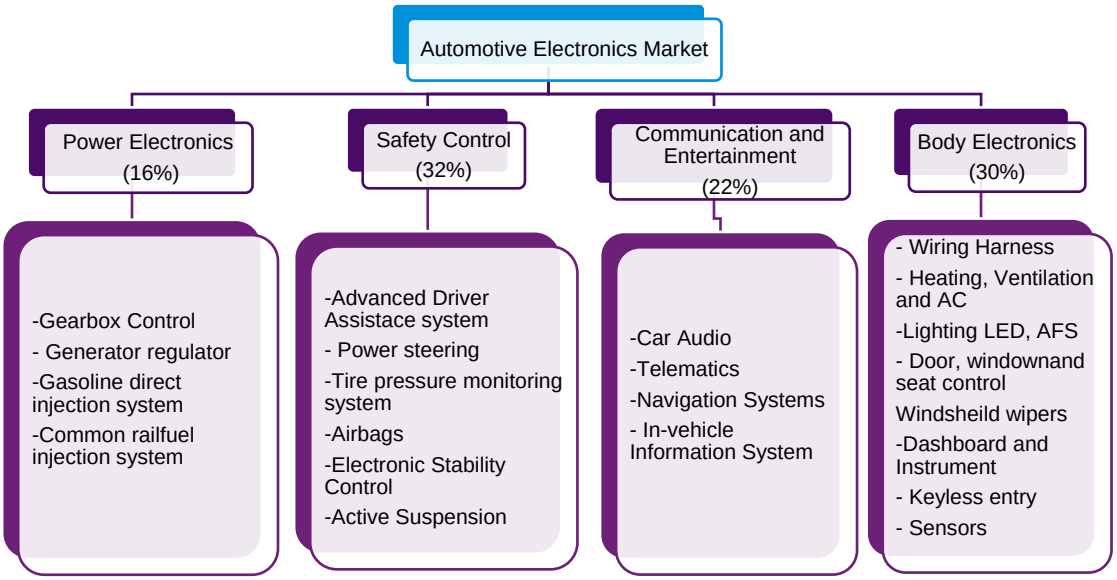

Figure 6:Components of the Automotive Electronics Market

The Tire Pressure Monitoring Systems (TPMS) market worldwide is estimated to reach $13.13 billion by 2024, at a CAGR of over 21%[51]. The direct TPMS segment is expected to dominate the growth of the market. Europe is the leading player in the market, while in the Asia-Pacific, the TPMS market is predicted to have the highest growth rate due to the rising demand for vehicles, particularly in China, Japan, and South Korea.

The Global Automotive Safety System (ABS) market is expected to reach $195.33 billion by 2026. expanding at a CAGR of 10.0%[52]. Major contributors to the market growth are rising need for safe and comfortable driving experience, growing demand for electric and autonomous vehicles, etc. Asia Pacific region is the largest market due to the growing demand for vehicle production in China, Japan, and India.

The Global Airbag Electronics Market is predicted to grow at a CAGR of 6.9% during the period 2020-2027. The airbag electronic industry has expanded its scope from four-wheel vehicles to two-wheel vehicles, which are driving the airbag electronics market[53]. Airbag Sensors Market is expected to grow at a CAGR of 5.9% over the period from 2018 to 2027. Many companies are increasingly focusing on innovations in the area of airbag sensors. Asia Pacific region is becoming prominent as the consumption market for airbag sensors and their derivatives.

The automotive electric power steering (EPS) market is expected to expand at a CAGR of 6.26% by 2025[54]. Segments that dominate the market: steering motor (30%), reduction gear (15%), ECU (40%), and torque sensors. One of the recent trends driving the growth of the market is the increasing popularity of self-driving vehicles.

[51] Tech Sci Research, 2019
[52] Allied Market Research, 2019
[53] Research Nester, 2020
[54] Mordor Intelligence, 2019

The global body control module market is estimated to reach $35.7 billion, at a CAGR of 2.6% by 2027[55]. The market growth is propelled by the growing demand for vehicle components and the increasing need for safety and convenient driving experience.

The global in-vehicle infotainment market is estimated to reach $54.8 billion by 2027, at a CAGR of 10.7%[56]. It is predicted that increasing focus on developing safety and security solutions, together with the demand for smartphone features in cars, will propel the market growth.

The global automotive telematics market is anticipated to reach $320.6 billion by 2026, at a CAGR of 26.8%. North America is a dominant player in the market. It is predicted that the adoption of the third generation of telematics (including Driver Interactive Vehicle Application (DIVA) and Vehicle Relationship Manager (VRM), voice-activated web service, and information related to the performance of the vehicle would significantly impact the market.

The Automotive Automatic Transmission Market is anticipated to record a CAGR of over 9% in the period 2020 - 2025. Adoption of Dual Clutch Transmissions (DCT) and Continuously Variable Transmission (CVT) technologies over manual and automatic systems is one of the recent trends that will drive the market.

2.1.7 The Global Medical Electronics Market

The medical electronics market is anticipated to strike over 4.2 billion by 2026 and will be growing with a CAGR of over 5% in the period 2019-2026[57]. The industry is awaited to witness stable growth in the following years, largely due to the increasing occurrences of chronic diseases, growing adoption of medical imaging, monitoring, and implantable machines, adoption of wearable electronic devices, increasing expense on healthcare over the globe, and a burgeoning society ageing[58]. The North America medical electronics market generated the most revenue in previous years i.e. $32.9 billion in 2018, precisely because of the high costs of health treatment, which cannot be compared to the European one. Nevertheless, technological modernization and portability with other medical equipment are some of the other determinants that are driving the development of the medical electronics industry in North America[59]. The Asia Pacific is forecasted to grow at a fast pace in the medical electronics market due to the increasing urbanization in emerging nations like India and China.

Medical electronic devices can be broadly classified as:

I. **Invasive Devices:** These devices are usually involved in entering the human body mostly by an incision, E.g. Endoscopes, Implantable loop recorders (ILRs), Pacemakers, etc.
II. **Non-Invasive Devices:** These devices do not enter the human body physically and are involved in over the skin, physical examination of the body, e.g. hearing aids, CT scan, MRI, Ventilators, etc.

To give a detailed account of invasive and non-invasive medical devices, they can be further classified as:

I. **Disposable electronics:** These are used in medical products like catheter cables, panel mount receptacles, EEG sensors, etc.
II. **Equipment's:** These can be classified as:
    a) **Imaging:** This equipment is used for either measuring or recording data for medical diagnosis, e.g. MRI, CT Scan, X-Ray, etc.
    b) **Patient Monitoring System:** This equipment is used for monitoring of the vital signs in a patient for the diagnosis of the data, e.g. Electroencephalogram (EEG), Electrocardiogram, etc.
    c) **Therapeutics:** These include either instruments or implants that are used to cater to myriad needs vis-a-vis disability, for example for a blind patient, a microchip retina is implanted on a trial basis to assist in reading letters and shape recognition, e.g. ventilator, heart-lung machine, dialysis equipment, etc.

[55] Markets and Markets, 2019
[56] Markets and Markets, 2020
[57] Maximize Market Research, 2019
[58] Markets and Markets, 2019b
[59] Acumen Research and Consulting, 2019

d) **Handheld/ Homecare Products:** These types of equipment help in monitoring an individual's health, e.g. Glucometer, digital thermometer, etc.

The global invasive products market is predicted to grow at the highest CAGR during the period 2019 – 2025. Major factors influencing the market growth include the growing demand for implantable cardioverter defibrillators, implantable loop recorders, endoscopes, and pacemakers. The markets for medical implants, endoscopy, and sensors are predicted to grow at the highest CAGR during the forecast period.

The global minimally invasive surgical instruments market is anticipated to grow from $ 20.1 billion in 2019 and reach $32.7 billion in 2025, registering a CAGR of 8.5%[60]. Major drivers of the market are the advantages of minimally invasive surgeries and a growing number of these procedures globally. In 2018, North America held the largest share of the market and Europe closely followed. Handheld instruments accounted for the leading type of minimally invasive surgical instrument in 2018.

The global non-invasive monitoring device market is expected to register a CAGR of 6.80% and is anticipated to reach $21,586.2 million by 2023. The North and South America were reported to hold the largest share in the market. The main drivers of the market are a technological advancement in non-invasive monitoring segment, growing prevalence of cardiovascular diseases, increasing awareness among the population, and high per capita disposable incomes. Additionally, the companies operating in the market are particularly focusing on mergers and acquisitions, which is expected to support market growth. Asia-Pacific accounted for the second-largest market share due to a large number of medical device manufacturers, low manufacturing cost, low labor cost, developing healthcare infrastructure, and a high ageing population. The European market is the third-largest market for non-invasive monitoring devices.

The global medical imaging equipment market size was estimated at $30,814.2 million in 2017 and is projected to reach $44,077.7 million by 2025, registering a CAGR of 4.6% from 2018 to 2025. The computed tomography equipment sub-segment held 19.4% market share in 2017, while the ultrasound equipment sub-segment held 22.9% share. The MRI systems segment held the largest share of the global diagnostic imaging market in 2018. The main reason is the rising demand for early and accurate diagnosis, high adoption of MRI systems by hospitals and diagnostic centers, and technological advancements. The number of patients undergoing CT, MRI, and X-ray scans is increasing, and one of the main reasons is rising awareness among countries worldwide of the importance of early diagnosis.

The global digital therapeutics market size was valued at $2.24 billion in 2018 and is predicted to reach $9.64 billion by 2026, at a CAGR of 19.9%. The main drivers of the market are increased adoption of smartphones and tablets, growing need to control healthcare costs and a rise in the incidence of chronic diseases. On one side, a lack of awareness in developing countries regarding the benefits of digital therapeutics and patient data privacy issues pose a barrier to market growth.

2.2 Global Electronics Design - Overall statistics and growth trends

The point of an immense relocation of Electronics Design in Asia (excluding Japan) occurred in the 2000s. The Asia Region experienced a significant increase in the global production of chip designs, while Taiwan became the leading area for fast-growing chip design (this segment also designated accelerating growth in Korea, China, India, Singapore, and Malaysia during the 2000s) (Ernst, 2005). According to Ernst (2005), as a consequence of 36% growth in the first quarter of 2004, a fast-growing market of Electronics Design Automation (EDA) tools enriched this region. In that period, North America and Europe recorded growth of 5% and 4%, respectively, while Japan registered a decline of 2%. In 2017, the situation in the Asia Pacific Electronic Design Market switched. The most notable market share refers to China, while the role of Japan in the market is increasing. Japan ruled the EDA market in 2018 and is expected to maintain dominance in the market covering the Asia Pacific region.

[60] Markets and Markets, 2020

According to the Electronics System Design Alliance (ESDA) Market Statistics Services report (2019), the Electronics Design Automation industry revenues in Q2 2019 increased by 6.6% compared to Q2 2018.

At the end of 2019, the EDA categories can be reviewed as follows (ESDA, 2020):

- *Computer-Aided Engineering (CAE)* created a revenue of $874.4 million in Q4 2019. The four-quarters moving average for CAE grew by 6.5 percent;
- IC Physical Design & Verification revenue was $466.4 million in Q4 2019. The four-quarters moving average rose by 9.5 percent;
- *Printed Circuit Board and Multi-Chip Module (PCB & MCM)* gained revenue of $ 295.3 million for Q4 2019. The four-quarters moving average for PCB & MCM progressed by 15.1 percent;
- *Semiconductor Intellectual Property (SIP*) revenue equaled $900.6 million in Q4 2019. The four-quarters moving average developed by 10.1 percent;
- *Services revenue* was $89.6 million in Q4 2019. The four-quarters moving average slumped by 10.9 percent.

2.2.1 Electronics Design Automation Market Overview

EDA market in the Asia Pacific region is presumed to grow with a CAGR of 13% in the period range between 2019-2027[61]. The rise in the scope of R&D expenditures in the semiconductor industry and growing purchaser surmise and flourish demand of consumer electronics are encouraging the increase of the EDA market in the Asia Pacific region.

The European EDA market is foreseen to increase with a CAGR of 14.9% between 2019 and 2027[62]. The most significant actor in the EDA European market in 2018 was Germany, with the prognostication of the growing importance of the UK. Even in the case of the European industry, electronic components and systems are strong supporters of the development of innovation and productivity in the entire European market. The increasing diversification of high-level technologies and the growth of the semiconductor industry are propelling the growth of the European EDA market[63]. The European EDA market is also fragmented, and a change in the dynamics of competition is awaited in the future. With the aim to stimulate the EDA market growth, governmental bodies are initiated several initiatives that are related to industrial policy, innovations, energy, and trade[64].

The North America EDA market is anticipated to progress with a CAGR of 10.2% between 2019 and 2027[65]. North America is the notable market for EDA tools under rising adoption in industries (automotive, consumer electronics). The development of this market is mostly due to the growth of the semiconductor industry. The major determinants that drive the growth of the EDA market are - the spiralling complexity of IC designs and the requirement for high efficiency and accuracy of semiconductor devices. Besides, the end-user industries, such as an autonomous vehicle, internet of things (IoT), and artificial intelligence, are progressively utilizing IC design and verification tools[66]. The U.S. EDA market is highly fragmented without dominant players. The U.S. government authorities are taking various initiatives to ensure the faster growth of the EDA market. For example, The National Export Initiative, MForesight, and the National Export Initiative produce numerous advantages to the production companies settled in the region[67].

2.2.2 Embedded System Market Overview

The embedded system market is anticipated to increase at a CAGR of 6.1% in the period range between 2020 to 2025[68]. The fundamental determinant that is moving the global embedded system market is the

[61] The Insight Partners (TIP), 2019a
[62] TIP, 2019b
[63] TIP, 2019b
[64] MarketWatch, 2020
[65] TIP, 2019c
[66] Mordor Intelligence, 2019
[67] TIP, 2019c
[68] Markets and Markets, 2020

exponential increase in the number of mobile users and its increasing infiltration into the urban population across the advanced and developing economies. Extensive utilization of embedded systems into sectors such as mobile communication, aeronautics, automotive, electronic payment solutions, and space is estimated to support the increase of the global embedded system market[69]. The dominant market share with over 45% appertains to North America due to the attendance of dominant companies such as Intel and Microsoft[70].

Technologically advanced countries such as the U.S. and Canada make North America the most profitable region. With the growth in robotics and the growing applicability of IoT, the region is expected to boost the demand in the following years. Despite, APAC is expected to possess the highest portion of the embedded system market in 2025. Several emerging economies, such as India and China, are expected to increase demand due to growing per capita income, urbanization, and large-scale industrialization[71]. The global embedded system can be segmented based on a type into embedded hardware and embedded software.

Embedded hardware was the biggest part of the embedded system market in 2015 and recorded more than 90 percent share of the total market[72]. This segment is anticipated to maintain its dominance in the global market from 2020 to 2025. Among embedded hardware, the field-programmable gate arrays (FPGA) segment is projected to grow with the highest CAGR. FPGA is one of the new trending fields in the Very Large Scale Integration (VLSI) design. In addition to FPGAs, VLSI includes Application Specific Integrated Circuit (ASIC) design and System on Chip (SOC) design. FPGA market size passed $5 billion in 2018 and is expected to enroll increases by approximately 8,7% from 2019 to 2025. Thriftiness, simple design cycle, more reliable performance, and real-time application, expand the scope of FPGA utilization in a deep range of telecommunications, automobiles, electronics, and others[73]. Data processing in data centers and cloud computing have appeared as an important field of application for FPGAs (Mordor Intelligence, 2019). Moreover, the increase in the requirement for optimization in big data analytics is one of the main forces for the market. The market can be bifurcated as low-range, mid-range, and high-range based on configuration. Low-range FPGA the fastest-growing segment of the FPGA market[74]. The Asia Pacific region achieved the greatest revenue percentage of the FPGA industry in 2019 and is awaited to continue its dominance, while the North America regional market obtained a revenue share of higher 25% in 2019[75].

2.3 General business trends

Apart from some specific trends existing in the ESDM sector (Consumer electronics, Electronic components, Industrial electronics etc.) there are some general business trends that are common to all the sub-segments. This section tries to highlight these common business trends prevalent across the ESDM sector sub-segments.

2.3.1 Manufacturing automation

Numerous electronic equipment companies have deployed robotics and automation processes to improve efficiency, productivity, and reduce production costs, according to a report by Boston Consulting Group (BCG), in 2016, 1.2 million industrial robots are expected to be deployed by 2025. Currently, the industry accounts for about 22% of the total robot shipments, coming immediately after the automobile industry at 33% which has been the major consumers for a long time. With this trend, the electronics industry is likely to replace the automobile and become the largest market for industrial and collaborative robots. Robotic automation can be applied to almost all the phases of electronics manufacturing, such as component fabrication, picking, placing, assembling, inspections, testing, etc. Deployment of robots increases production outputs, reduces errors, and contributes to lowering labor costs by reducing the number of employees.

[69] Future Market Insights, 2020
[70] Wadhwani & Yadav, 2020
[71] PRNewswire, 2018
[72] QYR, 2018
[73] Bhutani & Yadav 2019
[74] Bhutani & Yadav 2019
[75] Grand View Research, 2020

2.3.2 Reshoring

This is maybe an unexpected trend because offshoring has many financial benefits, such as lower production costs. Many macro-economic factors have contributed to the rising number of reshoring cases, such as higher labor costs, efforts of governments to reduce costs and lower administrative barriers to bring manufacturing to domestic land (World scientific reference on Innovation) Moreover, increased costs of transportation and the disruption in supply chains, especially due to the COVID-19 outbreak, has made numerous companies bring many of their operations to their original countries.

2.3.3 Product design outsourcing

There is a growing trend to move product design and development processes from Original Equipment Manufacturers (OEMs) to Electronic Manufacturing Service (EMS) partners. According to TBRC, the reason behind product design outsourcing is the need to reduce overall costs and shift from fixed costs to variable costs.

2.3.4 Shifting from B2B to B2B2C

So far, electronic manufacturers have mainly implemented a business-to-business (B2B) approach, which refers to a business that is conducted between companies, rather than between a company and individual consumer. The recent trend is moving to a business-to-business-to-consumer (B2B2C) model - an e-commerce model that combines business to business (B2B) and business to consumer (B2C) for a complete product or service transaction. B2B2C is a collaboration process that, in theory, creates mutually beneficial service and product delivery channels.

2.4 Countries with maximum production and concentration of the ESDM industries

ESDM sector across the globe is concentrated in a few Nations like China, USA, South Korea and Germany. This section aims at highlighting the countries with maximum production capabilities and highlight some of the major industrial clusters in that region as case studies

2.4.1 Consumer electronics

Consumer electronics is one of the most important sub-segments within the ESDM sector. Every household in the 21st century requires multiple consumer electronics items for e.g. TV, refrigerator, AC etc. The section tries to highlight the success factors of major consumer electronics producers across the Globe like China and South Korea with some case studies.

2.4.1.1 China

China will retain the leading position as the largest electronics manufacturer in the world. It is expected that it will produce about 50% of the electronics in 2025. Manufacturers were driven to China in vast numbers due to the favorable conditions to operate. The Chinese government investments in the economy, low labor cost, availability of large industrial zones, developed transport infrastructure, strong focus on industrial production, and promotion of export represent the main contributing factors that have led to the country's present position. China is the world's largest consumer electronics producer. It has the most extensive electronics manufacturing ecosystem and dense supply chain in the world and a labor force of manufacturing workers close to 150 million, enabling it to provide large scale orders at shorter production lead times. Commonly produced consumer electronics in China are smartphones, laptops, tablets, computers, LED TVs, wearable electronics, drones, and power banks. For example, a smartphone requires 2,000 different components – from tiny machine screws and capacitors to circuit boards and LCD screens – all of which are generated from China's supply chain.

Some of the main contributing factors are 'Special Economic Zones' (SEZs). One of the major goals of establishing SEZs was adopting advanced and new technologies to set favorable conditions for domestic export-oriented manufacturing to facilitate trade, SEZs were initially established in coastal cities. The advantages of these zones can be summarized as:

- The zone is a geographically delimited area, usually physically secured;
- It has a single management or administration;
- It offers benefits based on physical location within the zone;
- It has a separate customs area (duty-free benefits) and duty-free imports of raw materials and intermediate goods aimed at integration into exported products;
- It generally operates under more liberal economic laws than those in force in the whole country (tax breaks, export tax exemption, inexpensive land, the possibility to repatriate profits and capital investments, etc.);
- It brings direct economic benefits such as employment generation, foreign direct investment, foreign exchange earnings, export growth, on one hand, and many indirect benefits such as upgrading of skills, transfer of technology and know-how, diversification of export, enhancing domestic trade.

2.4.1.2 South Korea

The total production of the South Korean electronics industry was estimated at $171.1 billion in 2018, representing around 9% of the global market. According to the Korea Electronics Association (KEA) report, the country's electronics output in 2018 was the world's third largest in terms of value, after China (37.2) and USA (12.6), due to the sales of memory chips. Two global companies with the largest market share are Samsung Electronics and LG Electronics. Of the total electronic industry in South Korea, consumer electronics is the dominant segment, with 67.3% market share. It is predicted that the South Korea consumer electronics industry will amount to $15.3 billion by 2024, registering a CAGR of 7.6% in the period from 2017 to 2025 (Goldstein Research, 2020). The recent trend in the consumer electronic products manufacturing is adopting virtual reality (VR), which is bringing a benefit and advantage to the manufacturing industry in terms of efficiency and low costs.

2.4.2 Electronic components

Electronic components are the fulcrum on which the entire ESDM sector rests. Without these components, no manufacturer in the world can produce consumer electronics, automotive electronics or any other ESDM sub-segment. This section aims to highlight some of the major producers like Taiwan and Germany along with some successful case studies.

2.4.2.1 Germany

European Commission has focused on the development of six key enabling technologies (KETs): microelectronics, nanoelectronics, advanced materials, industrial biotechnology, photonics, nanotechnology, and advanced manufacturing systems. These sectors are predicted to have a major impact on boosting the growth of the manufacturing and industrial sectors throughout Europe. Micro- and nanoelectronics (jointly referred to as microelectronics) are strategically important multi-purpose technologies for the re-industrialization strategy of the EU[76].

[76] "Global Competition In Microelectronics Industry From A European Perspective: Technology, Markets And Implications For Industrial Policy." (2018).

In terms of workforce, microelectronics is the country's second-largest manufacturing industry. Germany is extensively investing in next-generation microelectronic components focusing on automotive and healthcare markets[77]. The microelectronics sector in Germany is organized into strong clusters. Germany

Silicon Saxony

Silicon Saxony is one of the largest microelectronics and IT clusters in Germany and Europe and the fifth largest in the world. It is the largest high-tech network for microelectronics, smart systems, photovoltaic, software, and application sectors in Europe with the focus on new technological innovations such as Internet of Things, artificial intelligence, robotics, automation, sensors, etc. It comprises of universities, research institutes, public institutions, manufacturers, suppliers, service providers, and start-ups. There is a strong academic environment including technical universities, Fraunhofer, Leibniz, Max Planck, and Helmholtz institutes with expertise in the area of microelectronics/ICT. The availability of resources and skilled workforce is the main reason behind the flourishment of the region and attracting investment. Some of the major players in the network include GLOBALFOUNDRIES, Infineon Dresdnen, and Bosch. Infineon Dresden is a subsidiary of Infineon Technologies AG and one of the largest Infineon production sites with a highly automated high-mix fab for 200 mm wafers.

is a leader in European semiconductor production. One in every three chips produced in Europe is made in Germany. German companies are particularly strong in energy-saving electronics and sensor systems.

2.4.2.2 Taiwan

Taiwan is occupying the second place in the global production of electronics components, after China. The country's production accounts for around 12% of the global production of electronic components. Taiwan is the world leader in semiconductor foundries, packaging, and testing of integrated circuits, and production of blank optical disks and MROMs (mask read-only memory)[78]. In the 1990s, the Taiwan Semiconductor Manufacturing Company (TSMC) had an important role in the development of the semiconductor value chain. It was a pioneer in the foundry business and remains the leader of pure-play foundries with over 50

World's Hub for Semiconductor Manufacturing: Hsinchu Science Park

Hsinchu Science Park (HSP) is one of the leading global high-tech clusters established in Longtan District in the vicinity of the National Tsing Hua University and National Chiao Tung University. It was formed in 1980 by the country government and the idea was to establish a high-tech science park as Silicon Valley in the USA. More than 500 companies, mainly involved in the semiconductor, optoelectronics, computer, and telecommunication industries, have been established in the park. The world's top semiconductor foundries are in the park. Taiwan Semiconductor Manufacturing Company (TSMC) and United Microelectronics Corporation (UMC), as well as the country's space agency National Space Organization, are placed inside the park.

percent market share. It largely contributes to the development of the semiconductor industry in Taiwan[79]. Some of the best-known Taiwanese brands are HTC, Asus, and Acer. Brands such as Apple, HP, and Siemens considerably rely on Taiwan's ODMs (original design manufacturers) (Goldstein Research, 2020).[80]

2.4.3 Automotive electronics

The World cannot be imagined without vehicles and they have become an indispensable part of our daily life. There are talks about moving from fossil-fuel based vehicles to electric vehicles and the Auto industry

[77] Microelectronics from Germany – driver of innovation for the digital economy
[78] EC document Ref. Ares(2015)1098263 - 12/03/2015 Taiwan Business information
[79] Global Competition in Microelectronics Industry from a European Perspective: Technology, Markets and Implications for Industrial Policy
[80] SIPA,

is adapting to the demand but there is no denying that the need for vehicles is going to increase with time as urbanization expands in the third world. With an expansion in the Auto sector, the need for Automotive electronics is going to increase manifold. This section tries to highlight the major automotive electronic player in the market like Germany.

2.4.3.1 Germany

The German automotive industry has gained global prominence, thanks to the country's excellent R&D infrastructure, complete industry value chain and highly skilled workforce are the major factors contributing to the strength of the automotive industry. In the area of high-tech automotive products, such as autonomous driving technology, Germany is one of the leading countries in the world. Around 40 percent of the world's premium car production takes place in Germany, with around 70 percent of worldwide premium cars manufactured by German OEMs[81]. Increased automotive electronics usage is driven by increased consumer demand for electric mobility solutions and the electrification of powertrains. Automotive electronic semiconductors hold the largest share i.e. around 42% of the country's electronic semiconductor market. According to some reports, around 5.5 million passenger vehicles were produced in Germany and around 20% of total domestic industry revenue was generated by the automotive industry[82]. Germany has a high regional concentration of automotive clusters. Among the 16 largest automotive clusters in the EU, the seven prominent industrial regions are in Germany: Stuttgart, Upper Bavaria, Braunschweig, Karlsruhe, Lower Bavaria, Hanover, and Saarland.

Germany's Automobile Cluster: Baden-Württemberg

An area of considerable importance for the German automotive industry is the state of Baden-Württemberg (BW) in south-western Germany with Stuttgart as the main city. It is the area where Porsche and Mercedes have their headquarters and where 1.2 Mn cars per year are produced yearly. The state has a population of around 11.07 million and it is one of the most economically successful regions in Germany. The State of Baden-Württemberg has traditionally spent more money on R&D than the German average (3.5% vs. 3%). It has an excellent education system and highly skilled employees, with more than 70 universities and over 100 non-university research institutions.

The BW cluster has a complete value chain of automotive production, ancillary services, and suppliers from the mechanical and plant engineering sectors (GM Insights, 2018). Moreover, strongly related industries such as electronics and machinery allow for additional sourcing and knowledge transfers, thereby increasing the competitive position of the cluster. High demands for premium vehicles are driven by factors such as high labor costs and the absence of natural resources. Around 40 vehicle and motor manufacturers and around 240 companies, direct suppliers to the vehicle industry, are in the state. The three Baden-Württemberg-based manufacturers (OEMs), such as Daimler AG and Porsche AG, are belonging to the premium segment and many suppliers specialize in powertrains.

2.4.4 Medical electronics

With an increase in the consumption of fast food, change in dietary habits and an increase in the sedentary lifestyle amongst people, the demand for medical services has increased all across the Globe. There has been an increased innovation in the medical devices like oximeter, glucometer etc. The innovations have prompted an increased demand for the medical electronics. This section highlights and discusses about the major player in the medical electronics domain i.e. USA.

[81] The Automotive Electronics Industry in Germany, Germany Trade&Invest, 2016
[82] The Automotive Industry in Germany, Germany Trade&Invest, 2018/9

2.4.4.1 USA

The dominant region in the medical electronics market in North America reaching $32.9 billion in 2018, accounting for 44.9% of the market share and is predicted to rise in the forthcoming period. Key factors facilitating market growth include high healthcare expenditure, increased income levels, and developed infrastructure coupled with growing adoption rates of advanced medical electronic equipment. In addition, The United States remains the largest medical device market in the world reaching $156 billion, accounting for 40 percent of the global medical device market in 2017, it is predicted to reach $208 billion by 2023[83].

Medical device companies in the US are prominent globally for their high technology products and innovations. Investment in medical device research and development in the domestic sector remains more than twice the average for all USA manufacturers. There are more than 6,500 medical device companies in the USA and most of them are SMEs. The industry is a major driving force of social and economic stability as it includes almost 2 million jobs in the USA. The success of the medical industry is also related to industries such as telecommunications, software development, microelectronics, and biotechnology, representing the areas in which USA is among the leaders in the global market. Medical device companies are located throughout the country but are largely located in the high-tech regions with the dominance of microelectronics and biotechnology. The states with the highest number of medical device companies include California, Florida, New York, Pennsylvania, Michigan, Massachusetts, Illinois, Minnesota, and Georgia.

Silicon Valley

California is one of the most successful MedTech clusters in the USA. The main factors contributing to its success are a strong support system of academic and research institutes; availability of government funding and venture capital; and a pool of skilled labor force. In addition, an important factor influencing technological innovations, commercialization, and wider adoption of the products in collaboration with California's research hospitals, among which are some of the most prominent in the country.

Main factors contributing to the success of the Silicon Valley are:

- Top universities surround the Valley like Stanford University, University of California at Berkeley, San Jose State University and other local universities.
- Collaboration between the academic, and private sector, supported by Government have resulted in the educated, talented, and trained workforce.
- High density of rich investors and funding institutions willing to invest in R&D (venture capitalists, angel investors, startup investors, etc.). Besides financial investment, they provide considerable support, guidance, connections, and mentorship.
- The state has delivered efficient laws, regulations, policies and stratgeies to protect intellectual property, buisness ideas and trae secrets. This is especially important for new buisnesses and small companies finding their ways to the market.
- Developed local infrastructure and port in Oakland of international importance.
- Metropolitan area and cultural diversity. Moreover, it is estimated that about 50% of the founders of start-up companies in USA were immigrants, and the same pattern is seen in Silicon Valley. The most talented, ambitious individuals with bright ideas from all over the world are driven to the Valley.
- Mobile and digital health are in the focus of medical companies. There is increasing collaboration between medical device companies and consumer technology companies, such as Apple and Google's life sciences sister company Verily.

[83] Medical Technology Spotlight, Select USA

2.5 Major Companies in the Global Electronics Sector

As the previous section highlighted some of the major Industrial regions around the Globe, this section tries to highlight the major private sector players in the ESDM sector across the globe.

2.5.1 Consumer electronics

Some of the leading players in the consumer electronics market are LG Electronics, Samsung Electronics Co. Ltd, HP, Hitachi Ltd., Apple, Sony Corporation, Panasonic Corporation, Fujitsu, Dell, and Toshiba Corporation

2.5.1.1 Samsung Electronics

Samsung Electronics was founded on January 13, 1969, and is headquartered in Suwon, South Korea. The company produces electronics and computer peripherals. The company includes the following segments: Consumer Electronics, Information Technology & Mobile Communications, and Device Solutions. It is the world's largest manufacturer of mobile phones, smartphones, tablet computers, and TVs. New developments include 5G smartphones and foldable phones. Samsung is also among the world's largest memory chips manufacturers. Global players such as Samsung, focus on offering a wide product portfolio and product variety as a core business strategy. In order to secure a wide adoption of consumer products, sales and distribution activities include a combination of direct sales, distributors, independent dealers, etc.

2.5.2 Electronic Components

Some of the dominant market players for electronic components include Infineon Technologies AG (Germany); NXP Semiconductors N.V. (USA-Netherlands); Texas Instruments Incorporated (USA); Toshiba Corporation (Japan); ST Microelectronics (France-Italy); Semiconductor Components Industries, LLC (USA), KEMET Corporation (USA), Panasonic Corporation (Japan), Bourns Inc. (USA), ROHM (Japan), Vishay Inter technology Inc. (USA), Yageo Corporation (Taiwan) and TE Connectivity Ltd (Switzerland).

2.5.2.1 KEMET Corporation (USA)

KEMET Corporation, now a subsidiary of Yageo Corporation, is one of the major manufacturers of capacitors that are used in almost all electronic devices, such as ceramic, polymer, tantalum, aluminum, film, and supercapacitors), amounting to about 35 billion capacitors a year. The company also produces a variety of other passive electronic components, such as inductors, sensors, relays, transformers, EMCs, flex suppressors, etc. The products have been largely applied in telecommunications, automotive, defense, aerospace, and consumer electronics. In November 2019, Yageo Corporation acquired KEMET Corporation at the cost of $1.8 billion. The aim of Yageo Corporation is to strengthen its market position and expand its geographical presence across the Asia Pacific, North America, and Europe. In March 2020, KEMET launched new metal composite power inductors, responding to the growing demands of the automotive market. These new inductors are used in DC to DC switching power supplies, which play an essential role in the growing electrification of modern vehicles[84].

2.5.3 Industrial electronics

The global industrial electronics market is fragmented with the presence of many major companies, including Altera Corporation (USA), Analog Devices Inc. (USA), General Electric Company (GE) (USA), Honeywell (USA), Intel (USA), Fujitsu Limited (Japan), ABB Limited (Switzerland), Siemens (Germany), Rockwell Automation (USA), Inc., Emerson Electric Co. (USA), Honeywell International, Inc. (USA) and Schneider Electric (France Out of these, Siemens, Schneider, ABB, GE and Honeywell are major global companies working in the field of industrial electronics, HV power electronics (IGBT, IGCT, Thyristor Valves etc.) and Industrial automation (PLC, DCS and SCADA).

[84] Mordor Intelligence, 2019

2.5.3.1 Emerson Electric

Emerson Electric manufactures products and provides services to a wide range of markets, including industrial and commercial. Emerson's Automation Solutions segment is engaged in automating the production and distribution processes in industries such as chemicals, oil & gas, power generation, water & wastewater treatment, pulp & paper, metals & mining, packaging, and food & beverages[85]. In a range of innovative solutions adopted by the company to optimize and advance its design and developing its products, Emerson is taking advantage of additive manufacturing. This new technology has enabled the company to significantly reduce the time (up to 85%) needed for design, prototyping, and testing of new products[86].

2.5.4 Automotive Electronics

Key players in the global automotive electronics market are Magna International (Canada), Continental AG (Germany), Bosch Group (Germany), Altera Corporation (USA), Infineon Technologies (Germany), Lear Corporation (USA), Delphi Automotive (Ireland), Hitachi Automotive Systems (Japan), Texas Instruments (USA), ZF Friedrichshafen AG (Germany), Voxx International Corporation (USA), Faurecia (France), Hyundai Mobis (S. Korea), and Valeo (France).

2.5.4.1 Infineon technologies AG

Infineon Technologies AG is headquartered in Neubiberg near Munich, Germany. The company is a world leader in semiconductor solutions. According to the company's reports, the 2019 fiscal year it marked sales of €8.029 billion with about 41,400 employees are working with the firm, worldwide.[87] The company offers a large portfolio of products, including Automotive System IC, Battery Management ICs, ESD and Surge Protection, HiRel, 32-bit Microcontroller (MCU), RF & Wireless Control, Security & smart card solutions, Sensor, Transceivers, Small Signal Transistors & Diodes, Wide Bandgap Semiconductors (SiC/GaN), etc. Infineon is the world's second-largest supplier of chips for the automotive industry. During the COVID-19 pandemic, it is reported that Infineon delivered around 38 million power semiconductors for producing medical ventilators. This demand in components is turning the company towards medical equipment. To strengthen their market presence and widen their product range, Infineon Technologies AG acquired Cypress Semiconductor Corporation at price around $10 billion in June 2019. This strategy has helped Infineon Technologies AG to strengthen its product offering and market position. In June 2020, the company announced Semper Secure NOR Flash device designed to provide security, safety, and reliability for the most advanced connected systems in the industrial, automotive, and communications segments. It is the first solution to integrate security and safety into one device[88].

2.5.5 Medical electronics

Largest companies in the global medical electronics market include Analog Devices (US), Texas Instrument (US), TE Connectivity (Switzerland), Medtronic Plc (Ireland), ST Microelectronics (Switzerland), NXP Semiconductors (Netherlands), (US), Maxim Integrated Products (US), ON Semiconductor (US), Renesas Electronics Corporation (Japan), Microchip Technology (US), Tekscan, (US), Monebo (US), Cirtec Medical (US), First Sensor (Germany), Sensirion (Switzerland), Innovative Sensor Technology (Switzerland) and Keller America (US).

2.5.5.1 Medtronic PLC

Medtronic PLC is one of the global leaders in designing, manufacturing, and marketing of medical equipment. The main products offered by the company include handheld instruments such as electrosurgical instruments, surgical stapling devices, vessel sealing instruments, retractors, dissectors, trocars, hernia mechanical devices, etc. By expanding its product portfolio and adding advanced products, Medtronic strengthens its global market presence. One of the strategies of the company for gaining a competitive advantage is to acquire other companies and enter into partnerships with other key players in

[85] Markets and Markets, 2019
[86] The future of manufacturing is here and its 3D, Emerson
[87] Digital Transformation- life in future, Infineon
[88] Infineon: Semper Secure- World's most advanced secured NOR Flash Memory

the market. FIn 2019, Medtronic partnered with KARL STORZ SE & Co. KG to integrate KARL STORZ's three-dimensional (3D) vision systems and visualization components into its forthcoming robotic-assisted surgical platform[89]**.**

2.5.6 Some Other Important ESDM Manufacturers

2.5.6.1 Siemens

Siemens AG is a German multinational conglomerate company which was established in 1987 by Werner Von Siemens, headquartered in Munich**. One of** the largest industrial manufacturing companies, Siemens and its subsidiaries employ approximately 385,000 people worldwide and reported global revenue of around €87 billion in 2019. Siemens offers a wide range of electrical engineering- and electronics-related products and services.

2.5.6.2 Schneider Electric

Schneider Electric is a European multinational company and one of the world leaders in industrial electronic manufacturing sector. It employs approximately 138,000+ people worldwide and reported global revenue of around €24.7 billion in 2019. The major products of the company are divided into various divisions such as Industrial Automation and Control, Critical Power Cooling Racks, Building Automation and Control etc.

2.5.6.3 GE

GE Power is the leading ESDM company of the world specializing in equipment, solutions and services across the energy value chain from generation to consumption. The company operates in more than 180 countries, produces a third of the world's electricity, equips 90% of power transmission utilities worldwide, and manages more than 40% of the world's energy.

[89] Markets and Markets, 2020

3. Indian Scenario

The section aims at highlighting the trends in the major ESDM sector sub-segments in India and describe regions leading in the ESDM production across the country.

3.1 Indian Industry Overview

The ESDM industry is one of the fastest-growing sectors in the country and is globally renowned for its consumption potential but lacks a competitive edge. According to the National Electronics Policy 2019, the Indian Electronic Manufacturing Services (EMS) market is estimated to witness exponential growth with CAGR of 34.1% over 2014-2020.[90] The sector is expected to reach USD 400 billion by 2025 and is growing at 17.5% Compounded Annual Growth Rate (CAGR) over the last 5 years.[91]

This surge in demand is huge which shows a positive outlook for the industry. However, the maximum part of this demand is catered by imports. Electronic items (products) are now the second most valued category of imports after petroleum products and if the situation persists, the country's electronics import bill may surpass its oil import expenses by 2020.

Today's ESDM sector in India is dominated by Sony, Samsung, LG Electronics, Panasonic, and others. However, the small-scale enterprises are stagnant due to factors discussed further in the paper in the challenges section.

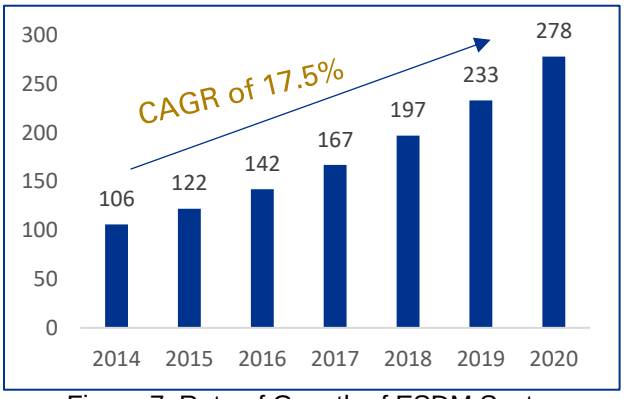

Figure 7: Rate of Growth of ESDM Sector

3.2 Indian Electronics Manufacturing Industry

The electronic Manufacturing segment has been one of the major beneficiaries of the Government's focused effort towards developing the ESDM sector – National Electronics Policy 2019, Make in India, Electronic Manufacturing Clusters 1.0 & 2.0, etc.

Indian Electronics Manufacturing market is estimated to witness exponential growth with CAGR of 34.1% over 2014-2020.[92] Indian Electronics Manufacturing has increased the production from INR 180,454 Crores in 2014-15 to INR 387,525 Crores in 2017-18, registering a CAGR of 26.7%, as against a growth rate of 5.5% in 2014-15[93].

3.2.1 Consumer Electronics

For the overall ESDM sector, the consumer electronic industry contributed more than 29% in 2017 and is expected to grow at a CAGR of 19.5% from 2014-2020[94]. With demand from households set to accelerate with a rise in disposable income, the market for consumer electronics such as TVs, mobile phones, computers, etc. will get a significant boost in the coming years.

[90] Frost & Sullivan – Electronics Manufacturing Industry in India, 2017
[91] NPE, 2019
[92] Frost & Sullivan – Electronics Manufacturing Industry in India, 2017
[93] Ministry of Electronics & Information Technology, Annual Report 2017-18
[94] Frost and Sullivan- Electronics Manufacturing Industry in India, 2017

Since India meets almost 65 percent of electronics demand through imports, the government is focused on strengthening local manufacturing and assembling units to boost the sector in India and achieve Net Zero Imports for the ESDM sector.

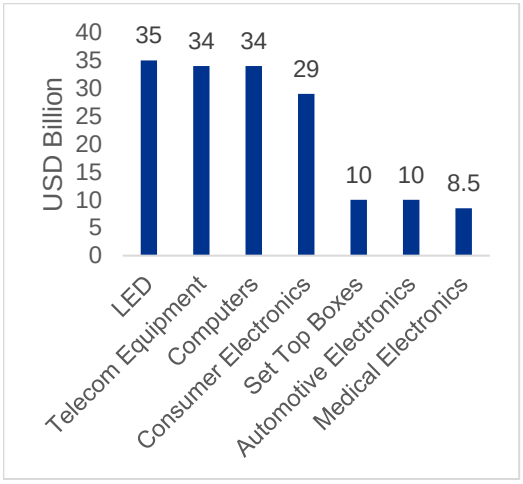

Figure 8: Electronic Products Market Size – India

Some of the major trends which are being observed in the Indian Consumer Electronics Manufacturing are:

- Growth in Indian middle-class, an increase in the disposable income and declining manufacturing costs have led to an increase in the sales of electronic devices in India.
- The focus of Government on eliminating digital divide with initiatives like Digital India, Smart cities, e-Panchayat, National optical fiber network, etc. has given an impetus to the demand of electronic products in the country.
- India is one of the largest electronics markets in the world and is expected to reach $400 bn by 2025. The consumer electronics and appliances industry are touted to become fifth largest by 2025[95].
- Appliances and consumer electronics market in India fetched $ 10.9 billion in 2019 and is expected to grow at 9% CAGR to fetch $ 48 Billion in 2022[96]. The same industry is expected to double and reach $ 21 billion by 2025.
- The penetration of air conditioners in India for FY 2019 was only 5% when compared to a global average of 30%. With the government of India driving rural electrification campaigns like Saubhagya, the demand for electronic products like air conditioners is expected to increase.
- In between 2010 and 2018 the Standard and Poor's (S&P) Bombay Stock Exchange (BSE), Consumers Durables Index has grown at 16% CAGR. The same index was up by 6.8% in Jan 2020 and has gained 32% in the last one year[97].
- A total of 142.3 million smartphone units were shipped in 2018 which grew by 14.5 % when compared to 2017. The year on year shipment and the number of smartphone users is expected to increase in India every year (8% increase from 2018 at 152.5 million smartphones shipped in 2019).

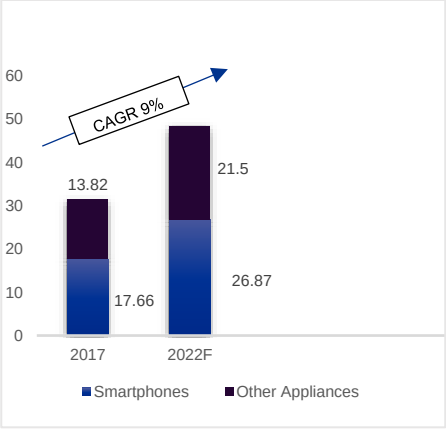

Figure 9: Rate of growth of smartphones and other appliances

- Domestic manufacturing of appliances and consumer electronics is still not optimum, and imports contributed 20% of the domestic market for Washing Machines and around 30% for air conditioners[98].
- Urban India is witnessing an increase in the existence of shared service providers like Rentamojo and Rentnickle that are renting electrical appliances for definite periods through an online platform.
- Energy efficiency has become a serious parameter to be considered amongst buyers after the introduction of the Star rating scheme by the Bureau of Energy Efficiency (BEE).
- Some trends in the consumer appliances section are given in the table:

[95] Asia as one of the largest consumer electronics markets in Asia Pacific Region, Electronics Systems, Invest India
[96] Indian Consumer Durables Industry Analysis, IBEF
[97] S&P BSE Consumer Durables Index Constituents, BSE
[98] Indian Consumer Durables Industry Analysis, IBEF

S. No.	Product	Trend
1.	Refrigerators	The refrigerator market in India stood at $3 billion and is expected to reach $5.3 billion by 2022. India produced 14 million units in 2018-19 and the production is expected to reach 27 million units by 2024-25.
2.	ACs	From 30 million stock of installed room ACs in 2017, it is expected to increase to 124 million by 2030.
3.	Washing Appliances	From the present 7 million productions of washing machines in India, 12 million washing machines are expected to be produced by 2025.

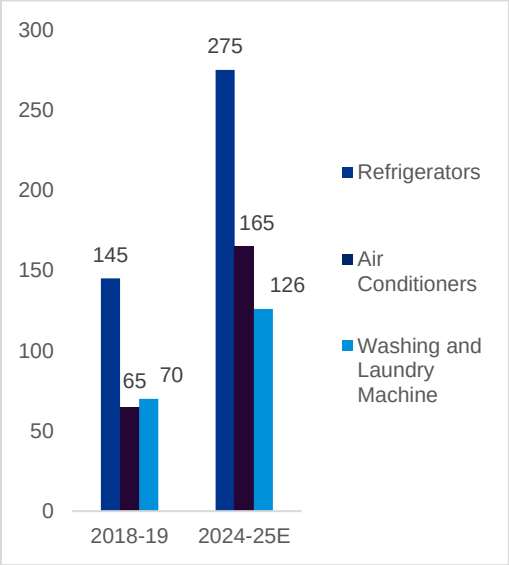

Figure 10: The projected growth rate of Refrigerators, Air Conditioners and Washing Machines

3.2.2 Indian Electronic Components Manufacturing

Electronic component market revenues from local manufacturing are considered in the total ESDM market size. It grew at a CAGR of 2% over 2013-2015 and is expected to grow at 34.9% from 2014 to 2020. Make in India, one of the flagship programs of the Government of India relies heavily on the growth of the electronic components industry in the country.

The manufacturing of electronic components in India has grown considerably from 5.31 billion $ in 2014 to 9.05 billion $ in 2018 as shown in the figure.

The total production of electronic components in India can be gauged from the figure. Indian component manufacturing is majorly dominated by electromechanical and passive categories. Electromechanical components form the largest segment of total supply with a share of more than 70%, while active, passive, and other components hold the remaining 30%.[99]

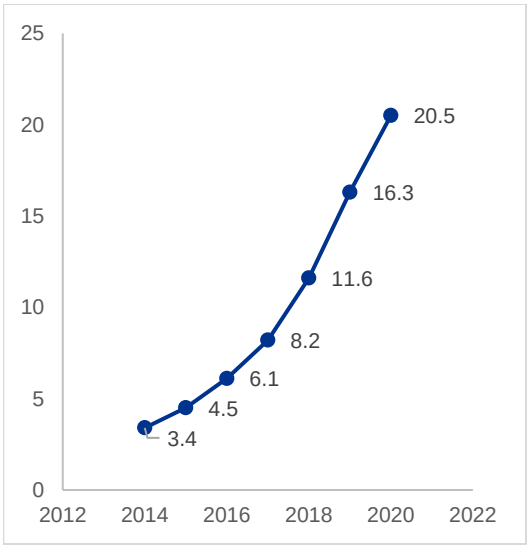

Figure 11: Revenue from Electronic Components (USD Billion)

[99] Ministry of Electronics & Information Technology – Indian ESDM Industry Update, 2017

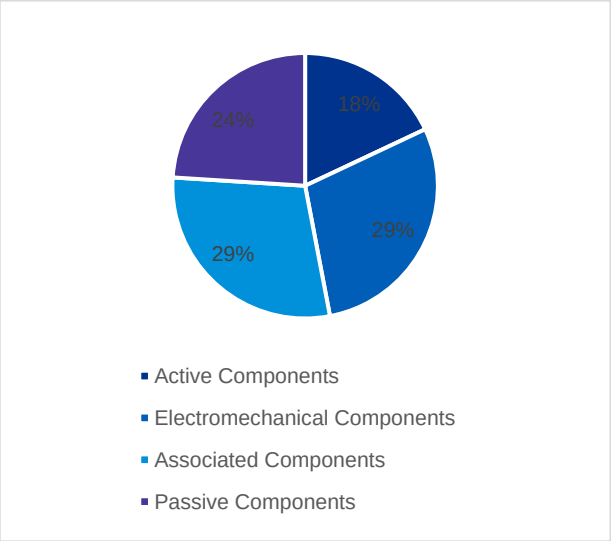

Figure 13: Share of different components in total production

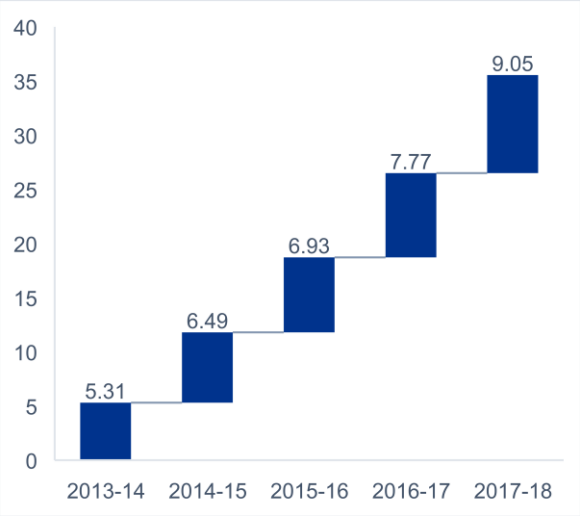

Figure 12:Revenue from Electronic Components in USD Billion

- An ELCINA report while depicting a scenario on-demand versus supply in the Indian electronic component market highlights that only 30% of the required electronic components are produced in India while the remaining 70% is imported.
- Printed circuit boards (PCBs) along with semiconductors are the most sought electronic components in India.
- ELCINA, NECTI analysis points out that the Indian semiconductor market will reach $ 32.5 billion by 2025. The CAGR growth will be at 10% from 2018 to 2025[100].
- Apart from a lot of international players like Intel & Samsung, the Indian semiconductor industry has seen a lot of indigenous manufacturers like MASAMB Electronics systems, ADROIT IC design, etc. evolve and tap the market share.
- PCB manufacturing of both types i.e. bare board and populated has increased immensely in India. Make in India coming into the picture and the basic underlying fact that all the consumer gadgets like PCs & smartphones require PCB for their manufacturing, the demand for PCBs has increased immensely amongst Indian manufacturers.
- ELCINA, NECTI analysis points out that the Indian PCB market will reach $ 6 billion by 2020 from $ 2 billion in 2017. The CAGR growth will be at 36%[101].
- Apart from a lot of international players like Samsung & Qualcomm, the Indian PCB manufacturing industry has seen a lot of indigenous manufacturers like AT&S India Pvt. Ltd, Shogini Technoarts Pvt. Ltd etc. evolve and tap the market share.
- The growth of Indian PCB manufacturing is directly dependent upon the growth in the Indian consumer electronics segment as well as some of the offerings in automotive & Industrial electronics.

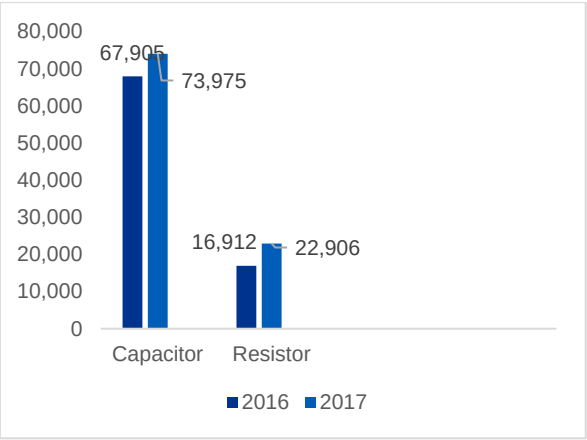

Figure 14: Increase in exports for capacitors and resistors

[100] Electrical & Electronics Manufacturing in India, ASSOCHAM
[101] Electrical & Electronics Manufacturing in India, ASSOCHAM

- The export of electrical capacitors (Fixed, Variable & Adjustable) and electrical resistors (including rheostats and potentiometers) has increased at 8.94 and 35.44% respectively[102].

3.2.3 Indian Computer Hardware Industry

Computer hardware is one of the products having a high demand in the Indian market. However, the manufacturing capacity of India has not increased drastically over the years and has remained constant. The manufacturing of computer hardware (in USD Billion) over the years can be gauged from the figure
Some of the major segments in computer hardware are desktops, notebooks, tablets, monitors, servers, USB drives, and printers.
The Indian PC market is booming with rapid industrialization and technological revolution that has engulfed different Indian cities. As per a report by International Data Corporation, India consumed 3.1 million units in the third quarter of 2019 and saw a whopping 15.8% growth. Some of the major trends being witnessed in this sub-segment are:

- The corporate culture and demand from students in technical education have boosted the demand for notebooks and their sale has grown at 18% in the last year.
- With a revolution in telecommunication and advances in mobile internet, the PC market is expected to stabilize in the coming years and buying a PC for domestic use will become a conscious decision. However, the purchase of PC for industrial and commercial purposes will grow to an extent.
- The Indian market in the early 90s was dominated by the unorganized sector, However, the present era has witnessed an increase in the branded PCs. Some of the major Indian players in the PC market are HCL and Micromax while the international players include Compaq, Dell, IBM, HP, and Lenovo.
- All these players keep competing with each other because of the price sensitivity amongst Indian buyers. HP leads the race and is the largest producer as well as a seller in the country.
- Indian hardware production is far behind that of China and still most of the Indian firms focus on assembling desktop PCs using components imported from China, Taiwan, and Malaysia. Thus, the large quantum of imports from East Asian giants is a huge concern for the Indian Government.

In this segment the global integration of markets, rapid changes in technology and reduced lifecycles for product and technology have made the Micro Small and Medium Enterprises (MSMEs) to focus on considering innovation as an essential aspect to attain benefit in sustainable competition. However, the Indian MSMEs are not currently geared to take up or get the benefit of innovation within India.

The five major challenges facing the Indian computer hardware industry are:

(i) Lack of a vibrant domestic component industry. The computer hardware industry is heavily dependent on quality parts supply. A cost-effective supply chain is absent in India for this industry.
(ii) Existing Disconnect between manufacturing and design capabilities among Indian suppliers especially MSMEs.
(iii) The MSMEs lack an innovation system.
(iv) There is a Lack of Technical standards. Standards are needed to contribute to productivity growth. Standards promote diffusion of technological knowledge. Standards help the MSMEs to get constantly updated technical specification and performance parameters.
(v) The work that is outsourced to India is at the lower end of the value chain and it the workforce to be relegated to mundane and dead-end jobs in terms of employment. That in a way prevents India from getting the gains from its participation in the global economy.

Due to the above-mentioned reasons India could not get involved so much in developing computer hardware without the support of a strong component industry. Now that the component industry is getting the support from the various schemes of the government, the computer hardware industry can draw the benefits of the same. TC can also help to mitigate the challenges as shown below:

[102] Export and Import Data, ELCINA

Area /domain	Challenges faced	How TC can help the MSMEs
Production facilities	Lack of domestic component market	The primary reason being the inability of MSMEs to provide samples to OEMs for try out. TC can help them to make these prototype through AM and get the approval. Train the potential suppliers in low-cost automation and techniques and thereby offer competitive prices to OEMS in comparison to imports.
Design and product development	disconnect between manufacturing and design capabilities	TCs can also help in minor design modifications /improvements to reduce the processing time. TCs can offer the services of their simulation facilities for the evaluation of product performance and thereby help the OEMs on optimum designs.
innovation	No access to innovation centers.	TC can set up dedicated incubation centers for electronic products. And support the MSMEs to avail such innovations on a commercial basis.
Technical standards	Lack of standards and lack of awareness of the existing ones among the MSMEs	TC to impart training on simplification, specialization, and standardization of electronic components to the MSMEs. This will help the MSMEs ready to meet the changes called for by OEMs.
Order acceptance from a global supply chain	Now mostly low end of the value chain is given to Indian suppliers. This does not help for the growth of this sector to become an active participant in the global supply chain.	TC can help the cluster or a group of MSMEs to form a joint marketing platform so that they can take up value added components for development and supply. This will help the MSMEs and the OEMs engaged in this segment.

3.2.4 Indian Industrial Electronics Industry

Industrial electronics can be regarded as an important parameter to gauge the overall development of the economy. Industrial electronics contribute immensely to the growth of the manufacturing sector in any economy. Some of the major trends in the Indian industrial electronics industry are:

- The Industrial electronics segment has never seen a declining trend. The production of industrial electronics has always increased from the year 2010. The estimated value of production stood at around $ 10.7 billion in the year 2018. The year on year manufacturing trend can be seen from the figure 16.
- There has been a tremendous increase in the demand for automation and analytical instruments which can be attributed to a boost in R&D concerning automation and robotics.

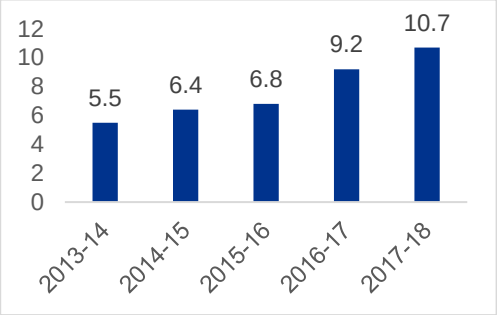

Figure 16:Revenue from Industrial Electronics (In USD Billion)

- Of the total industrial electronics production PCE, A&AE and PEE together hold 81% while T&ME accounts for 19% of the manufacturing.
- BHEL, BEL, ECIL, SU-KAM and Blue Star are some of the major Indian players while GE, Honeywell, and APC are some of the Global players existing in the Indian market.
- The industrial electronics market in India is witnessing the evolution of new products like Solar Photovoltaic equipment which can be attributed to rising investment in clean technology.
- Adoption of renewable energy, electric vehicles will further provide a conducive environment to set up manufacturing parks providing impetus to industrial electronics manufacturing. For instance, Ministry

of New and Renewable Energy has urged all the states to set up renewable energy (RE) equipment manufacturing parks to meet domestic and global demand and make India a global production hub.

- Industrial electronics production is expected to grow in India because of the following reasons:

With an increase in rural electrification, Inverters and UPS sales are increasing which directly drives Industrial electronics manufacturing.

Government initiatives like Smart Cities project, metro rail projects in multiple cities and focus on solar electrification is expected to give a lot of impetus to industrial electronics manufacturing.

3.2.5 Indian Strategic Electronics Industry

Strategic electronics is an area of immense importance with GOIs increasing focus on defence indigenization and schemes like Make in India. It's a key aspect of defence and forms part of nearly all the weapon systems and equipment employed in land, aerospace, and water. The manufacturing of strategic electronics has increased manifold in the country and that can be gauged from the following figure.

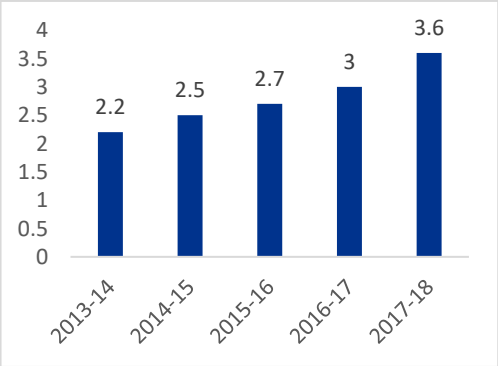

Figure 17:Manufacturing of Strategic Electronics (USD Billions)

Some of the major trends witnessed in the Indian Strategic Electronic sector are:

- With the investment by the Indian government in defence budget increasing year on year coupled with the fact that Make in India is a major policy thrust, the defence electronics in India are expected to grow leaps and bounds
- With innovations in the Indian Defence equipment's like Futuristic Infantry Combat Vehicle (FICV), Future Ready Combat Vehicle (FRCV), Tactical Communication system, Light Combat Aircraft (LCA), Air Force Network (AFNeT), etc., the opportunities in Indian strategic electronics market are increasing day by day
- The platform electronics segment carries a lot of opportunities in the Indian strategic electronics market, especially in the Naval segment. With the launch of Indian Submarine programs like Project 75-I focusing on Scorpene-class submarine and Project Arihant class, the Indian platform electronics segment is bound to offer a plethora of opportunities

Unlike commercial electronics, strategic electronics Industry in India is in the nascent sage of developing the technological systems. They use the know-how, by using SKDs (Semi-Knocked Down)/CKDs (Completely Knocked Down) kits primarily due to non-availability of core competency or home grown technologies in the critical areas like Chips, Sensors, Field Programmable Gated Array (FPGA) technology, Artificial Intelligence (AI), Micro Electro Mechanical Systems (MEMS) design and manufacturing, Miniaturization, Ruggedization of displays, and Design Changes (technology up-gradation) of existing equipment.

The key technology capability gaps[103] for the domestic players in defense electronics systems lie in the areas of Internet Protocol(IP) Radios/Software Defined Radio(SDR)s, Military Grade Geographical Positioning System(MGPS), Encryption and Secrecy Modules, 3D Tactical Control Radars(3D TCRs), Target Acquisition Systems, Electro-Optics, Battery Backup Systems, Field Wireless Systems, and support of Long Term Evolution(LTE) while adhering to the defense services security protocols and core electronics technologies.

[103] A framework for Building Technological Capability in India-Strategic Electronics Perspective Kishore Balbadra, K. Kalidas. International Journal of Research in Engineering, Science and Management Volume-2, Issue-1, January-2019 www.ijresm.com | ISSN (Online): 2581-5792

To maintain the technological leadership in the strategic field, an eco-system to give an impetus for the growth of technological capability in mission critical components, line replacement units (LRU)s through indigenous R&D, Reverse Engineering, Joint/Co-Development with foreign OEMs encompassing the available Innovation System in the country are needed.

The product development and production involve the following steps:

- Establishing the user needs
- Design aspects consisting of design review, prototype, and verification
- Production methodology – validation and bulk clearance
- User trials
- Design of Product sub system

Till recently the projects involved many partners in the form of design agency, production agency, inspection agency and finally the users make the developmental activity a “project based” technology development program with good track of technological learning out of each stage of technology development (i.e., component level, assay level, sub-system level and system level).

Now the trend is to use a cluster of System Integrators from MSMEs /OEMs along with labs with other research centers (like DRDO) in India an eco-system at every level of manufacturing of technology beginning with requirements elicitation, technology demonstration, model/prototype building, and bulk production along with a gamut of agencies contributing to the success of the project. A framework has been proposed taking into consideration of various factors for the developing nation like India, as depicted below in the figure giving the required Framework for building technological capability in strategic electronics. This scheme enhances the role of MSMEs.

TC’s can play a pivotal role in the challenges faced by MSMEs as is highlighted in the table below:

Domain	Challenges faced	TC and MSME contribution
Design	To design and make prototype at shortest time and to get the OEM approval	An exclusive cell with in the existing TCs to specialize on the electro, electromechanical and pure electronic items. They can with the latest software help the MSMEs and OEMs to develop design alternatives based on one of the design systems – i.e., generative, interacting and model-based designing system. There after the most suitable design can be taken up for prototype production in TC’s own 3D printing facilities. The TC can help the MSME to identify components that are most suitable or the MSMEs to join the global supply chain.
Prototype making	Manufacture of prototypes., testing and getting the product ready for approval of sample	This is an area where the TC can set up a model cell with the existing machines to make prototypes and small batch production. The cell shall have all the basic operations covered in the manufacturing cycle – for example CNC milling, 3 axis and 5 axis machines, AM machines, 3D scanning for inspection This cell can support the MSMEs to make the prototypes, inspect and test and offer the same for approval. Once approved small batches of the product can be supplied to the OEMs through these facilities. Once the product line is established, MSMEs can take over regular production, on their own.
Technology absorption	To absorb the product design given by the OEM and to produce the same	Defense segment relies on some imported designs and drawings. It is essential to absorb the technology aspects of those products to ensure smooth supplies. TC can help the MSME is understanding the importance of each feature, the relative weightage to be given to those features and the most economical way to make them on the available machines. Also, TC can help to suggest, design, and supply the needed tooling and fixtures to ensure smooth production.

Skilling	The existing workforce and staff need reskilling while taking up these items for production.	Training and reskilling being the core strength of TC , they shall take up the MSMEs – all levels – in understanding the requirement with respect to quality , interchangeability apart from mere functional requirements of the component.

3.2.6 Indian Automotive Electronics Industry

The Automotive Industry has become a vital part of the electronics industry with its increasing growth due to the digitization of automotive controls. The industry serves as a pillar in the promotion of flagship schemes like "Make in India" and "Digital India" by the Government of India. The industry features a range of technologies that are distinguished based on the type of technology and its application. Some of the major trends being witnessed in the automotive electronics industry are:

- The Automotive Sensor Market is expected to rise to $1.51 bn at a CAGR of 11.64% in FY 2016-21[104]. The market includes varied types of sensors like reverse parking alert, security, proximity, oxygen, intelligent battery, level sensor, gas sensor, torque sensor, pressure sensor, motion sensor, level sensor and, optimal sensor. The chart below features illustrates some of the points viz a viz volume and revenue.
- Some major players in the sensor market sector are Bajaj Auto, Mahindra & Mahindra, Ashok Leyland and, Tata Motors.
- A **tire-pressure monitoring system** (TPMS) is used to assess the pneumatic pressure in the tires and report real-time pressure. This information was initially extracted via a gauge or a pictorial display, but the new market has been introduced to low-pressure warning lights on the display screen to alert the driver. The market is being driven by better efficiency and safer TPMS which has caused a hike from INR 17 crore to INR 128 crore (FY 2016-20) at a CAGR of 66%. Major components dominat8ng the market are tire pressure sensors, display units, and controllers.
- The **Automobile Safety System (ABS)** incorporates the driver's input to the wheels of the vehicle for braking and to avoid skidding or locking/jamming. A report by ACMA features major components as ECU (40%), wheel speed sensors (30%), and Hydraulic/Pneumatic modular unit (30%) in the market. The market has risen from INR 1,203 Crore to INR 7,810 crore (2016-2020) with a CAGR of 59.6%[105].
- An **airbag** is widely used as a restraining safety measure in case of a crash where a thin nylon bag, ideally stored in the steering wheel, blows up and reduces the impact of the crash on the driver. A Road Transport and Safety Bill was passed in October 2017 that announced mandatory crash tests for new vehicles sold in the country and has contributed to the market growth from INR 995 Crore to INR 5,045 crore in FY 206-20 at a CAGR 50.1%. Components like Airbag Modules (18%), Airbag Control Units (45%) and Crash sensors (15%) share the market where players like Takata and Autoliv are integrating airbag inflator units and airbag modules to prepare the final product.
- **Electric-power steering** functions due to its direct attachment to the gearbox using a hydraulic system. The market is driven by components like power steering motor (30%), reduction gear (15%), ECU (40%), and torque sensors (15%) which have observed a market growth at a CAGR of 15.2% from 2016-2020. Almost 100% of mechanical components are assembled in India by Indian manufacturers whereas sensors, ECUs, and actuators are vastly imported or supplied by Tier 1 OEMs.
- **The Body Control Modules** control and monitor the motor vehicle's accessories and communicate with the on-board computer for operations like the functioning of power windows, central locking, etc. The market has undergone a drastic shift due to increased demand in-vehicle of safety features, communication systems, and comfort. This has driven the market from INR 901 Crore to INR 1.764 crore[106] within FY 2016-2020 at a CAGR of 18.3%. However, there is a major import dependency on components that is majorly met by Germany, Singapore, USA, and, China.

[104] India Automotive Sensors Market - Applications, Trends, Forecast - (2020 - 2025)
[105] ACMA Report – Automotive Electronics, Master Plan Development for Auto Components Industry in India
[106] ACMA Report – Automotive Electronics, Master Plan Development for Auto Components Industry in India

- **In-Car Entertainment** System is responsible for delivering the vehicle's entertainment with the help of an in-car entertainment system. The sector was valued at INR 1,388 Crores in 2015 and is expected to grow at a CAGR of 19.7% by 2020, valued at INR 2,484 Crores[107]. This includes audio content, navigation and rear-seat comforts like games and movies where the radio unit takes 60% share by value and speakers contain 40%, however, demand is driving ICEs to be a touchscreen with additional features and has shifted the trend form standalone units to integrated units. Nippon Audiotronix ltd., Alpine, and Pioneer are some of the major players working on the market. Some major players in the field are Continental, Delphi Bosch and Magneti Marelli.

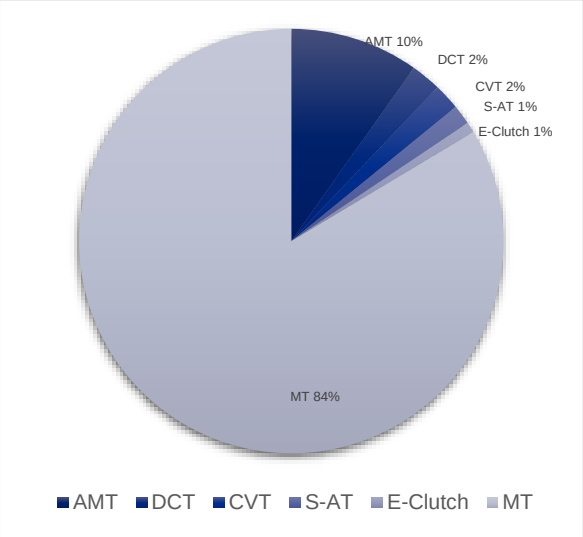

Figure 18:Transmission type of market share in India

- The current **automated transmission** market in India has grown from 0.5% in 2015 to 10% in 2020, the dual-clutch transmission from 0.6% to 2.3%, and continuously variable transmission risen from 0.3% to a predicted 2%. The involvement of AMT to the market is expected to strengthen the hold AMT& DCT has over stepped-AT.
- Among the many safety controls used in automotive, **Immobilizer** is prominently used as an anti-theft precaution. It gets activated when the ignition key is removed and is synced with engine controls to allow detection of unauthorized access. The market is shared among RF Based Controllers and Transponder Based Controllers which have grown from INR 281 crore to IN 880 crore at a CAGR of 33.1%.
- **Driver Information System** has grown from INR 819 crore to INR 1,529 crore (CAGR 16.9%) for FY2016-20. DIS analyses information from all ranges and alters the vehicle's current working permanently according to input. The market is shared between Instrument clusters (60%) and displays (40%) where the current instrument clusters are those with 3D dials and increased digital penetration. Other features like colored LCD displays, integrated displays, TFT displays and, clusters driven by stepper-motors are on the rise. Big players like Visteon, Denso, Delphi, JNS Instruments, Varroc, and Magneti Marelli are prime in the current market trend[108].
- Today's market is gradually shifting towards **Electric Vehicles** because of factors like decreasing battery price and supportive government policies that contribute towards growth in electrification. The Electric Vehicle market is currently the most dwelled upon transition and is pushing the automotive industry's contribution to India's GDP to 12% from 7% as a part of the Automotive Mission Plan 2016-26.[109]

The developments in automotive engineering, need lot of improvements in automotive power electronics in the next decade. The basic challenges viz a viz MSMEs are:

- Change in the voltage: The automobile is undergoing a revolution in the design of its electrical system. The design uses sophisticated engine and body controls and new electrically controlled functions. The main electrical bus of the future will be 42 V, and it will be buffered by a 36 V battery. As many devices and electronic control units require voltages different from 42, conversion from the 42 V bus to these other voltages will be necessary.
- Increase in the number of electronic components: Further, the number of electronic components used in an electric vehicle (EV) is higher than in any conventional vehicle, as EV has an electric

[107] ACMA Report – Automotive Electronics, Master Plan Development for Auto Components Industry in India
[108] ACMA Report – Automotive Electronics, Master Plan Development for Auto Components Industry in India
[109] The future of mobility in India's passenger-vehicle market, Mckinsey report, 2018

motor, battery and other complex connections to ensure optimum utilization of power. Owing to the critical role of electronic components in EVs, surface mount devices are used as they are lighter, occupy less space, are safe and last longer. This SMD technology is to be absorbed by MSME for future growth.

- Technology changes needing more power: Some anticipated features, such as electromechanical engine valves, will demand both conversion and sophisticated control at power levels in the 2 kW to 10 kW range. The transition to X-by-wire technology, replacing mechanical and hydraulic systems with electromechanical systems will require more power electronics. Integration of power transistors and smart power devices into the electromechanical actuator will require power devices to operate at 175/spl deg/C to 200/spl deg/C. Hybrid electric vehicles and fuel cell vehicles will also drive the demand for higher temperature power electronics. In the case of hybrid electric and fuel cell vehicles, the high temperature will be due to power dissipation. The alternates to high-temperature devices are thermal management systems which add weight and cost.
- Need for more sensors: With more electrically controlled systems along with digital control and displays the number of sensors in vehicles is increasing.
- Use of high temperature electronics: Many of these sensors must work in high-temperature environments. The harshest applications are exhaust gas sensors and cylinder pressure or combustion sensors.
- Newer accessories: With the addition of new systems such as mobile multimedia, control-by-wire systems, advanced safety interiors, and collision avoidance coupled with smart sensors and actuators, in a potentially new integrated vehicle wiring system, there will be more electronic content in the automobile of the future. This offers a major headroom for the growth of MSMEs.
- Newer areas for TC: The challenge faced by the automotive electronics industry is to develop a vision of these future products, and then follow a defining process to develop the technologies necessary to offer timely, reliable, and cost-effective products to the automotive consumer. TC can partake the load of development, prototyping, testing along with the training of the manpower in the newer technology areas.

3.2.7 Indian Medical Electronics Manufacturing

Medical Devices play a role through the entire spectrum of healthcare ranging between diagnosis to after-care. The quality, awareness, and, affordability of these devices directly impacts the accessibility of health care services in a country. As the 4th largest market in Asia and a top 20 in the world, the Indian medical devices industry is driven by macroeconomic factors like GDP, population, income profiles; Industry trends and, Segment considerations like market competition, the impact of outside factors, etc. Some of the trends that have been observed in this sector are:

- The medical devices market in India stood at $ 5.2 billion in 2017 and is expected to grow at 16% CAGR to fetch $ 8.16 billion in 2020[110] as shown in the figure. The sector gains importance because of an increasing thrust of the Indian government on ensuring universal health care with schemes like Ayushman Bharat. Some of the clusters that have emerged in India are[111]:
  i. Bangalore & Mangalore in Karnataka with companies like GE Healthcare, - Bigtec Labs, etc.
  ii. AMTZ MedTech Park in Vishakhapatnam at Andhra Pradesh with companies like B Braun, St. Jude Medical, Medtronic, etc.

[110] WHO & Indian Government
[111] Medical Device Manufacturing in India, A Sunrise, WHO

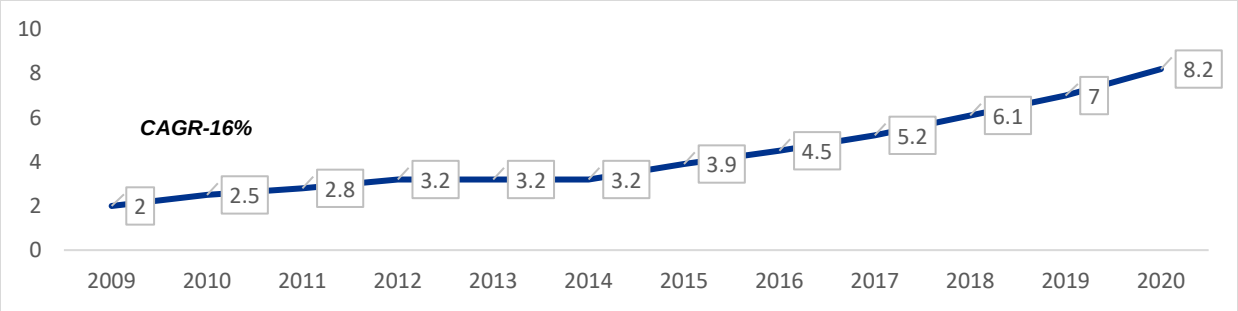

Figure 19: Rate of growth of Indian Medical Devices Market

- The Indian government is also focused on developing medical electronics as a popular manufacturing stream in the country through its initiatives like IIPME i.e. Industry Innovation Programme on Medical Electronics. IIPME is a collaborative venture between the Ministry of Electronics and Information Technology (MeITY) and Ministry of Science & Technology to fund Indian pilot projects aiming to innovate in the field of medicinal devices.
- The Indian Medical device market is dominated by diagnostic imaging because of increasing awareness amongst people about the benefits of diseases getting diagnosed early. As per market analysis, this segment alone is expected to garner revenues of $ 2.5 billion in 2020.
- The diagnostic market is followed by some other segments like ECG machines which are expected to garner $ 2 billion in 2020.
- There is a direct link between the electronics component industry and the medical electronics industry. The existence of medical electronics manufacturing would not be feasible without a firm presence in the electronics component industry. Some of the widely used semiconductor components in the medical electronics industry are given in the following table[112]:

Product	Widely used semiconductor components
Infusion Pumps	Sensors, Transistors, Rectifiers, Microcontroller, Comparators, Regulators, amplifiers
Patient Monitoring Systems	Rectifiers, EEPROMS, sensors, Controllers, ZigBee modules, microcontrollers, application-specific integrated circuits
Medical Imaging	Application-specific integrated circuits, data converters, application-specific standard products, microcontrollers
Digital Hearing Aids	EEPROMs, audio processor integrated circuits, linear accelerometers, microcontrollers

Table 1:Widely used semiconductor components in different products

- Medical electronic instruments that have a lot of import dependency and are not manufactured in India are[113]:
    i. CT Scans, MRI, PET Scans, and other electronic radiography instruments have an import dependency of 52%.
    ii. The artificial dialysis apparatus, EEG, and ECG have an import dependency of 83%.

3.2.8 Status of MSMEs in ESDM Sector

Though the Indian ESDM is showing an overall growth, the larger units are not using the MSMEs and their strength in sourcing the components and services. This is due to MSME's lack of competitiveness and ability to supply at fast speed to market. The major challenges faced by the MSME's in meeting the needs of larger OEMs are the following:

[112] Pulse of Indian medical electronics market; electronics b2b
[113] Medical Device Manufacturing in India, A Sunrise, WHO

- Sharp swings in labor costs, energy costs, and currency exchange rates in recent years have narrowed some of global differences in cost competitiveness. This had a direct impact on MSMEs. A stimulant needed for MSMEs to use the low-cost automation technologies. This will help them to overcome some of the issues.
- The MSMEs do not get a workforce with skills and educational qualifications at par with international standards and levels. The available workforce has not been trained or reskilled in newer technologies and processes. The majority of the MSME's in this sector need a reorientation and skilling – which can help them to handle the OEM requirements and thereby get an enhanced share in component supply to OEMs.
- ESDM sector survives on constant improvement in product design, miniaturization The MSMEs have no time or resource to bring in components with the newer design, features and commercializing them. Adequate innovation and incubating facilities can feed them with this need.
- There is a need to attract many Indian graduates of higher educational institutes by providing "on the job work exposure" and facilities for innovation. The TC and academic institutions have a definite role to play in this area.
- The overseas manufacturers – competitors to Indian MSMEs - are already availing the benefits of emerging technologies coming under Industry 4.0. Applying Industry 4,.0 leads to cost reduction, higher efficiencies, safer factories, and faster speed to market. The Indian MSMEs are yet to get those benefits.
- The ESDM components – many of them - are generally sustainable on large volume production due to relatively low unit cost. These production capacities imply large initial investments and MSMEs do not have the required financial muscle to go in for them. The ESDM manufacturing sector faces this dichotomy. Unless large quantities are produced the unit, cost is not competitive. Alternately, If MSMEs resort to import of basic components freight, inventory costs make them equally uncompetitive. A possible way to come out of this egg and chick situation will be to start a few anchor ESDM manufacturing units in the existing clusters based on a CFM model.

In the manufacturing sector, MSMEs act as specialist suppliers of components, parts, and sub-assemblies to larger companies because these items can be produced at a cheaper price compared to the price large companies must pay for in-house production of the same components. Parallelly, trade liberalization has increased the capacity of well-established foreign manufacturers and retailers to penetrate both remote and underdeveloped markets – like India . Because of this development, local SMEs find it increasingly difficult to survive or even maintain their current business position in their respective markets. In the new products, they have no scope for entry, as a component supplier. The challenges faced by MSMEs and how TC can help to mitigate them are shown below:

Domain	Challenges faced by MSMEs	Role the TC can play
Inputs and its quality control	Presently the input of poor-quality products/raw material is adversely affecting the competitiveness of MSME units. This inability of MSMEs to supply quality components compel the OEMs to turn to cheaper and dependable imports.	— TCs can offer training on input quality control. — TCs to have material cum component testing lab and offer the testing services to MSMEs – at competitive rates.
	In this industry, raw materials, and smaller components especially, standard electronic components are bought in and used in the assembly. MSMEs shall have	— TCs can create a data cell to give real time data regularly on sources for small items. The same can be availed by MSMEs for their use.

	an online source to help them in selecting the best supplier considering the quality, price, and delivery time for their production.	— TC can also help the MSMEs to set up a Common raw material procurement facility / RM bank. Such bulk buying of standard items will help to get cost advantage to the entire MSMEs in this sector.
Design and development	MSMEs are not quickly adopting to changes in designs and developing new products. They do not have in house or access to such facilities to carry out minor design modifications to suit the process needs.	— TC can have an exclusive design cell to take care of the industry needs. The needs are for shorter innovation cycles, lower prices, more complex products, increased flexibility, individualized production, or productivity. The TC can adopt virtual prototyping methods right from the early stages of designing process. This would enable the assessment of the adaptation of the future object to the forces and loads to which it will be exposed. This will help the MSMEs to meet the component needs more effectively and to elevate itself into global supply chains.
Facility planning	MSMEs to develop internal capabilities such as ‘‘soft technology’’ (methods and processes that support the firm) and ‘‘hard technology’’ (externally acquired equipment, in-house development of machinery and innovation in raw materials).	— TC through their consulting division shall guide the MSMEs to upgrade themselves on facilities.
Innovation and Incubation	Currently, they are doing narrow specialization and work on too small niches. They lack the innovation and incubation facilities. They need a strategy of continuous improvement, innovation, and ability to do changes in the process.	— The MSMEs by themselves cannot afford to carry out innovation initially. TC can offer innovation facilities and support for interested young professionals to carry out practical product innovation. The TC can have an exclusive facility for incubation.
Manpower skilling	They cannot employ and retain skilled or high caliber people.	— Skill development has been one of the core competencies of TC. The ESDM industry needs constant training and upskilling of the operatives at all levels. TC shall devise the training programs for industry.
Cost	SMEs face major pressures to reduce costs, improve product quality, deliver goods and services on time. Moreover, Indian SMEs operate generally in an unsupportive environment	TC s can help in the following ways: — Shall train them in introducing a simple product costing method. — One of the major factors leading to the success of Component industry is sourcing. TCs to train MSMEs to choose a “make Buy” decision that too based on real time basis in the input costs both in the national and international markets.
Government schemes	To position India as a global hub for Electronics System Design and Manufacturing (ESDM) several government schemes have come. **(A**	— Each electronic manufacturing scheme has been carefully constructed to incentivize the electronics manufacturing industry — This has to be passed on through intensive awareness program and orientation sessions.

	detailed explanation on the existing schemes is given in section 3.6) .	The TC can take up this to facilitate the industry.

3.3 Indian Design Services

The design service industry has shown robust growth, both in hardware and software, with the entry of international and domestic companies in the Indian design landscape. It comprises of VLSI design, embedded software development, and hardware design and is expected to grow by USD 33.1 billion by 2020, at a CAGR of 17% over 2014-2020. As a segment, it is highly dependent on export demand[114].

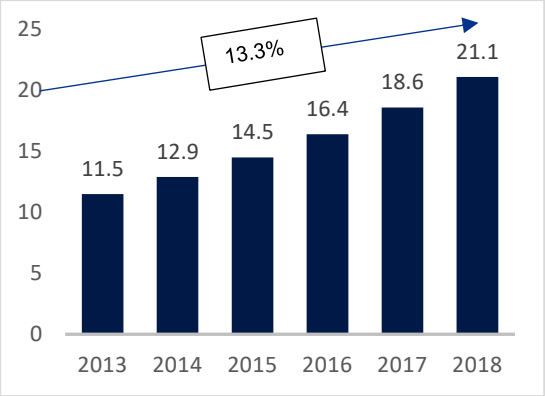

Figure 20:Semiconductor Design Market, Source: India Electronics and Semiconductor Industry: Opportunities for Japanese Engagements, 2014

The Embedded system is the largest contributor (~ 85% revenue share) within the design services market. Its key consuming verticals are telecom and consumer electronics products. With global players having their R&D centers across India, in the past decade, quite a few Indian entrepreneurs have started their own design houses. India is a highly attractive destination for global R&D centers owing to the availability of talent, and lower cost. Connectivity, portability, and IoT are the key themes that are driving demand for embedded systems services across verticals such as automotive, consumer electronics, mobile handsets, healthcare, and industrial related applications. Indian MSMEs have vast scope to venture into Design for Manufacture (DFM) and Design for Testing (DFT).

The design services industry has been grown immensely over the past years at a CAGR of 12% (FY 2015-2020)[115]. The industry has introduced opportunities for various domestic and global companies with its rising revenue of $23.5-$29.2 Billion at a CAGR of 13-18% (predicted FY2020)[116]. The local talent in India is dedicated to establishing the industry for its ER&D (Engineering Research and Development) to cultivate stronger export demand, as well as domestic, by improving the demand factors (portability, IoT, automation, and connectivity) of embedded systems which holds 85% revenue share in the design services segment. Currently, India is taking steps towards a homegrown fabless semiconductor design ecosystem, by the example of China's homegrown chip program, to move on from relying on global companies like Qualcomm, Intel, MediaTek, AMD and ARM, and Intel. Figure 20 depicts the growth in the Semiconductor Design Market from FY 2013-18.

The current progress towards a digitized India has increased the demand for design services in household products like LED Illumination, broadband connectivity, and miniaturized communication. This demand is being met by Indian MSMEs and IoT based startups, with the help of Independent Design Houses, Captive Design Houses, Electronic Design Automation, and Original Design Manufacturers[117]. One such example is Cirel Systems, a startup that designs chips for digital pens to be used on touch screen devices like tablets and phones. Another Bangalore based startup is Signalchip who launched 'Agumbe', a series of chips focused on 4G and 5G modems.

3.3.1 Embedded Software Design

Embedded software is non-PC programming in the form of microchips and applications that run certain functions on the electronic component/device. A technology like chip fabrication requires calls for high-cost

[114] Indian Brand Equity Foundation – Semiconductor Industry in India
[115] Indian ESDM industry update, IESA 2017
[116] Indian ESDM industry update, IESA 2017
[117] Strategic Necessity: India Is Seeking to Become A Chip Designing Hub, Economic Times, 2019

R&D and hands-on know-how that need large amounts of capital and specialized facilities to expand to a profitable scale. Major PSUs like BEL and WIPRO have dived into this segment and produced System on Chip (SOC) to be applied in tablets and phones. In India, fabless chip designing is taking a new turn due to a rise in IoT expertise and the establishment of COEs that can accommodate new start-ups. In 2018, IESA launched the Fabless Semiconductor Fabless Accelerator Lab (SFAL) in Bangalore to help MSMEs gain funds and market access. The Government of Karnataka invested INR 21.5 Crore in the facility and has committed to investing another INR 56 crore towards the expansion of the facility and help it meet the target of incubating 50 new startups by 2022.[118]

3.3.2 Electronic Design Automation

EDA is a segment that involves designing of Integrated Circuits and Printed Circuits Boards with software tools. It is further segregated into Computer-Aided Engineering, Integrated Circuit Physical Design, and Verification and Printed Circuit Board and Multi-Chip Module. The Indian semiconductor component market is expected to reach $32.35 billion by FY25 at a CAGR of 10.1% between FY 2018-25[119]. The automotive industry has great opportunities for application and growth of EDA since automotive today run on the complexity of electronics than any other hardware problem. Some of the major Indian players adapting to this development are Ashok Leyland, Mahindra, and Mahindra, TATA, and Motherson.

3.3.3 Very Large-Scale Integration Design (VLSI)

VLSI technology rides on the success of scaling transistors and nano-sizing components to meet current market demand. In India, the designing of these chips and precision in a factory model involves other industries like Networking, Telecommunications, Consumer Electronics, Industrial, and Healthcare. According to a Silicon India report, the industry saw a hike in FY 2012-17 at a CAGR of 16.25% and was expected to reach $3.2 billion by then. Now predicted to reach $2.2 trillion by 2020[120], India is trying to set up the VLSI ecosystem similar to companies like eSilicon, Open-Silicon, and GUC. However, it is companies like WIPRO Technologies, TCS, MindTree, L&T Infotech, HCL Technologies, and TCS that are leading in India. The Government of Karnataka also opened an incubation center, 'VLSI/ESDM Incubation Centre', through KITS (Karnataka Information Technology Services) and aims to leverage the local talent and empower VLSI/ESDM start-ups.

VLSI covers many phases of design and fabrication of integrated circuits. For a commercial chip design, it involves system definition, VLSI architecture design and optimization, RTL (register transfer language) coding, (pre- and post-synthesis) simulation and verification, synthesis, place and route, timing analyses and timing closure, and multi-step semiconductor device fabrication including wafer processing, die preparation, IC packaging and testing, et al.

As the process technology scales down, hundreds or even thousands of millions of transistors are integrated into one single chip. Hence, more and more complicated systems can be integrated into a single chip, the so-called System-on-chip (SoC), which brings to VLSI engineers ever increasingly challenges to master techniques in various phases of VLSI design. For modern SoC design, practical applications are usually speed hungry. For instance, Ethernet standard has evolved from 10Mbps to 10Gbps. Now the specification for 100Mbps Ethernet is on the way. On the other hand, with the popularity of wireless and portable computing devices, low power consumption has become extremely critical. To meet these contradicting requirements, VLSI designers have to perform optimizations at all levels of design.

3.4 Testing & Calibration

With increase in complexity of electronic hardware, it is imperative to evolve new techniques and methods to test these hardware devices to check for any functional / manufacturing inaccuracy. Testing is important at every stage of product's life cycle and is used in design phase, product development phase, pre and post market testing, as well as after sales support. Product certification ensures that the product being manufactured by an industry is robust and complies with the standards existing in the sector. Thus, the

[118] IESA opens Bengaluru Lab to Incubate Chip-Designing Startups in India, December 2018
[119] IESA, 2019
[120] VLSI Design Services Ecosystem in India: A Study, SiliconIndia

growth of the testing, calibration and product certification is synchronous with the growth of the ESDM industry in the country.

Other factors driving growth in this domain are the stringent quality, safety, and environmental standards for manufacturing, maintenance and the use of electronic equipment across various applications.

The worldwide testing and measurement equipment market size is estimated to expand at a CAGR close to 4% from 2017 to 2023. Its valuation is expected to touch USD 28 billion by 2023. Testing and measurement equipments comprise devices which can display accurate values of electronic devices. Strict regulations and quality standards pertaining to these devices are expected to drive its demand during the forecast period. Indian MSMEs have vast scope to venture into testing and calibration services to cater to the burgeoning demand in ESDM industry. Testing / calibration can be of various types:

- In house functional testing/parametric testing
- FBT/BBT/Boundary Scan, ICT, AOI, SPI, X-Ray
- Statistical Tools
- Reliability & Qualification Testing
- Environmental Test (Dry Heat, High/Low Temperature, Bump, Vibration, Shock, Altitude, HALT & HASS)
- EMI / EMC Testing
- Flame, Ingress of Water, Dust etc.
- Primary and secondary calibrations

The electronic Testing and Measurement (T&M) industry is on the up curve, with growth fueled by opportunities across industries including communications, semiconductors, automotive, computing, consumer electronics, industrial, energy and medical devices among others. In the coming years, the growth shall be driven by segments like semiconductor automatic test equipment's, radio frequency tests, digital tests, electrical and environmental tests and data acquisition.

Some of the prominent players in the global test and measurement equipment market are Fortive, Bureau Veritas, Rohde & Schwarz, Anritsu Corporation, Keysight Technologies, Yokogawa Electric Corporation, National Instruments Corporation, EXFO, Advantest Corporation, Viavi Solutions, Texas Instruments Inc. and Fluke.

Some of the prominent players in the global market for calibration are ABB Group, Endress+Hauser, ESSCO Calibration Laboratory, General Electric, Keysight Technologies, Siemens AG, GE Kaye, Bruel & Kjae, Tektronix, SGS and Lockheed Martin.

The global test and measurement equipment market has been segmented as follows:

a) Based on the product, the test and measurement equipment market has been segmented into mechanical test equipment and general purposes test equipment. The general-purpose test equipment segment is sub-segmented into oscilloscopes, signal generator, digital multimeter, logic analyzer, spectrum analyzer, network analyzer, power meter, electronic counter, modular instrumentation, and automatic test equipment.

b) Based on the service, the test and measurement equipment market has been segmented into after-sales services, calibration services, and others. Calibration is an important aspect of maintenance and if calibration data is analyzed correctly, it can help maintain and improve compliance, efficiency, quality and safety.

Some of the segments in which there is growing demand for test and measurement equipment are automotive industry, Data Centers and New Standards, 5G and Pre-5G Technologies, Power Management Applications, Aerospace & Defense, IoT, Medical Devices.

3.4.1 Product Certification

Most electronic products require multiple certifications in order to be sold. The certifications required for equipment depends upon myriad factors like product specification and country of sale. Certifications being

employed by the USA, EU and Canada are the most sought certifications across the globe. Some of the globally acceptable ESDM standards are:

3.4.1.1 Federal Communication Commission (FCC)

Federal Communications Commission (FCC) certification is required in the United States for all electronic products that oscillate at 9 kHz or higher. This regulation falls under what the FCC calls “Title 47 CFR Part 15” (15th subsection of the 47th section of the Code of Federal Regulations). There are two classes of FCC testing:

- Class A: An easier test to pass and is intended for products that will be used in industrial applications.
- Class B: For consumer products and requires stricter testing.

FCC certification can be further split into two types determined by whether your product incorporates wireless capabilities such as Bluetooth, Wi-Fi, cellular, or any other type of radio transmitter:

- Intentional radiator
- Non-intentional radiator

3.4.1.2 Comité International Spécial des Perturbations Radioélectriques (CISPR)

CISPR 22 is also known as International Special Committee on Radio Interference in English. The requirements for CISPR are very similar to FCC, but somewhat stricter regarding RF emissions at some frequencies. CISPR 22 is specifically applicable for the EU. Other countries and regions have similar regulations on electromagnetic emissions. For all intents and purposes, these regulations include almost all electronic products, since very few products can run at frequencies less than 9 kHz.

3.4.1.3 Specific Absorption Rate (SAR)

SAR is concerned with the absorption of electromagnetic energy by the human body. SAR testing is mostly applied to smartphones, tablets and laptops that have high power radio transmitters, and is something to be aware of when designing such products.

3.4.1.4 Underwriters Laboratories (UL)

UL certification is necessary in the United States and Canada if the product plugs directly into an AC outlet. UL is one of several companies approved to perform safety testing by the U.S. federal agency Occupational Safety and Health Administration (OSHA). OSHA maintains a list of approved testing laboratories, which are known as Nationally Recognized Testing Laboratories.

3.4.1.5 Canadian Standards Association (CSA)

CSA is an alternative to UL certification and is valid in both Canada and the United States. CSA is based on internationally recognized criteria and procedures and has identified 57 areas for standardization. CSA mark is voluntary, meaning there are no laws requiring their application, but companies may get their products independently tested by CSA to meet certain standards.

3.4.1.6 Conformité Européenne (CE) Marking

CE marking is required for most products marketed in Europe. CE is an abbreviation for the French phrase Conformité Européenne which translates to European Conformity. The CE marking on a product is a manufacturer’s declaration that the product complies with the health, safety and environmental requirements in Europe. It is quite like a combination of the UL and FCC certifications.

3.4.1.7 Restriction of Hazardous Substances (RoHS) Certification

The RoHS certification verifies that a product contains no lead, or other harmful substances such as Cadmium and Mercury. RoHS is necessary for products sold in the European Union and the state of California. Since most products are sold in California and/or Europe, their requirements have become the de-facto standard for environmental regulation.

3.4.1.8 Waste Electrical & Electronic Equipment (WEEE)

WEEE regulation is a directive in the European Union that designates safe and responsible collection, recycling and recovery procedures for all types of electronic waste. Waste of electrical and electronic equipment (WEEE) such as computers, TV-sets, fridges and cell phones is one the fastest growing waste streams in the EU. WEEE is a complex mixture of materials and components that because of their hazardous content, and if not properly managed, can cause major environmental and health problems. It is required that the companies selling electrical and electronic goods in the European Union must conform to the EU legislation for electrical and electronic equipment (EEE).

3.4.1.9 ESD Immunity

Electrostatic Discharge, or ESD, is easily produced in the electronic devices and can damage the device. For example, the triboelectric effect of simply walking on a carpet can produce enough static charge to damage sensitive electronic equipment. While generally not a safety issue, ESD immunity testing is highly recommended. While some ESD induced failures are immediate, others may not manifest for a while. The accepted test protocol for ESD immunity is the IEC 61000-4-2, with at least Level 2 passing. However, it is recommended that the aim should be for Level 3 or higher.

3.4.1.10 ASTM

ASTM International, formerly known as American Society for Testing and Materials, is an international standards organization that develops and publishes voluntary consensus technical standards for a wide range of materials, products, systems, and services. ASTM's electronics standards are instrumental in specifying, evaluating, and testing the performance requirements of the materials and accessories used in the fabrication of electronic components, devices, and equipments. These components include thin films and substrates, membrane switches, surface mount devices, electron tubes and emitters, integrated circuits, microelectronic devices, bonding wires, gas distribution system components, and flat panel displays.

3.4.1.11 OIML

The International Organization of Legal Metrology (French: Organisation Internationale de Métrologie Légale - OIML), is an intergovernmental organization that was created in 1955 to promote the global harmonization of the legal metrology procedures that underpin and facilitate international trade. Such harmonization ensures that certification of measuring devices such as weighing devices, taxi meters, speedometers, agricultural measuring devices, in one country is compatible with certification in another, thereby facilitating trade in the measuring devices and in products that rely on the measuring devices.

3.4.1.12 DKD

DKD, also called Deutscher Kalibrierdienst (German Calibration Service – DKD) has identified a set of standards for the electronics sector which is tested with the help of accredited calibration laboratories. The accredited calibration laboratories are now accredited and monitored by the DAkkS as legal successor of the DKD. They carry out calibrations of measuring devices and measuring standards for the measured values and measuring ranges defined during accreditation.

3.4.1.13 Miscellaneous

Some types of products will require even more certifications. For example, toys have a very comprehensive list of required tests and regulations to ensure they are safe for children. Or, if a product comes into contact with food then one needs to follow FDA guidelines on what materials can be safely used.

Technology Centres can support & facilitate the industry by providing testing & certification facility by getting international accreditations like FCC, UL, RoHS etc. This will ensure that TCs testing facility can perform product validation & certification for the manufacturers, domestic & international brands and exporters. Out of all the certification techniques mentioned, ESD, SAR & RoHS are immediately required for certifying smart phones, feature phones, tablets etc.

3.5 Geographical concentration of ESDM Production

ESDM production in India is concentrated in three major states of UP, Maharashtra & Karnataka. This section tries to highlight the major industrial clusters and manufacturing ecosystem in these three states.

3.5.1 UP ESDM Industry

There are around 196 ESDM units in UP with working capital of Rs 4,109 crore and an invested capital of Rs 6,617 crore. The state is home to various key electronic manufacturing companies like Oppo, Mediatek, LG, Intex, Lava, Vivo, Samsung, Freescale Semiconductor, ST Microelectronics, Dixon, etc. UP state government has played a major role in the development of ESDM industry with initiatives like allotment of Rs 5,000 crore for the sector.

Some of the key ESDM clusters in the state are:

i. **Yamuna Expressway Electronic Manufacturing Cluster:** This cluster is spread on a total area of 100 acres and is in Sector-24 on the Yamuna Expressway. This cluster is expected to provide employment to around one lakh people and boasts around Rs 2,000 Crore in investment. There are eight major companies like Lava which are located in this cluster. Some of the major products produced in this cluster are[121] Mobile Phones & Accessories, TFTs, LEDs, Telecommunication Products

ii. **Electronics Manufacturing Cluster, Ecotech VI & VII, Greater Noida:** Greater Noida within the state of UP has become a major hub for the ESDM sector owing to its proximity to the national capital. The cluster is spread on a total area of 210 acres. The cluster boasts of skilled manpower, good infrastructure, 24*7 utility supply, and connectivity (Road/Rail/Air).The cluster is famous for its support facilities like IT communication center, Testing, and Certification labs, Tool Room support, and a design house.

3.5.2 Maharashtra ESDM Industry

ESDM sector has been one of the key focus of the Maharashtra government. Recently three brownfield Electronic Manufacturing Clusters have been established at Navi Mumbai, Pune, and Aurangabad[122]. Some of the factors that ensure the growth of the ESDM sector in Maharashtra are dedicated policy support by the government, the strategic location of the clusters with port connectivity, a very strong domestic market, good vendor base, and the presence of skilled labor.

Some of the key players in Maharashtra's ESDM sector are Qualcomm, Emerson, Whirlpool, Bosch, LG, Blue Star, Kirloskar, Videocon, Voltas, Bharat Electronics, Schindler, Kenstar, Haier, Godrej, Honeywell, and Philips.

Some of the Key ESDM clusters in the state are:

i. **Mahape Electronics Cluster, Navi Mumbai:** Maharashtra Industrial Development Corporation (MIDC) established an industrial estate at Thane Belapur Road, Navi Mumbai in 1963 which is usually called TTC MIDC Estate. The Estate is basically located along the Thane Belapur towards the Northern side of the road with a total geographical area of 27 sq. km.
In the Industrial Estate there are more than 2200 micro/small/medium and large enterprises (Both registered + Unregistered) of various product categories, relevant to industry engaged in manufacturing and services of chemicals, dye, dye-intermediates, bulk drugs, pharmaceuticals, textile auxiliaries, pesticides, petrochemicals, textile processors, engineering units, electronics units, etc. There are 170-180 units engaged in Electronics production operating in the area of TTC-MIDC Mahape. TTC-MIDC is one of the oldest and most developed industrial areas of Maharashtra Industrial Development Corporation.

[121] Electronics Sector, UP Niveshmitra
[122] Maitri Maharashtra

ii. **Deogiri Electronics Cluster, Aurangabad:** Deogiri electronics cluster has been incorporated as a private unlisted company[123]. The cluster is built on a 2-acre land given by the Maharashtra Industrial Development Corporation (MIDC), Aurangabad. The cluster boasts of providing facilities like[124]:

- Electronics Design and Testing (PCB Design, PCB Prototyping, Product Design)
- Electronics Manufacturing (Pilot batch manufacturing and Rapid prototyping)
- Cabinet Manufacturing (CNC Setup, Power Coating Facility, etc.)
- Training and Innovation(Academia support, Startup support, and sector-specific training)

Some of the industries in this cluster are SS Controls, Manu Electricals, Precision Power Products, Selwel, Kirti, etc.

3.5.3 Karnataka ESDM Industry

Karnataka is one of the most preferred investment destinations for ESDM and is amongst the top five states contributing to India's electronic industry. It yields more than 10% of the country's electronic industrial output and has more than 85 chip designing houses[125]. The CAGR of electronics export has increased by 8.66% (Billion dollars)[126]. Karnataka alone accounts for ESDM revenues of $ 2.8 billion[127].

The state is a perfect destination for the ESDM industry as it has the presence of a large number of high-end R&D organizations, access to several venture capitalists funding ESDM ventures, and availability of low cost skilled/technical manpower. Karnataka has drafted its second ESDM policy for the year 2017-2022. The policy has numerous benefits for the sector like incentives for international marketing, R&D grant, capital subsidy, concession on power tariff, interest subsidy, etc. Cisco, Intel, Nokia, Croma, Siemens, Qualcomm, JVS Electronics, Hitachi, Panasonic, etc. are some of the major players in Karnataka.

One of the most important clusters in the state is:

ELCIA ESDM Cluster, Electronics City, Bengaluru: The Electronic City Industrial Association ESDM cluster has been established under the EMC scheme of the GOI. Seven major electronic manufacturing companies have come together to form a CFC[128]. This CFC is in the heart of Electronics city and provides many important facilities like Innovation and design center, rapid prototyping, PCB manufacturing, testing & measurement, etc.

IESA Electronics Manufacturing Cluster, Mysore: The Brownfield Clusters in Karnataka were established under the EMC Scheme of GOI for setting up of State-of-the-art testing facilities required by Original Equipment Manufacturers (OEMs) and Electronics Manufacturing Services (EMS) companies.

3.6 Existing Government Initiatives in the ESDM Sector

Indian Government has taken a number of initiatives to boost the ESDM manufacturing in the country. These initiatives have focused across the ESDM sub-segments. Some of these initiatives are:

3.6.1 Electronics Manufacturing Cluster (EMCs)

EMCs aim to attract investments for the ESDM sector by building a world-class infrastructure. The idea is to assist Greenfield and Brownfield projects financially in the tune of 50% and 75% of the project cost respectively.[129] Following clusters have been chosen to be developed under the EMC scheme:

- ELCINA Electronics Manufacturing Cluster, Bhiwadi, Rajasthan
- Adityapur Industrial Area Development Authority, Jharkhand
- West Bengal Electronics Industry Development Corporation
- Odisha Industrial Development Corporation
- Chhattisgarh State Industrial Development Corporation

[123] ,Deogiri Electronics Cluster Private Limited, Economic Times, 20 May 2020
[124] CMIA initiates work for Deogiri Electronics Cluster in Aurangabad, lays foundation stone, Knn India
[125] Karnataka to develop 1,000 acre chip design cluster across four districts, Times of India
[126] Annexure 5, In Principle_CFC_Aurungabad, MeITY
[127]Electronics and Electrical, KIADB
[128] ELCIA ESDM Cluster, ELCIA
[129] EMC Gazette, MeiTY, 2012

- Siri City, Andhra Pradesh
- ELCINA Raaga Mayuri Electronics Park, Andhra Pradesh
- Kerala Industrial Infrastructure Development
- Department of Information Technology, Goa
- Madhya Pradesh State Electronics Development
- Mundra Solar Techno Park, Gujrat
- Mysore ESDM Cluster
- Info valley Electronics Manufacturing Cluster, Bhubaneswar
- Deogiri Electronic Cluster Private Limited, Aurangabad

The Modified Electronics Manufacturing Cluster Scheme 2.0 has been set up to assist industries with improved infrastructure and to cultivate an ecosystem for the manufacturing of electronics. The scheme is focused on market linkages to attract major players, domestic and international, for supply chain of amenities like Ready Built Factory/ Plug and Play Facilities.

The scheme has a total amount of INR 3,762.25 crores proposed out of which INR 3,725 crore is sorted out for financial assistance of common facility centers and infrastructure and INR 37.25 core towards administrative and management expenditure.

3.6.2 Make in India

The Make in India campaign was launched to uplift the design and manufacturing services available in India and to establish the country as a manufacturing hub. The initiative focuses on bringing out the domestic potential to communities abroad and build an agenda across 25 sectors to reach out across platforms for better opportunities. The campaign rests on the promotion of innovation which has contributed towards the growth of the ESDM sector via improvement in “Ease of Doing Business” rankings and adoption of emerging technology on a domestic level.

3.6.3 Modified Special Incentive Package Scheme (M-SIPS)

The Modified Special Incentive Package Scheme (M-SIPS) aims to provide subsidy to SEZ (20%) and non-SEZ (25%) units in the ESDM sector and to promote investment and manufacturing in India. The scheme is spread across 29 verticals and has investment thresholds (variable between INR 1 crore to INR 5000 crore) under every category to be eligible in order to gain incentives. With the electronics sector as a target group, the scheme incentivizes the value chain inclusive of procurement, manufacturing, assembly, testing, and packaging in order to reduce import dependency.

3.6.4 National Policy on Electronics, 2019

The National Policy on Electronics 2019 replaces the National Policy on Electronics 2012 and focuses on a productive global ecosystem for the ESDM sector to extend its competitive grounds in manufacturing and export. The scheme offers various incentives for the production of core components, for high-tech projects like those based on semiconductor services, for capacity and skill-building of existing human resource. The scheme also involves the promotion of R&D in all sub-sectors to encourage start-ups and emerging technology in the industry. This strategy is set to aid value addition to domestic hardware manufacturing.

3.6.5 Electronics Development Fund

The Electronics Development Fund is under the “Digital India” campaign to achieve “Net Zero Imports” to become a manufacturing hub for domestic demands and exports. The EDF is set up to cater to companies in the electronics sector for risk capital. This allows companies to indulge in Research and Development in specific areas and exercise building the country’s intellectual property capacity. A subsidiary of Canara bank, CANBANK Venture Capital Funds Ltd. is the fund manager for EDF.

3.6.6 Scheme for financial assistance to select states/Union Territories for skill development in ESDM sector

The scheme targets students from 9th-10th grade for their education and provides access to higher certification courses like diploma, non-technical graduation, etc. to increase employability rates in the country. The scheme provides 75% fee assistance for courses chosen by the Electronics Sector Skill Council, Telecom Sector Skills, and NIELIT. It also pays attention to the economically weaker sections and SC/ST segment with a reservation (40%) and a reimbursement (100%). An Empowered Committee selected the states of Andhra Pradesh (including Telangana), Jammu and Kashmir, Karnataka, Kerala, Punjab, Uttarakhand, and Uttar Pradesh to take under the scheme.

3.6.7 Scheme for skill development in ESDM for Digital India

The scheme also falls under the “Digital India” agenda and aims to facilitate 3,28,000 persons in the ESDM sector for skill enhancement. The goal is to reach the target number in four years with an outlay of INR 411 crore. It falls under the scheme for Financial Assistance to select States/UTs for skill development in the ESDM sector and is being implemented in all 8 states.

3.6.8 Building Awareness on Intellectual Property Right Scheme

The aim is to create awareness about intellectual property among MSMEs and the appropriate measure to protect it. More than 60 IP Facilitation Centers are set up throughout the country to assign an IP lawyer to assist MSMEs to apply and register for Trademarks and Patents. The scheme takes multiple activities under that are to be promoted through a PPP model. Some of those initiatives are setting up IP Facilitation Center for MSMEs, Grant assistance on patent/registration, workshops/seminars, and programs.

3.6.9 Production Linked Incentive Scheme (PLI) for Large Scale Electronics Manufacturing

The scheme offers a production linked incentive to boost domestic manufacturing and attract large investments in mobile phone manufacturing and specified electronic components, including Assembly, Testing, Marking and Packaging (ATMP) units. The scheme extends an incentive of 4% to 6% on incremental sales (over base year) of goods manufactured in India and covered under target segments, to eligible companies, for a period of five (5) years subsequent to the base year as defined.

4. Challenges faced by ESDM Sector in India

ESDM manufacturing in India is marked by myriad challenges owing to various factors which have been elaborately discussed in this section. These challenges try to connect the Indian shortcomings with the successful case studies which have been discussed in the initial sections of the White Paper. Some of the challenges discussed in this section are huge imports, policy reforms, high manufacturing cost, lack of collaboration between Indian industry and academia, lack of skilled manpower, etc.

4.1 Huge Imports

India in its National policy on Electronics had set a vision of net zero imports by 2020 which till date remains a distant dream. The expected gap between the demand and supply of ESDM products for the FY 2020 is expected to be 294 billion dollars. In percentage terms the gap between imports and exports is expected to stand at a mammoth 75% as can be seen from the figure 22.

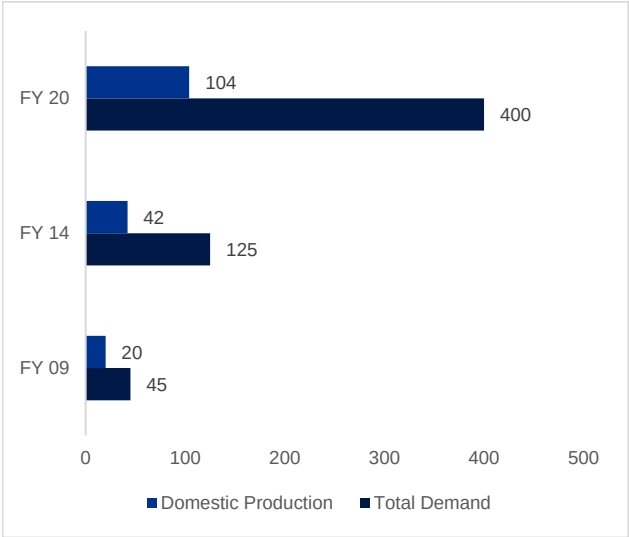

Figure 21:Demand Supply Gap in ESDM Sector (USD Billion)

4.2 Low Share of emerging sectors in Indian export pool

Medical electronics and Strategic electronics as discussed is the above sections are the emerging domains within the ESDM sector. However, India's export share in these domains stand at a dismal 4% and 7% respectively[130].

4.3 High Manufacturing Cost

India is on it's to become a manufacturing hub for the ESDM sector but is competing with countries like China and Taiwan that can accommodate lower manufacturing costs. The factors influencing this gap in manufacturing costs are:

- Pricing: The purchase in India is much more competitive than other countries. Even though India provides a significantly lower labor cost, the additional costs of transport, water and electricity contribute to increasing costs. Since power supply is not 24/7 in India, there is decrease in productivity whereas wasted capacity contributes to the cost.
- Logistics: The transportation time in India is higher as compared to its competitors. The disruption in road transportation and unpaved pathways not only causes delay but also make the goods susceptible to damage. As an alternative, when the packages are shipped it adds to the costs incurred.
- Product Expertise: India is not at par with its ability to scale production. Clusters in countries like China are within a close geographical range to increase flexibility and improve reaction time, which is not the case in India.
- Anti-Large Enterprises: The culture in India of small-scale production hinders with its growth globally as a mass producer. This practice has impacted the industry's image with larger firms and companies which demand a machine instead of manpower and large-scale operations.

4.4 Skilled Man force

A National Skill Development Corporation (NSDC) survey highlights the need for 8.9 million skilled workers in the electronics sector by 2022. The game of global manufacturing has changed, and it has moved away

[130] Electronics B2B

from low labor cost advantage to high labor productivity advantage. Indian workforce lacks the desired skills required to be Industry ready and it is a huge challenge for the already struggling Indian ESDM sector.

4.5 Lack of collaboration between the Academia & MSMEs

A serious human resource problem is posed by the lack of collaboration between the industry and academia. The demand of the hiring companies is not met by the curriculum of the technical institutions. Most of the students studying Electronics & Communication in premier educational institutions who are expected to pursue job roles in ESDM sector end up joining the IT sector in college placements. A further lack of coherence amongst the academic institutions, research institutions and MSMEs doesn't yield innovation and hinders the growth of a creative ecosystem.

4.6 Research and Development

Research and development support is essential for growth in innovation and it can add immense value to the sector. The core segments of the ESDM sector like semiconductors and AI based devices need an ecosystem that promotes technology transfer and commercialization of the shared technology. Today, India's focus on research and development (R&D) is very limited and is spending on R&D as a % of the GDP is a meagre 0.65%[131]. According to the Economic Times, India had not increased any investment in research and development for two decades and stayed stagnant at 0.6-0.7% of the GDP till 2018. This has caused a rift big enough for India to feature 26 Indian companies in the Forbes 2017 list of '25,00 Global R&D Spenders' whereas China features 301 of those companies in various sectors[132].

The article also highlights that about 3/5th of the central investments for research and development are made towards agencies like Space, Earth Sciences, Atomic Energy, Science and Technology and Biotechnology. These key government science funding agencies do not leave much flexibility of resources for other sectors like the ESDM sector itself.

As shown in figure 23, India utilizes the least of its monetary resources for research and development as compared to China, Germany, Japan, Korea, USA and Vietnam. This is another contributing factor in the progression gap between India and the global competitive market.

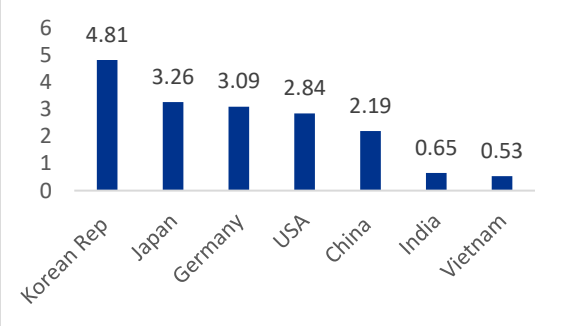

Figure 22:Comparative statistic for expenditure of Research and Development (% of GDP) 2018, Source: World Bank

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4.7 Huge Investment Requirement

As per TSMC, Taiwan one of the leaders in semiconductor fabrication, the cost of setting up a fabrication plant from scratch is expected to be around US $ 4-5 billion. Finance and investment remain a massive challenge for setting up a fabrication ecosystem in the country. A Bangalore based startup called Mymo

[131] World Bank Report
[132] India's R&D spend stagnant for 20 years at 0.7% of GDP, Economic Times, 2018

Wireless gained chip making expertise and focused primarily on IP and licensing of technology for clients. The start-up however could not stay afloat because of the high cost required to sustain the segment; Even a 30% profit could not suffice. Failure to raise an investment of $20 million led the company to be acquired by one of Qualcomm's competitors.

4.8 Dump yard of Refurbished goods

With a rapidly expanding digital economy, the demand for refurbished goods has increased immensely in India. India has allowed the import of second-hand devices subject to the approval of Bureau of Indian Standards (BIS) and Directorate general of foreign trade (DGFT). Experts believe that with the boom of gray markets in metro cities like Delhi, Chennai, Mumbai and Bengaluru, India is at the risk of becoming the dump yard of refurbished electronic goods of the World. This has the potential of damaging the manufacturing ecosystem of the country.

4.9 Taxation

The GST on electronic manufacturing equipment is very high, Intune of 18-28% for computer hardware, consumer electronics, strategic electronics, industrial electronics, electronic components etc. This taxation policy has different impact for different sectors for e.g. consumer electronics apart from smartphones have become expensive by 3% and laptops have become expensive by 15%[133]. The taxation on electronic manufacturing can be relooked by the GST Council to boost domestic demand.

4.10 Tough Competition in wake of changing technological landscape

Indian startups have to compete against global giants like HP, Intel etc. Not only these startups must achieve their revenue goals or growth targets, but they must innovate and adapt to changing consumer needs. With new technologies unfolding themselves on every front, even a minor advance is being termed as a breakthrough. However, to incorporate this minor technological advance into a product, it requires immense spending in terms of IP and changes in manufacturing lines.

A Mckinsey report highlights that all these technologies might not alter the business or consumer needs landscape but some of them have the potential to alter the status quo. These technologies have been termed as *"Disruptive Dozen"*. Internet of Things (IoT), Cloud Computing, Advanced Automation, Robotics, 3-D Printing etc. are some of these technological advancements.

Some of the Manufacturing Operations Management (MOM) challenges faced by companies in the electronics industry are:

- Shrinking Operating Margins
- Complex Global Supply-Chain
- Service and Warranty Management
- Short Product Lifecycles
- Uncertain Demand
- Sustainability

While it is very convenient for the existing manufacturing clusters of the World to adapt these disruptive dozens, it becomes a huge challenge for the Indian startups/ firms to adapt to these changes.

4.11 High Dependence on Original Equipment Manufacturers (OEMs)

Indian Electronic Manufacturing Service (EMS) providers have a lot of dependence upon the OEMs for outsourcing of product design and product planning, manufacturing integration with the design provided for mass production, for technological Support, and for research and development.

4.12 Lack of manufacturing facility for high end electronics in India

Though India has high-end design capabilities in ESDM, the lack of manufacturing facility for high end electronics in India is leading private entities to rely upon offshore production facilities like China & Taiwan.

[133] Electricals and Electronics Manufacturing In India, NEC-ASSOCHAM Analysis

In the electronics sector, just like other countries, India is also heavily dependent on China and Taiwan which meets 40% of the total import of electronic goods

For example, companies like Dell and HP rely on a handful Taiwanese original design manufacturers to assemble their ESDM components. These assemblers in turn, depend on multiple subsystem manufacturers, or raw material suppliers having factories in Malaysia, China or Taiwan. Similarly, the microprocessor chips made by Intel are packaged in China and AMD has them made in Taiwan. In the same fashion the leading private entities of India also sources their electronics from China to such an extent that 32 percent of the total imports from China in India includes electronic goods. More than 90 per cent of the electronic goods imports from China are of integrated circuits, and television sets. As per India Cellular and Electronics Association (ICEA), India has enormous opportunity in building an additional export base, and not just a producer for the domestic market. For example, India built its mobile phone industry primarily for the domestic market by increasing production during 2014-15 with mobile handsets worth Rs 18,900 crore, which increased to Rs 54,000 crore in 2015-16, to Rs 90,000 crore in 2016-17, and over Rs 2,10,000 crore in 2019-20. Though China still dominates and makes up for around 70% of the global phone exports, India has got 15% of this pie and needs to further boost the same.

If this COVID crisis is seen as an opportunity, there is a need to introduce structural reforms like significant labor and land reforms, allowing businesses to hire and fire, handholding investors, direct tax benefit in SEZs and plug-and-play facilities.

4.13 Performance and quality assurance as per Global standards

The Ministry of Electronics & Information Technology (MeITY) has notified "Electronics and Information Technology Goods (Requirement for Compulsory Registration) Order, 2012 The Order is progressively being applied to increasing product categories of Electronic Goods. As per the Order, no person shall manufacture or store for sale, import, sell or distribute goods which do not conform to the Indian Standard specified in the Order. Manufacturers of these products are required to apply for registration from Bureau of Indian Standards (BIS) after getting their product tested from BIS recognized labs. Bureau of Indian Standards (BIS) then registers the manufacturers under its registration scheme who are permitted to declare that their articles conform to the Indian Standard (s). The registered manufacturers are then allowed to use the Standard Mark notified by the Bureau.

There are multitude of certification required to meet the global market's standards which certifications will be need depends on product specifics and the countries where you will market and sell it. The list of certifications necessary in the United States, Canada, and the EU are detailed out in the separate section on Testing and Calibration. The compliance of global performance and quality standards by Indian manufactures is less than satisfactory. Due to a requirement of multiple certifications, the compliance of global performance and quality standards has been a key challenge for the Indian manufacturers.

From chips in computers and smartphones to the semiconductors and circuits that Aerospace, Defense, and Automotive makers rely on, the products and components that Electronics companies manufacture and assemble are at the center of the exciting, fast-moving, and increasingly complex technologies that touch every aspect of modern life. In this fast-paced and dynamic market space, Electronics manufacturers are challenged by:

- Increasing global competition
- A need to produce the highest quality products
- A continual need to drive down costs
- Supplies sourced from across globe

As a result of these challenges, Electronics suppliers and manufacturers must comply with industry and customer standards for quality, consistency, and security by product testing & Certification by the Accredited Testing Facility.

TCs can get their Testing facility accredited for testing of such products for manufacturers and sellers.

4.14 E-Waste

The quantum of e-waste in India is growing rapidly at a CAGR of 30% and is estimated to reach a waste stream of 48.5 MT[134]. According to a UN Report presented in World Economic Forum, approximately 95% of e-waste in India is recycled informally and an estimate of 0.036 MT of the e-waste if treated as per guidelines. The report also highlights that due to poor extraction techniques, only 30% of extraction is successful for metals like cobalt which are in huge demand for laptops, handsets and car batteries.

As shown in the figure below, the growth of e-waste generated every year is exponential due to rapid changes in technology, falling prices etc. It is being estimated that around 50 million tons of e-waste is produced every year. As per Environmental Protection Agency (EPA) only 15% to 20%[135] of e-waste is being recycled every year and rest of the waste is dumped directly to landfills and incinerators.

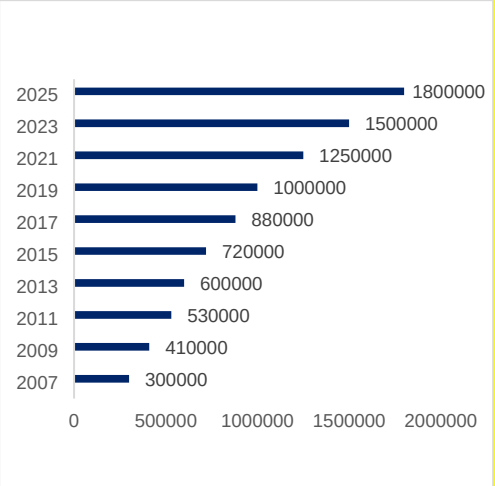

Figure 23:Growth of E-Waste (MT) in India

India alone produces around 1 million tons of e-waste annually and it could rise by as much as 500% over the next decade as reported by United Nations Environment Programme (UNEP) in their report “Recycling – From E-Waste to Resources”.

4.15 Local Value Addition

The local value addition in ESDM manufacturing in India is abysmally low at the moment. The reason behind this can be attributed to the ESDM components – being generally sustainable on large volume production due to relatively low unit cost. These production capacities imply large initial investments and MSMEs do not have the required financial muscle to go in for them. The ESDM manufacturing sector faces this dichotomy. Unless large quantities are produced the unit, cost is not competitive. Alternately, If MSMEs resort to import of basic components freight, inventory costs make them equally uncompetitive.

A possible way to come out of this egg and chick situation leading to low value addition can be overcome by starting a few anchor ESDM manufacturing units in the existing clusters based on a CFM model.

[134] ASSOCHAM
[135] Statistics on the Management of Used and End-of-Life Electronics US Environmental Protection Agency, 2012.

5. Emerging Technologies

The emerging technology in the ESDM sector maps across all segments, however, its relevance is variable. Figure 25 depicts the degree up to which an emerging trend can impact the sector and can help in realigning resources and strategies for more efficient and productive operations in the electronics systems design and manufacturing sector.

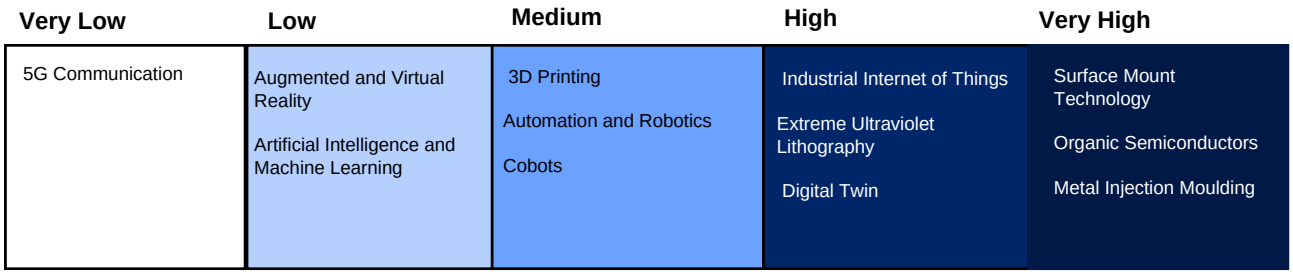

Figure 24: Emerging Technology and degree of relevance for ESDM Sector

5.1 General Technologies

The world is witnessing a huge change. Technology is changing the way humans think and manufacture. From Industrial revolution in the 1800s to the Industry 4.0, the human civilization has achieved a lot on the technological front. There are some overarching general technologies that have advantages across the manufacturing sector. Some of these technologies are IoT, AR/VR. 3D printing etc. These technologies and their advantages in the ESDM sector have been elaboratively discussed in this section.

5.1.1 Internet of Things (IoT)

Internet of Things technology is the interconnectivity of physical objects and devices that are integrated with sensors and software that allow them to exchange and collect data. Currently, more than 100 Centres of Excellence focusing on Blockchain, IoT and Analytics[136] are present in India and the IoT Market in India is poised to reach USD 9 billion by 2020[137].

Presently IoT is implemented in a partial form such as in Logistic industry, Smart Cities, Smart Homes, etc. IoT plays a very significant role in shaping the consumer electronics market. Household appliance manufacturers are integrating their products with IoT technology to make customers lives more convenient. In the consumer durable industries, some of the appliances like an air conditioner, refrigerator, etc. are already equipped with IoT technologies in the Indian market.

IoT and predictive analytics are having a major impact on electronics manufacturing, offering new opportunities for connecting operations and transforming business processes. Improving customer experience, enhancing employee productivity, and finally generating more revenue for the organization are few of the benefits of using IoT.

Few of the companies that are active in IoT space in India are Intel, Volkswagen, Hero MotoCorp, Hindustan Petroleum, Bharati Infratel, Cisco, and IBM. Major regions where IoT has taken off in India are Bangalore, Mumbai, Pune, and Hyderabad. Here lots of startups have ventured into IoT domain and one of the pioneering communities in IoT space is IoTBlr, based out of Bangalore which has been instrumental in driving the IoT ecosystem in India.

Required Skills

[136] Ministry of Electronics & Information Technology, Annual Report 2017-18
[137] Invest India, Electronics Sector

- Hardware Interfacing
- Networking
- Application design & development
- UI/UX design
- Information Security
- Business intelligence and data analytics
- Machine learning and artificial intelligence (AI)

Successful Application of Industry 4.0: Limtronik

Limtronik is a Germany based company specialized in Electronic Manufacturing Services (EMS). It produces electronic components and customized systems ranging from complex circuit boards and components, over large switch cabinets to system assembly. Limtronik markets its products to customers in telecommunications, security technology, medical technology, and industry control technology throughout Germany and abroad. It employs around 160 people in Smart Electronic Factory in Limburg and around 25 people in the subsidiary company in the USA.

Limtronik has taken advantage of IoT technologies in order to optimize and detect specific problems in manufacturing processes in order to avoid reductions in quality of the products and production downtime due to process deviations, problems with parts, or signs that maintenance is needed. For this purpose, a unique industry 4.0 evaluation environment was created at the factory in Limburg with the support of iTAC Software AG1. The goal is to 'teach' device to learn from their mistakes and generate intelligent algorithms. Namely, this system helps smart devices not only detect and report problems but also test and fix any issue early in the production process before the device can be used in the real environment. The main benefit of the company is seen in a considerable increase in output cost reductions.

The wider application of Industry 4.0 is predicted to support the implementation of IoT sensors in manufacturing process to increase efficiency, performance and productivity. The manufacturers are using smart mini sensors to gather important information regarding manufacturing process and supply chain. Major manufacturers are focusing on implementing advanced technologies, such as cloud computing along with industrial sensors, driving the market size. The rising trend to implement advanced technologies in businesses such as cloud computing is creating growth opportunities for the industrial sensors market. By integrating wireless sensors with cloud computing, enterprises can certainly manage large amounts of sensor data and increase the efficiency of the connected systems. In November 2018, Texas Instruments launched a new single chip mm Wave industrial sensor, which can support various industrial applications. The sensors can enhance industrial automation through on-chip processing capabilities, offering real-time decision-making and signal processing. In March 2019, STMicroelectronics announced the development of a new water-resistant MEMS pressure sensor to deliver high stability, accuracy and chemical compatibility for various applications including industrial sensing[138].

Industrial Internet of Things (IIoT) is used immensely by MSMEs as a system of devices and things that are implanted with sensors, software, and electronics to initiate the exchange and collection of data and information. MSMEs can attach sensors to machines and other physical assets on the production floor to collate data that influences decisions in real-time leading to increased efficiency as well as productivity. The interconnectedness of different devices allows for better user experience and help in effective decision making. The opportunities offered by IIoT . To avail any of these opportunities, the most crucial aspect is the data, therefore, an effective approach to data acquisition and centralization is required. Organizations require reliable data to make informed decisions at every step of the process.

IIoT frameworks present numerous advantages to both consumers and industries. Inherent to any advanced computer framework is the unfailing nature of codes and commands, which can help avoid the commonly accepted issues and human errors. Subsequently, the unwavering quality of numerous basic

[138] GM Insights

frameworks can be enormously expanded. In combining numerous self-governing frameworks, IIoT frameworks can convey and decipher information at a level incomprehensible by human knowledge. With

Case Study on application of IOT by an SME

Lido Stone Works, a small, family-run, upstate New York manufacturer of high-end architectural stone products (e.g., stone fireplaces, fountains, floors, etc.).

Challenge: Lack of access to worldwide clients for its premium stone products, it was needed to accelerate and streamline design and production of products. It was seeking to realize a more automated production environment.

Solution: It leveraged IoT to craft an intelligent manufacturing system that directly links Lido, engineers at companies like Italy-based Breton that manufacture the stone-cutting machines Lido uses and Lido's clients' architects into a seamless, IoT-enabled cloud platform. By IoT-enabling its stone-cutting machines, thus generating a real-time stream of information as the stone is actually being cut, both the client and Breton technicians (located thousands of miles away in Italy) can monitor the job's progress in real-time, detecting, and even fixing, problems as they may unfold.

Outcome: Lido estimated that its IoT-based solution

- Increased its productivity by 30 percent (largely by reducing downtime),
- Boosted revenues by 70 percent,
- Saved a half-million dollars in travel costs annually,
- Helped it grow its workforce by 67 percent.

bits of knowledge picked up from a bigger "huge information" pool, perpetual new conceivable outcomes in productivity, scale, and execution are currently conceivable.

5.1.2 3D printing

3D printing, or additive manufacturing, can help electronics manufacturers perform faster and less expensive manufacturing, as the industry puts efforts to deal with shortening product life cycles. For example, it enables rapid prototyping as a way of fast fabricating, scaling, and testing products. One of the shortcomings of traditional manufacturing is difficulty in responding to rapid changes in customer demand. 3D printing, thus, helps in the process of developing and providing products on demand, without being manufactured and stored. There is also a business risk involved, especially for OEMs that have extended supply chains including assembling operations in East and South Asia, due to factors such as changes in the global geopolitical situation, rising labor costs, long lead times, quality control, etc. Additive manufacturing holds the potential to disrupt much of the electronics supply chain, from product design/prototyping to materials/ supplier sourcing, manufacturing, inventory, distribution, and aftermarket service.[Error! Bookmark not defined.] Moreover, additive manufacturing should not be perceived as completely replacing traditional manufacturing; instead, it can be deployed to help primary production operations by minimizing risks and delivering products on demand on time.

3D Printing and PCB Manufacturing: PHYTEC

Printed circuit boards (PCBs) are essential parts of almost all electronic devices. Designing and developing PCB prototypes and product manufacturing is a time-consuming multi-level process and it often involves outsourcing design for prototype creation. PHYTEC is an industry-leading provider and integrator of System on Modules and embedded middleware that enables customers to bring complex products quickly and easily to market. This company has been employing 3D printing to manufacture a complete multilayer PCB. It enabled them to provide on-demand products with fixed lead time, reducing the time for market reach.

Optical Printed Circuit Boards

Electro-optical printed circuit boards combine optical and copper paths on the same board. While the copper paths distribute power and low-speed data, the optical paths handle the high-speed signals. This segregation has several advantages. At high frequencies, signal integrity suffers due to skin effect, crosstalk, and skew when passing through copper systems. Optical systems do not have those issues, while also presenting greater channel density than copper does. Moreover, as optical signals do not need signal conditioning and equalization, optical systems consume lower power than do electrical signals. Additionally, optical systems can reduce the surface area of a PCB by 20% and the number of layers on the board by 50%.

5.1.3 Augmented and Virtual Reality

Assistive technologies, such as augmented reality (AR) and virtual reality (VR), continue to create mutually beneficial partnerships between man and machine that positively impact manufacturers. It is being adopted by global manufacturing companies to improve efficiency. Due to VR software interfacing seamlessly with computer-aided designs, developers can use VR to quickly make modifications and additions to products during the product design stage before they go into modeling and manufacturing processes.

AR and VR can also decrease inspection time and assist in detecting errors in addition to improving workers' sightline, which enables them to complete tasks faster. For example, by using AR devices such as electronic glasses, computer-generated graphics can be placed in a worker's field of vision that enables him to learn the task more effectively.

The VR can be used in requirement analysis (RA) in CIM system development, suitable for SMEs. The methodology can reduce the costs and the time involved at this stage by producing precise and accurate plans, specification requirements, and a design for CIM information systems. These are essentials for small and medium scale manufacturing enterprises.

Virtual Reality is computer-based and has better visualization effects for representing manufacturing systems than any other graphical user interface, and this helps users to collect information and decision needs quickly and correctly. A VR-RA tool is designed and developed as a software system to realize the features outlined in each phase of the methodology. A set of rules and a knowledge base is appended to the methodology to remove any inconsistency that could arise between the material and the information flows during the requirement analysis

AR technology can also be used with cameras and sensors for training in the ESDM sector. Workers can be shown how to perform a task beforehand by using the data feed, which makes it possible to quickly and effectively train unskilled workers for high-value work. This technique will be highly useful for the MSME sector in up-skilling and cross-skilling the current workforce. The required skills in the area are:

Required Skills

- Knowledge of web-based content
- 3D modelling
- Marker detection
- Low-level programming
- Video/sound production

- Graphic design

Case Study on application of Augmented Reality/ Virtual Reality in the energy industry

The augmented reality and virtual reality is changing the way we observe in the real world to learn and respond about it. It is enhancing capacities of available human senses and thus Lloyd's Register a technical and business services Organisation, leveraged the technology for enhancement of safety related to use of energy equipment

Challenge: The industry has cut its Investment, so it became critical that Lloyd's Register's training services maintained its market share and 1. Enhance the knowledge gained in the training classroom, creating a memorable, stimulating experience. 2. Use technology to replicate real-life situations in order to test and improve learning outcomes beyond any competitors. 3. Make it possible to train beyond the high-tech classroom facility in Houston and so create an international offering.

Solution: To address these, the team created a virtual reality safety simulator. Three catastrophic industry events were created in VR and gamified. In each scenario, lives are at risk if people don't take the right action. 'Players' put on a headset, see the incidents and then have the chance to fix them and learn more. The headset, a laptop and an iPad are the only items needed making the learning experience far more portable than the real safety equipment used in the classroom.

Outcomes: Since the launch, Lloyd's Register has seen an uplift in training bookings and has already achieved 3x ROI. The company is now taking its training offering even further, creating AR experiences so that whole teams can work together to solve scenarios.

5.1.4 Artificial Intelligence & Machine Learning

Machine learning is an application that enables the system to automatically / semi-automatically learn and improve from experience without being explicitly programmed. Products like Alexa and Siri are the best examples of this technology.

Many companies are implementing these technologies to increase their revenue. One can see its applications across multiple sectors like automotive (autonomous vehicles), finance (fraud detection), healthcare (diagnosis, drug discovery), etc.

With the growth in these sectors and an increase in applications of AI and machine learning, the ESDM sector will play a key role in the development of related products and services. It gives an unprecedented opportunity to semiconductor design companies to create innovative products and solutions for the local as well as global markets.

Required Skills

- Programming languages
- Data modelling and evaluation
- Algorithms
- Distributed computing

- Advanced signal processing techniques

US Military and Raytheon

Raytheon has partnered with the US military in developing an AI-based tool for predictive maintenance. This tool can comprehensively tell whether a multi-mode radar needs maintenance or whether the radar is fully functional. The AI tool has completely removed the need for a technician and any human analysis in the prediction of flaws in such a strategically important tool.

5.1.5 Robotics / Automation

Automation entails the use of technology and control systems to replace human mental and physical labor in the engineering and manufacturing sector. Tasks executed by people are replaced by automated systems and products that combine hydraulics, mechanics, electronic and electrical components. It is used in numerous sectors, the most prominent being in manufacturing.

Industrial automation covers everything from digital manufacturing to simple control systems of machines and processes, Industry 4.0 to the smart factory. Automating the end of production line not only offers cost benefits but also resolves health and safety issues since workers no longer need to lift heavy and potentially dangerous parts. Likewise, wrapping, labeling, packing, and palletizing, all involve vigorous and repetitive manual work that can be easily done more effectively by automated systems.

Figure 25: Automation in Electronics Manufacturing

The main benefits of automation are:

- Increased efficiency and productivity
- Increased accuracy/reliability
- Improved work quality
- More customization opportunities - The demand for customized and personalized electronic products to cater to special preferences and market needs is on the rise. And such needs are catered by using configurable robots and sensors on assembly lines.

5.1.6 Surface Mount Technology (SMT)

Surface-mount technology (SMT) is a mechanism to install electronic components directly on PCB. Active and passive components of SMT are called a surface-mount device (SMD).

This technology is widely used globally in terms of all electronics PCB assembly manufacturing. However, the Indian electronics manufacturing companies have not yet fully developed and adopted SMT in order to cater to the domestic needs and global demands. Electronic devices such as mobile phones, computers, laptops, LAN devices, etc. require high-end SMT lines. The current eco-system in India doesn't permit to do PCB assembling locally. Hence, the majority of these PCB assemblies are imported.

If we see the imports data in India for the ESDM sector, the majority is from Mobile / IT / Computer / Telecom equipment. Thus, their lies a bigger opportunity in the ESDM sector for MSME's to adopt SMT for all such types of Electronic PCB Assemblies.

Required Skills

- Screen printing
- Component placement

- Soldering
- Programming
- Re-flow soldering
- Electronics & PCB

5.1.7 5G Communication

5G is the latest cellular technology that will provide seamless coverage, high data rate, and highly reliable communications. The wireless industry will go through a tremendous shift with the introduction of 5G. It will open a new era for electronic test-and-measurement (ETM) manufacturers. 5G will provide an impetus to the growth of mobile handsets, support extensive connectivity between devices, and improve security. It will play an enabling role in utilizing the full potential of IoT, internet, and other emerging technologies.

5G mobile services are expected to create an over $27 billion business opportunity for India by 2026, as per a study by Ericsson which has also installed the first public access 5G testbed at IIT Delhi in July 2018 for developing applications in the broadband and low latency areas. It has provided access to the industry and institutions to work on India specific usage scenarios and applications.

We need to encourage innovations by joint ventures and collaborations in R&D with other countries to tap the full potential of 5G. It will help us in moving upwards in the manufacturing value chain, especially with IoT based industries.

Required Skills

- LTE advanced
- Mobile edge computing
- SDN/NFV and API driven architecture
- Networking
- Automation & orchestration
- Network security

5.1.8 Extreme Ultraviolet Lithography

Semiconductor chips are integrated within almost all kinds of electronic devices. By integrating a greater number of components inside a chip, the result is faster and more energy-efficient chip. Extreme ultraviolet lithography, (EUVL) or (EUV), is the next generation lithography technology that uses a range of extreme ultraviolet (EUV) wavelengths, roughly spanning a 2% FWHM bandwidth about 13.5 nm. It is expected that this technology will significantly advance photolithography, which is one of the crucial steps in semiconductor manufacturing. With EUV technology, the photolithography step is performed by utilizing a light source with an extreme ultraviolet wavelength, thus enabling finer patterns compared to previous methods[139].

[139] A look at the core technologies behind next generation chips, Global, Samsung

Samsung: One of the largest manufacturers in the world

On February 20, 2020, Samsung Electronics' new semiconductor fabrication line in DRAM (dynamic random access memory) chip plant in Hwaseong, Korea, started mass production. It is Samsung's first semiconductor production line utilizing the EUV lithography technology, manufacturing chips using process node of 7 nanometer (nm) and below. The V1 line is assumed to have the major role in responding to increasing global demand for single-digit node foundry technologies. According to the company's plans, the cumulative total investment in the V1 line will reach USD 6 billion by the end of 2020. Samsung is the first to deploy the new technology for producing memory chips, while its rivals Intel and Taiwan Semiconductor Manufacturing Co. have already been using it in processors manufacturing.

5.1.9 Organic Semiconductors

The demand for organic semiconductors has rapidly grown in recent years. The organic semiconductors can be fabricated using lightweight materials, with low temperature techniques, in thin films and allow for much space in chip design for various products and even customization to meet the client requirements. Moreover, organic materials allow for easy shaping and tuning of materials properties compared to inorganic material - it is possible to modify organic semiconductors in ways that it is not possible with silicon and other materials. Organic semiconductors provide considerable advantages in developing next-generation electronic devices, systems and applications, such as smartphones, TV sets, sensors, IoTs, etc. The advantages of their usage are reflected in reduction of production cost and increase in production volume, chemical versatility, compatibility with biological systems. The discovery of organic semiconductors has opened up new opportunities for low cost, bendable and green electronics. Today, the most developed semiconductor-based devices are Organic Light-Emitting Diodes (OLEDs). They are promising as a new technology for manufacturing of emissive displays. Organic semiconductors can also be used as active layers of photovoltaic cells (PV). Field-effect transistors (FETs) can also be made of organic semiconductors. Solar cells and sensors with integrated organic semiconductors are very popular today due to high scalability, process-ability, bendability and more[140]. According to Techavio report, the sales volume of OLED display panels is increasing because they are thinner in comparison to LCD display panels. The organic FETs market has seen a growing trend in flexible OLED display demand and one of the major reasons is increasing investments from OEMs such as Apple and Samsung in flexible display technologies[141].

The emerging of 2D organic semiconductors has gained considerable attention due to their optical, electronic, optoelectronic and mechatronic properties[142]. 2D organic semiconductors can be applied in designing highly-efficient bio-sensors due to the fact that 2D organic nanostructures express bio–functionality and are highly sensitive to bio-analytes. Moreover, the biocompatible, bio-degradable behavior and natural origin of organic nanomaterials can contribute to reduction of electronic waste.

5.1.10 Collaborative Robots (Cobots)

According to several reports on automation process in electronics industry manufacturing, there is a growing demand for collaborative robots to increase productivity, lower production costs and improve workplace safety [143,144]. Cobots provide various benefits as they are adaptable to changing environment, and they are easily reprogrammable and re-deployable, which particularly suit smaller companies. Furthermore, large manufacturers are increasingly using cobots for the same reasons.

[140] Is organic Semiconductor the solution to build future electronics devices, Semiconductor Review
[141] Technavio, 2017
[142] GP Neupane et al. (2019). 2D organic semiconductors, the future of green nanotechnology. Nano Materials Science.
[143] Markets and Markets, 2020.
[144] Electronics Industry increasingly relies on collaborative robots to boost productivity, PR News Wire

For many years, manufacturing industry has deployed model of production known as Industry 4.0. It brought about digitalization of the manufacturing process through the application of technologies such as cyber-physical systems, IoT, cloud computing and artificial intelligence. The goal was to establish smart, automated production taking advantage of digital communication and big data analytics to optimize production. On the other side, Industry 5.0 is putting humans back into development and production. The focus is on highly skilled employees and robots working side-by-side on the same task.

ASM: A leader in electronics manufacturing components

ASM Assembly Systems (ASM), a major global supplier of packaging and electronic manufacturing components, adopted Rethink Robotics' Sawyer cobot in its factory in Munich, Germany. ASM wanted to relieve its skilled employees from performing monotonous and repetitive tasks to establish better division of work and increase the productivity. ASM uses Rethink Robotics' Sawyer robot in its production facility to insert circuit boards into a test adapter, inspect flaws and sort the boards according to the test results[144].

5.1.11 Digital Twin

According to Gartner, digital twin is defined as a digital representation of a real-world entity or system. The implementation of a digital twin is an encapsulated software object or model that mirrors a unique physical object, process, organization, person or other abstraction[145]. It is a dynamic digital replica of an object, structure or system, which must be identical to the physical product in order to accurately model its characteristics. Internet of Things (IoT) and machine learning are the technologies underlying digital twins. Digital twins receive input signals from sensors and produce real-time output describing how the object, structure or system would behave in a virtual environment.

Digital twin technology represents a part of a broader concept of digital transformation and digital manufacturing, trends that more and more companies around the world are embracing. It can be applied in manufacturing, production planning and product design. Digital twins can contribute to costs reduction, performance optimization and extension of equipment and assets life. Furthermore, this technology can minimise failure rates, accelerate time to market and enable a company to create a wider portfolio of products.

Siemens and Digital Twin

The Siemens Transformers factory in Nuremberg, Germany has digitalized test assembly, a complicated step in the production process, with the help of a digital twin. The most important results are costs reduction and shorter production lead time. Test assembly is a complicated and time-consuming step in the production process where the active part of a transformer is placed into the tank and measured before it is dried. With the help of a digital twin, this process has become more efficient, reliable and accurate. Beatrix Natter, CEO of Siemens Transmission Products stated: "This digital solution underlines once more the innovation leadership of our products, also in manufacturing. Time savings and further perfection of our product quality are a real benefit for our customers".

5.1.12 Metal Injection Moulding

Metal Injection Moulding (MIM) is a technique used for manufacturing small, complex, tight-tolerance and high-performance metal parts[146]. Wider application of MIMs is found in electronics industry, driven by the demand for smaller electronic devices, high precision components with better performance and at lower cost. MIM offers precise manufacturing of small electronic components. Currently, main MIM products are connectors with complex geometries. For example, MIM is used in production of Apple's Lightning

[145] Digital Twin, Glossary, Information Technology, Gartner
[146] Metal Injection Molding Advantages, Indo-MIM

connector. MIM has also been used extensively on smartphone camera systems. Lens protection rings manufactured with MIM technology ensure the relative positioning of lens modules and sensors and include a variety of functional requirements that include a bright appearance, non-residual magnetism, conductivity, thermal conductivity, and even biocompatibility[147].

5.1.13 Renewable Energy - Testing & Certification

Photovoltaic (PV) power supplied to the utility grid is gaining more and more visibility due to many national incentives like National solar mission. With a continuous reduction in system cost (PV modules, DC/AC inverters, cables, fittings and manpower), the PV technology has the potential to become one of the main renewable energy sources for the future electricity supply. The demand for cleaner, smarter energy—in the form of solar energy—is greater than ever in countries across the globe, with the US, China, and India leading the way. The global PV market itself has grown every year for over a decade, giving manufacturers the chance to play a critical role in promoting sustainable energy production and reducing carbon emissions, while enjoy substantial sales. **There is a huge potential for the TC to setup these testing facilities:**

5.1.13.1 PV and environmental testing facilities

PV and environmental testing facilities offer testing of the highest accuracy and quality. These facilities feature:

- Advanced technology A+/A+/A+ grade solar flashers to precisely reproduce high-intensity light under controlled temperatures
- Expertise with all PV technologies: c-Si, thin film, PERC, and bifacial
- Environmental chambers to evaluate performance in controlled temperature and humidity conditions
- Light-soaking and UV chambers to simulate extended sunlight exposure
- IEC testing capabilities to help ensure conformity with international safety and performance standards
- Outdoor testing area to evaluate PV modules on fixed racks and both single-axis and dual-axis trackers

5.1.13.2 Certification to ANSI, CSA and IEC standards

- PV Modules, ANSI/UL 1703, IEC 61730/61215, ANSI/UL 61730/61215, CSA 61730/61215
- Racking, ANSI/UL 2703, Tracking, ANSI/UL 3703, IEC 62817, CSA 62817
- Inverters, ANSI/UL 1741, UL/CSA 62109, CPV, IEC 62108, UL 62108

5.1.13.3 Module Performance Testing

- IEC 61853-1, PAN Files
- IEC 61853-2, EQE, IAM, NMOT
- CEC Testing, PID Testing, LID Testing. Bifacial Testing, Outdoor Yield Studies

The status of the various newer and emerging technologies among ESDM industry is brought out in the following table. Also, the scope for TC and the MSMEs to adopt and avail them are also indicated. The scope for MSME and TC differ in a few cases, as TCs have a good scope in training the manpower for larger firms as well under their training activity.

No	Technology	Scope for TC	Scope for MSMEs to implement
1	IIOT	High	High
2	3D printing	High	High
3	AR/VR	Medium	Low

[147] Metal Injection Molding in the 5G era opportunities for growth, Staging, PIM International

4	AI/machine learning	Low	Very low
5	Robotics and automation	High	Medium
6	SMT	Medium	Low
7	5G communication	Low	Low
8	Ultraviolet lithography	Low	Low
9	Organic semi-conductors	Low	Low
10	Collaborative robots	High	Medium
11	Digital twin	Low	Low
12	Metal injection molding	medium	Low
13	Renewable energy	Medium	Medium

5.2 Specific Technological Trends

While section 5.1 highlights the technological trends that have ramification across the sector, this section focusses on certain technological trends within the sub-segments like consumer electronics, electronic components, Industrial electronics etc.

5.2.1 Consumer Electronics

The latest technological trends in the consumer electronics market is the development of connected devices, including the adoption of smart speakers displays, the emergence of 5G smartphones, and convergence of connected devices using voice as a platform[148]. Adoption of smart speakers with personal assistants has tripled since 2016, and adoption of smart displays has more than quadrupled since 2017. In order to encourage consumer interest and to increase sales, smartphone manufacturers are deploying innovative technologies such as augmented reality. New advances in smartphone hardware include 3D sensing cameras and AI chips. In the global TV market, innovations include voice assistants integrated into TV sets, more realistic image and sound and more OLED TVs.

5.2.2 Electronic Components

According to market analysis reports, innovative connector technologies in transportation applications are a major emerging technology in the field of electronic components. Nowadays, the electrification of vehicle systems is the primary trend in transportation. Moreover, smaller connectors are important in reducing the overall packaging footprints demanded by a growing number of high-density, space-constrained applications[149].

The globally increasing trend towards automation is seen in the automotive sector and there is a growing demand for advanced electronic devices such as power integrated devices, driver assistance systems, controllers, Global Positioning Systems, etc. It is predicted that there will be a growing adoption of these devices due to the rising demand for electric and autonomous vehicles and the requirement posed by governments worldwide for the reduction of global carbon emission. Moreover, with the new trend of connected vehicles, major telecom companies are investing considerable resources into the development of 5G infrastructure, which requires new installation of telecom equipment and other networking devices.

Major companies in the market are constantly focused on developing new products in order to improve their profitability and strengthen their market position. For example, in September 2019, NXP Semiconductors

[148] Consumer Electronics 2020 trends telecom network impact, ISE Mag
[149] Report Linker, 2019

N.V. introduced secure fine ranging chipset, SR100T, mainly designed for next-generation Ultra-Wide Band (UWB)-enabled mobile devices in order to provide highly accurate positioning performance. In March 2019, AVX Corporation introduced a new series of miniature, surface-mount and J-lead tantalum capacitors. These capacitors provide improved reliability and volumetric efficiency in high-temperature industrial and automotive applications[150].

5.2.3 Automotive electronics

It can be said that the driving force behind innovations in automotive electronics are semiconductors. For instance, the company Infineon was reported to have more than 80% of its automotive semiconductor components with zero failure and overall failure rate of less than 0.2 parts per million due to the implementation of the Automotive Excellence program. Hyundai Motor has developed an innovative and low-cost platform called Active Geometry Control Suspension (AGCS). The AGCS platform automatically controls and adjusts the rear suspension arms to aid cornering at the limits of adhesion to pass the Fish Hook test (roll over test), instead of using highly sophisticated sensors and actuators to control the braking and torque of each wheel[151]. Enabling advanced driver assistance systems (ADAS), automotive body electronics, advancements in electronic control units (ECUs), electronic stability control (ESC), automotive entertainment and connectivity and automotive safety technologies are major emerging technologies behind advanced automotive electronics solutions[152].

With the development and global adoption of IoT solutions, vehicle connectivity and communication with the environment has also been given high importance. A global auto supplier Visteon has recently launched its new SmartCore Domain Controller platform. It is the first product of this type in the world - cockpit domain controller with a third generation Qualcomm Snapdragon Automotive Cockpit Platform. The cockpit will be launched on a new pure electric vehicle platform Aion LX from Chinese automaker Guangzhou Automobile Group. (GAC)[153].

5.2.4 Mechatronics

Mechatronics can be envisaged as a multidisciplinary technology which synergizes precision mechanical engineering, electronic control and systems thinking in the designing of products and manufacturing processes. It is related to the design of systems, devices and products aimed at achieving an optimal balance between the basic mechanical structure and its overall control.

The use and real-life utility of mechatronics is immense and can be found in our daily lives. Consumer electronics like dishwashers and washing machines employ mechatronics as a technique in their operation. Mechatronics is excessively used in intelligent measuring devices like calibration devices, measuring and testing of sensors.

5.2.5 Agriculture Electronics

Technological Innovations have immensely enhanced the efficiency of the Agriculture Sector as a whole. To feed the growing population, agriculture industry is bound to adopt new technological innovations so as to enhance productivity, reduce time, reduce physical labour and increase efficiency of the agriculture sector.

Devices such as Soil Moisture Sensor, Soil PH Sensor, Agriculture Drones, Temperature Monitor, Smart Farming Equipments, Automated Tractors etc. have not only made farming easy and efficient, but are also pocket friendly and easily accessible. Some of the hardware sensors being used excessively in agriculture electronics are:

5.2.5.1 Soil Moisture Sensor:

Soil Moisture Sensor (Transmitter) is a high precision, high sensitivity soil moisture measuring instrument. This product is a metal shell, high compressive strength, good sealing performance; the use of

[150] Grand View Research, 2019
[151] Driving Asia - As Automotive Electronics Transforms a Region,
[152] Research and Market, 2019
[153] Visteon Launches Smartcore Domain Controller, Mirrorview

electromagnetic pulse principle to measure the apparent dielectric constant of the soil. For example: Intellia INT G01- Soil Moisture Sensor.

5.2.5.2 Soil PH Sensor

The transmitter is widely used in soil PH detection, sewage treatment and other occasions requiring PH monitoring. The three parts of input power, induction probe and signal output are completely isolated. For example: Intellia Soil PH Sensor INT-PH1

5.2.6 Electric Vehicle & Infrastructure Testing and Certification

The electric vehicle (EV) industry is driving the future of transportation and requires comprehensive services such as testing and certification of infrastructure components and batteries. There is a need for complete portfolio of services and solutions aimed at addressing areas of concern across the entire product lifecycle from checks on safety, performance and interoperability, to testing, key standards & meeting the demands of the global marketplace. The categories of testing required in EV are charging systems, batteries, personal e-mobility devices, electric motors, fuel cells, etc. ISO 15118 describes the communication between Electric Vehicle Communication Controller (EVCC) and the Supply Equipment Communication Controller (SECC) of Electric Vehicles (EV), including Battery Electric Vehicles and Plug-In Hybrid Electric Vehicles, and the Electric Vehicle Supply Equipment (EVSE). Technology Centres (TCs) can setup testing and certification lab for EV products as per the required testing standards.

5.2.7 Medical electronics

The dominant product segments in medical electronics – diagnostic and therapeutic devices – have been constatly enhanced with the use of state-of-the-art technologies. Increasing deployment of emerging microtechnology and nanotechnology electronics, such as diagnostic chips for remote monitoring of vital organs, is anticipated to have considerable impact on the efficiency of the devices and the development of precision medicine[154]. In the field of medical implants and endoscopy, new technologies have been deployed, such as 3D systems, capsule endoscopy and miniaturized endoscopic systems. In the diagnostic imaging market, there is a growing adoption of emerging technologies such as artificial intelligence, big data analytics and multi-modal imaging technologies.

5.2.7.1 Medical Device Testing & Certification

Electronic devices used in the medical environments have important safety and performance requirements to ensure safety and compatibility with other critical care equipment. These devices also need to reduce unacceptable risk to patients, as a result, medical device regulations continuously evolve. Some of the standards prevalent in the market are:

Medical Device Safety Testing

An active medical device is considered as any medical device which relies on a source of electrical energy or any source of power other than that directly generated by the human body or gravity in order to function. Product Safety requirements for electrical active medical devices are documented and internationally harmonized under the IEC 60601-xx standard family which is the base for the approval procedure of medical electrical equipment in most regulatory frameworks all over the world. IEC 60601-1-2 defines the basic and essential performance for medical equipment regarding emissions and immunity to electromagnetic disturbances. IEC 60601-1-2 applies to the basic safety and essential performance of medical-electrical equipment and medical-electrical systems in the presence of electromagnetic disturbances as well as electromagnetic disturbances emitted by medical-electrical equipment and medical-electrical Systems.

IEC 60601-1-2 4th edition has introduced significant technical revisions such as risk management, risk analysis and changes to immunity requirements. These significant changes include specification of immunity test levels according to the environments of intended use, which are categorized according to

[154] Market Watch, 2020

locations that are harmonized with IEC 60601-1-11: the professional healthcare facility environment, the home healthcare environment and special environments.

Laser Safety Testing

Laser Safety Testing ensures that the optical radiation from laser-based products is compliant with standard requirements and safe for end-users. Optical radiation safety considerations are critical when designing laser-based products for compliance. Optical dangers are not considered in general product safety hazard assessments (burn, electrical shock, etc.) and can lead to product failures if safeguards are not designed appropriately.

5.2.8 Power Electronics

Power Electronics is the amalgamation of the fundamentals of Power Engineering, Analogue Electronics, Semiconductor Devices and Control Systems, to assist in the conversion of power from the available form to the required form. It is a sector which has grown rapidly over the years. The basic innovations which has contributed largely for the advancement of this sector are:

1) The development of advanced semiconductors like MOSFET, IGBT etc., which can handle higher voltages and currents, besides, the devices, being switchable between the ON and the OFF states at high frequencies. They need no forced commutation mechanism as required by most of the devices of the Thyristor family which were used in the earlier decades.

2)The development of ultra-modern micro controllers including the digital signal processors that could be used for precisely timed and high-resolution parametric control systems.

3) PC and the software tools which have contributed for the development of almost all fields of engineering so also for the field of power electronics that has led to fast research, development and prototyping.

The contemporary development of the above factors and the look out by every industry and every government for an alternate source of electrical power than the conventional electrical power has led to recent advances in power electronics, which has enabled the rapid development of applications in power systems, including renewable energy generation, high-voltage DC (HVDC) transmission, flexible AC transmission systems (FACT), energy storage, electric vehicles, and microgrids etc. Power electronics are also the foundation of new mobile power system technologies, such as variable-frequency AC distribution for more-electric aircraft and medium-voltage DC grids for electric ships.

5.2.9 Printed Circuit Boards (PCBs)

PCBs are thin plates of fiberglass, composite epoxy or other laminate material with conductive pathways to connect components like transistors, resistors and integrated circuits, so that data can be collected and distributed and functional networks can be established.

PCB layout is an important step in the designing of any electronic device which determines the success or failure of a piece of equipment. With advancement in technology, PCB design rules and production processes have evolved to achieve new layouts and capabilities. While modern PCBs are being produced at incredible rates and complexity, there is always scope for further development to meet consumers' demand and expectations.

With high requirement for the smartphones there began many innovations in the market to make the device better and easy to use. One of the innovation which was incorporated for making these smartphones compact and lesser in weight, was the use of multilayer printed circuit board. A multilayer printed circuit board has more than two layers which is way more different than a Double-Sided printed circuit board which only has two conductive layers of material. The multilayer printed circuit board has at least three layers which are buried in the center of the material. Alternating layers of prepreg and core materials are laminated together under high temperature and pressure to produce Multilayer printed circuit board. The application of such PCBs can be found in communication infrastructure, data storage and servers, computers, etc.

Several tests are performed to check the quality of PCBs including the bare PCB, the raw materials that the PCB is comprised of, as well as the finished PCB Assembly (PCA). The most commonly used PCB testing performance specifications for qualification, acceptance, and/or conformance are IPC-6012, IPC-6013, IPC-6016, IPC-6018, MIL-PRF-55110, MIL-P-50884, or MIL-PRF-31032 which comprises of continuity testing, electrical testing, peel strength, etc.

PCB Board Cameras

PCB cameras are mounted directly onto a circuit board. It consists of a lens, aperture and image sensor and are designed to take both digital pictures and videos. Overall, the size of camera is small enough to slip into any electronic device and can be mounted on any size PCB. These small cameras can take high-resolution images and video with ease. In the next few years, board cameras are expected to develop even further, creating powerful solutions for both industry and consumer electronics. Some of its applications are:

Consumer Electronics - Smartphones, tablets, laptops and other small handheld electronics commonly use board cameras. Consumer electronics companies are constantly pushing for smaller and more powerful cameras.

Medical Instruments - Small board cameras have found a niche in the medical industry for non-invasive and minimally invasive procedures. Pill-sized cameras are now in use that can be swallowed by patients so doctors can take comprehensive videos and images from inside the digestive tract without invasive surgery. Also wearable cameras are gaining traction during surgeries as an instructional tool.

Surveillance Technology - Due to their small size, these cameras are extensively used for surveillance purposes. Many consumers, security companies and organizations use these small cameras to monitor their homes and businesses for surveillance.

Flexible PCBs (FPCB)

A Flexible PCB or FPCB is a patterned arrangement of printed circuitry and components that utilizes flexible based material with or without flexible coverlay. These flexible electronic assemblies may be fabricated using the same components used for rigid printed circuit boards but allowing the board to conform to a desired shape (flex) during its application.

A rigid flex printed circuit board (PCB) is a hybrid circuit board design that integrates elements from both hardboard and flexible circuits. Rigid flex PCBs are rigid at some points on the board and flexible at others. Because of this, rigid flex circuits can be folded or continuously flexed while maintaining the shape of areas that need extra support. The circuits are typically multi-layered and are comprised of flexible circuit substrates joined with rigid boards.

Both flex boards and rigid flex boards have risen in popularity for PCB manufacturing recently due to the flexibility that it offers, therefore making it possible to handle more stress and bending than rigid PCBs and can even be folded to fit into awkward 3D spaces, making them useful for applications where bending is a regular occurrence. They are also very light and thin, yet remain relatively easy to manufacture in mass quantities. Several industries are pushing the trend towards flexible PCBs including LED lighting, wearable technology, medical instrumentation, etc.

6. Recommendations

The white paper has focused on leading ESDM clusters across the globe, some best practices being followed in these clusters and major trends across sub-segments in the ESDM sector both globally and in the domestic arena. This section tries to assimilate all the knowledge from clusters around the globe and recommend changes for relevant stakeholders and policy/ makers which are as follows:

(i) Boost Domestic Manufacturing

Indian Government has taken multiple strides in the last couple of years to boost manufacturing ecosystem. However, there are many experts who believe that India is turning into a mere assembly hub and all the major components are being imported (75% in FY 20). There is an urgent need to boost domestic manufacturing if India wants to address the ever-increasing domestic demand.

Indian Government in June 2020, has launched the following schemes with a financial outlay of Rs 48,000 crore and an aim to eliminate the disabilities in domestic manufacturing ecosystem:

- Scheme for Promotion of Manufacturing of Electronic Components and Semiconductors (SPECS): The scheme aims to provide financial incentive of 25% on capital expenditure for the identified list of electronic goods.
- Production Linked Incentive: The scheme targets Mobile phones and specified electronic components and aims to incentivize ten firms (5 Local and 5 Global) to an extent of 4 to 6% in incremental sales (Over base year)

As per the Ministry of Electronics and Information Technology statement, these schemes have an ability to offset 6 to 10% disability existing in the ESDM manufacturing setup and bring the Nation at par with the likes of Vietnam. There needs to be a qualitative assessment of these schemes launched and major milestones or impact on Indian manufacturing scenario should be released in public on a half yearly basis. Also, the production linked Incentive is excessively focused on Mobile phone Production. India is already the 2nd largest producer of Mobile Phones in the World. There needs to be an excessive focus on emerging sectors like medical and strategic electronics.

It needs to be seen that what will be the impact of these initiatives amidst COVID-19 pandemic as recently the electronic manufacturers have asked the government to relax the rule on production volume for incentives as due to declining demand the production will be lesser than the previous fiscal. Also, the domestic component manufacturers have cited concerns over the minimum investment of Rs 100 Crore that has been kept for availing benefits under mega incentives scheme. Domestic manufacturers feel that same threshold for Indian and foreign players is discriminatory and would limit their chances of availing incentives.

(ii) Linkage Between Academic Institutions, Research Institutions and MSMEs

The case studies of Silicon Valley in California, Daejeon Daedeok Innopolis in South Korea, Saxony in Germany and almost any other successful Industrial cluster across the globe has highlighted the importance of convergence amongst Academic Institutions, Research Institutions and the MSMEs. There needs to be a mechanism to bring them together on a common platform to boost domestic manufacturing and innovate.

(iii) Specialized Research Institutions and Increased spending on R&D

There is an unending need to focus on semiconductor and electronic research to support the manufacturing ecosystem in India. A research Institution namely National Institute of Semiconductor and Electronics Research (NISER)[155] on the lines of Interuniversity Microelectronics Centre (IMEC), Belgium

South Korea with ESDM giants like HTC, LG, Samsung etc. had come up with Highly advanced National program (HAN) that aimed at spending $ 4.7 billion on R&D and development of electronic ecosystem. India needs a massive push viz a viz investment in R&D for development of a high-end production ecosystem.

[155] IESA

(iv) Focus on Coastal SEZs and Infrastructure boost

Following the Chinese footsteps, India can strengthen its Coastal Special Economic Zone (SEZ) infrastructure. The strengthening will help us focus on export led production and make the utilization of imported raw materials optimum.

With massive infrastructure project announcements SAGARMALA, Indian port infrastructure is bound to improve. However, The Government has to ensure that there are no delays in these massive infrastructure projects as these projects hold the key for eliminating issues like turnaround time for raw materials.

(v) Encouraging Design led Research & Development and Manufacturing

There is an urgent need to boost the idea of *"designed and manufactured in India".* An incentive mechanism to promote in-house research and development should be drafted and a dedicated fund should be created for the same.

(vi) Reduction in Operations Cost

The cost of availing credit in India is estimated to be 12-14% which is very high when compared to the likes of industrial giants like China offering credit within 5-7%. There is a need for huge interest subvention and reduction of interest rate on borrowed capital to boost domestic manufacturing and establish an ecosystem conducive to ESDM sector.

(vii) Boost Strategic Electronics Sector

India is amongst the top 5 nations with the maximum defence budget. With an increasing focus on Make in India – Defence and Atmanirbhar Bharat, the need for strategic electronics is expected to increase manifold. Some of the steps which can be taken to boost the sector are:

- The strategic electronics value chain has a very limited representation of industrial stakeholders as most of the market, at present is captured by the Government Players. There needs to be a consortium led approach with participation from both Government and Private Players.
- An exercise for the standardization of strategic electronic product requirements at par with the global standard products needs to be undertaken by MeitY.
- The Government needs to strengthen the testing facilities established within the defence production clusters for a comprehensive testing regime.

(viii) Share for domestically manufactured goods in National Missions

A fixed percentage of domestically manufactured goods should be set aside to be procured in the implementation of our National missions like Digital India, Smart City Mission etc. This step will incentivize the domestic manufacturers and boost domestic manufacturing.

(ix) Boost Exports

A comprehensive policy targeting exports should be envisaged. The policy should focus on FTAs with the regions like Brazil, South Africa, The EU, Middle East etc. as these regions are the largest consumers of Indian goods. The policy should also lay the framework for establishment of regional manufacturing hubs in the country with a built-in export clause. The long pending demand of 100% income tax exemption on export income for ICTE manufacturers can also be explore.

(x) Localized product design and development

Testing facility & manufacturing are effective when there is local Product Design & Development (R&D), There's a need to encourage Start-up, Micro, Small and Medium Enterprises to design & Develop product locally, so that industry shift from importing PCBA & components to exporting product which is designed & developed locally at India.

This approach will help in developing end to end Product business ecosystem such as:

- Independent design House (IDH -R&D centres) as available at other countries
- Localisation of Component supply chain
- CKD Manufacturing Industry

To drive innovation and cost competitiveness in the sector, some of the recommendations where Technology Centres can pitch in for the technology adoption are given in the table on the next page:

S. No.	Technology	Results of newer technology	Challenges faced: job losses/ skill shortages/ changes in the existing value chain	Initiatives to bridge the gaps in access and adoption	The role the TC can play to fill in the gap and ease of adoption/BDS need
1	5G Communication	▪ Greater speed in transmission thereby enabling a greater number of connected devices and the possibility of implementing virtual networks ▪ Significantly reducing the latency – time that elapses since we give an order on our device until the action occurs. Latency in 5G will be ten times less than 4G. ▪ Enable companies to conduct remote operations and increase manufacturing efficiencies ▪ Support smarter factory equipments like robots, augmented and virtual reality, artificial intelligence, etc.	▪ In India, 5G spectrum is yet to be allocated to telecom companies. The main reason for this delay is exorbitant costs involved in buying 5G spectrum. ▪ Compatibility of existing devices to be checked for 5G technology. ▪ 5G will increase the power consumption of the UE's battery. getting Efficient battery is a challenge both on availability and cost for MSMEs. ▪ However, the battery used will have 4 times the life of the 4G battery.	▪ Existing digital infrastructure needs to be strengthened to adapt to the 5G technology. ▪ Orientation programs to SMEs/ clusters on long term benefits of the technology through cost-benefit analysis.	▪ TC can develop courses and training for creating awareness and capacity building of MSME employees for implementation of the technology. ▪ TCs can conduct webinars in clusters highlighting the importance of 5G technology in connected devices domain and its future applications.
2	Augmented and Virtual Reality	▪ Improves plant performance, uptime, reliability and safety ▪ Improves skill retention versus traditional training methods by up to 100 percent and reduces the length of technical training by up to 150 percent ▪ Employees' training progress is tracked as part of a formal competency management system ▪ Turns data into insight enabling plants and businesses to run better	▪ Identifying use-cases, which are feasible to implement ▪ Shortage of in-house expertise and insufficient back-end infrastructures ▪ MSMEs will be able to train , service , take advice from remote locations at no cost ▪ The cost is still high and not with in the reach of MSMEs.	▪ Government support to develop AR/ VR lab and get trainers trained from institution such as Harvard Innovation lab. ▪ Facilitating creation of programs in AR/VR in Indian institutions/ universities.	▪ TC can set up a full-fledged AR/VR lab to train the students and the industry. ▪ Consultants/ Subject Matter experts can be engaged by TC to carry out feasibility study at different enterprise for implementation of Augmented and Virtual Reality.
3	AI and ML	▪ Reenergizing of mechanical, instrumentation, electrical and electronics engineering	▪ The lack of expertise in Research and development and application of Artificial	▪ The national Strategy on Artificial Intelligence which aims to develop a	▪ TC can develop courses and training for creating awareness and capacity building of MSME

		streams to encompass overlapping disciplines ▪ Ability to respond and scale supply chain issues using AI visual inspections ▪ Elimination of faulty machines using predictive maintenance and ensure rising productivity ▪ Gradually making its way as a back-end tool in the automotive sector to build sophisticated interfaces that will replace manufacturing practices in age-old companies.	Intelligence and Machine Learning. ▪ Inability to access intelligent data for constant development ▪ Privacy and security issues that are currently not under any formal regulations for the anonymization of the data ▪ Limited collaborative resources to adopt and apply the technology ▪ The lack of trained personnel and expertise in application is a major constraint. For MSMEs ▪ Privacy and security issues that are currently not under any formal regulations for the anonymization of the data ▪ Limited collaborative resources to adopt and apply the technology	research ecosystem and address skilling challenges in order to leverage AI under the Sabka Saath Sabka Vikas policy. ▪ Release of the National Artificial Intelligence Portal to serve as a one-stop platform for all AI development in the country.	employees for implementation of the technology. ▪ Consultants/ Subject Matter experts can be engaged by TC to carry out feasibility study at different stages of value chain for implementation of Artificial Intelligence ad Machine Learning (AI&ML)
4	3D Printing	▪ Feasibility of consolidation of multiple parts into a single component. ▪ Lighter parts can be made. ▪ Complex/customized shapes can be developed, which is difficult to achieve in conventional tooling. ▪ Reduces the prototyping time and facilitates small batch production of tooling and parts. This enables the “Just-in-time” movement of components of the final product giving comparative advantages of different locations.	▪ The conventional materials and sources can not be used. Comparatively limited Alternative materials are available in the market. The right availability is a major challenge. ▪ The raw material cost is high. Third party source is available for only a few materials .This dependance with machine supplier leaves no control on RM cost , with the MSME.	▪ Development of separate training courses for AM machine operation. ▪ Orientation programs to SMEs/ clusters on long term benefits of the technology through cost-benefit analysis. ▪ Reduction in production cost ▪ Government policies to avoid copyright infringement for digital design templates	▪ TC can develop courses and training for creating awareness and capacity building of MSME employees for implementation of the technology. —CAD design usage at operator level —3D printer technology – operation details —Raw material handling in 3D operations

		▪ It will result in producing components at a location where the assembly of the final product takes place. ▪ More localized manufacturing and delivery ▪ Warehouse space requirement reduction	▪ There is a size restriction in making metal parts. However, in polymer larger parts can be made ▪ With the recent introduction of "design for printing" the staff will need focused and specialized training. ▪ Needs special ambience for locating the 3D printers. This is major challenge for MSMEs both in terms of space and cost. ▪ The number of parts that can absorb the 3D printing cost leaves the MSMEs with low-capacity utilization issues. This situation will continue till MSMEs are are able to muster a number of orders or regular supply in small batches. ▪ Will require up-skilling of resources (existing operatives, designers) on CAD drawings, 3D product design etc. ▪ Orientation programs would be required for MSME, which are not exposed to such technology yet. ▪ Unavailability of raw material required for 3D printing. Also, resulting in high cost of production.	▪ To address certification and liability of 3D printed parts	—Cost analysis of 3 D printed parts —Design for 3D operation (for design engineers) ▪ Consultants/ Subject Matter experts can be engaged by TC to carry out feasibility study at different stages of value chain for implementation of additive manufacturing. ▪ The TC can develop a separate team or collaborate with a BDS provider (on revenue sharing) to implement these services for MSMEs
5	Automation & Robotics	▪ Reduces dependency on humans by deploying hydraulics, mechanics, electronic and electrical components, thereby reducing chances of human error	▪ For Automation and robotics, the MSMEs shall standardize their process, movement of materials during the process. This is a practical challenge	▪ Extensive t/raining of the factory floor personnel. ▪ The engineers need to be trained on data analytics.	▪ TCs can develop related infrastructure like Advanced Automation lab, Robotics lab, etc. to train the upcoming workforce and make

		▪ Provides cost benefits over a longer duration by reducing chances of rejection of products/production lots and minimizing human intervention ▪ Automating not only offers cost benefits but also resolves health and safety issues since workers no longer need to lift heavy and potentially dangerous parts. ▪ Availability of real time machine data would reduce dependency on personnel for supervision, chasing and follow up in production area.	considering the product range and quantities covered by them. ▪ Setting up of automation systems entail high capital expenditure making it difficult for many MSMEs ▪ Advanced robotic automation technology significantly impacts employment opportunities for workers. Robots can perform consistently and quickly reducing the need for workers.	▪ Orientation programs to SMEs/ clusters on long term benefits of the technology through cost-benefit analysis.	them market ready for this technology ▪ Develop courses related to factory automation and Industry 4.0 for creating awareness and capacity building of MSME employees ▪ Orient MSMEs in the concept of low cost automation which would be suitable to them.
6	Cobots	▪ High precision and accuracy of output ▪ Can replace humans for all repetitive tasks. ▪ Very high productivity in manufacturing is realized. ▪ Cost comes down drastically.	▪ The process and the existing line operation shall be streamlined to ensure continuous flow. This is a major challenge for MSMEs. ▪ High initial capital cost. ▪ Programming & managing skill to be developed.	▪ Funding to be provided to MSMEs to adopt use of robots and Cobots. ▪ Benefits to be explained to MSMEs by taking examples of situation such as COVID-19, wherein robots would have proved useful.	▪ TCs can have in house Robotics lab where in people can be trained on the use and benefits of robots. ▪ They can conduct special programs to appraise the MSMEs on benefits of using robots. ▪ TCs can undertake cost-benefit analysis ▪ Consultants/ Subject Matter experts can be engaged by TC to carry out feasibility study at different stages of value chain for implementation of additive manufacturing. ▪ TCs can undertake cost-benefit analysis of using cobots ,.

					▪ TC can help the MSMEs to use low cost automation techniques.
7	Industrial IoT	▪ A shift from traditional supply chain to a digital network by shifting to the concept of smart factories that eliminate pressurizing ecosystems for operations ▪ Penetration of progressive technology like IoT enabled sensors based on the micro-electro-mechanical-systems (MEMS) technology ▪ Digitization opportunities for operations like additive manufacturing, cognitive bots, digital twin and cognitive bots via rapid real-time production od prototypes that produce minimal waste and have high accuracy	▪ The high investment for infrastructure to implement futuristic IoT ▪ The right to privacy affecting the free flow of data across all segments in the industry ▪ A major challenge faced by MSMEs is security, privacy, and management of personal data. As, IoT is an interconnected platform all the personal data is out there uploaded in the cloud which is highly vulnerable. If there is a glitch in security of IoT it will evidently compromise a person's privacy as well as security. MSMEs fear of loosing the know-how . ▪ Another challenge is having sensors or devices in the unit that require very less or no maintenance. ▪ Most of the devices use battery and as once the sensor is in the field, it is almost impossible to replace its battery which will lead to heavy power consumption. Therefore, another challenge is designing sensors that do not require any battery change over lifetime	▪ The Internet of Things draft Policy to introduces an advisory committee of stakeholders to monitor the receiving the IoT technology and information ▪ The Draft Data Protection Bill that states data privacy regulations like Right to Information and proposes efficient data localization	▪ TC can develop courses and training for creating awareness and capacity building of MSME employees for implementation of the technology. ▪ Consultants/ Subject Matter experts can be engaged by TC to carry out feasibility study at different stages of value chain for implementation of Internet of Things (IoT)
8	Extreme Ultraviolet (EUV) Lithography	▪ Feasibility of creating smaller, faster and more powerful chips by harnessing light of a much shorter wavelength (13.5 nanometer light) than with previous lithography	▪ High Cost of procurement EUV lithography for manufacturing leads to huge capital investment, hence, can MSME and	▪ Orientation programs to SMEs/ clusters on long term benefits of the technology through cost-benefit analysis.	▪ TC can develop courses and training for creating awareness and capacity building of MSME employees for

		machines (193 nanometer light). ▪ Continue making smaller, faster and more powerful chips while keeping costs in control ▪ Complex/customized chips can be developed, which is difficult to achieve than with previous lithography ▪ Advanced Lithography will immensely Impact the Micro Electro-Mechanical Systems (MEMs) Fabrication Industry	TCs cannot adopt this technology at this stage ▪ The Indian industry is not mature to adopt this technology at this stage ▪ Orientation programs and exposure visits would be required for MSME, which are not exposed to such technology yet.		implementation of the technology. ▪ Consultants/ Subject Matter experts can be engaged by TC to carry out feasibility study at different stages of value chain for implementation of (EUV) Lithography
9	Digital Twin	▪ Help the Electronics Industry to Perform Product Lifecycle Management ▪ Reduces operating costs and extends the life of equipment and assets because of their ability to enable disruptive IoT solutions ▪ Digital twins find wide application in design customization and production in the electronics sector ▪ Availability of real time machine data would reduce dependency on personnel for supervision, chasing and follow up in production area.	▪ Only a few Technology Developers are Providing Digital Twin Implementation Assistance and Services	▪ Technical collaboration with Technology Developers for implementation of Proof of concept at TCs ▪ Orientation programs to SMEs/ clusters on long term benefits of the technology through cost-benefit analysis.	▪ Consultants/ Subject Matter experts can be engaged by TC to carry out pilot projects to implement digital twins for some of the enterprises ▪ TC can develop courses and training for creating awareness and capacity building of MSME employees for implementation of the technology
10	Surface Mount Technology	▪ Scope of growth for SMT cleaning equipment with the rise of smart electronics and industrial devices ▪ Growth in the use of flex circuits in wearable electronics in smart chip technology with increased feasibility ▪ Elevate the domestic PCB manufacturing industry with penetration of SMT	▪ The Electronics Manufacturing Service industry in India is not mature to onboard SMT in all segments of manufacturing. ▪ The Organic Source Preservative (OSP) left being during testing of PCB assembly.	▪ Orientation programs to SMEs/ clusters on long term benefits of the technology through cost-benefit analysis.	▪ TCs can have in house Robotics lab where in people can be trained on the use and benefits of SMT. ▪ TCs can undertake cost-benefit analysis .shall educate the MSMEs the vis -a – vis benefits and selection criterion between PCB and SMT . ▪ Consultants/ Subject Matter experts can be

					engaged by TC to carry out feasibility study at different stages of value chain for implementation of additive manufacturing.
11	Organic Semiconductors	▪ Uses lightweight materials for fabrication hence allowing more space for chip design across products ▪ Significantly reduces the production cost with increase in volume – justifying economies of scale ▪ Organic materials allow for easy shaping and tuning thus providing mechanical flexibility of materials which is not possible with silicon and other materials ▪ Organic nanomaterials are bio-compatible and bio-degradable thereby reducing the electronic waste.	▪ Shortage of skilled manpower to implement usage of organic materials in electronics manufacturing ▪ Orientation programs detailing advantages of this technology and difference in manufacturing value chain to be conducted for MSMEs	▪ Development of separate training courses for manufacturing techniques involving organic materials. ▪ Organic materials to be made available at cheaper rates	▪ TCs to create awareness on the multiple advantages of using organic semiconductors ▪ Capacity building of MSME employees for implementation of the technology. ▪ Consultants/ Subject Matter experts can be engaged by TC to carry out feasibility study at different stages of manufacturing value chain by using organic materials
12	Metal Injection Moulding (MIM)	▪ Manufacturers will be able to Produce Components with Ultra-Small Dimensions ▪ Enables designers, engineers to develop connectors with complex geometries for miniature electronic devices to achieve better performance at lower cost. ▪ Reduction in production cost for high volume products such mobile connectors	▪ Will require up-skilling of resources (existing operatives, designers and manufacturers) ▪ Orientation programs would be required for MSME, which are not exposed to such technology yet. ▪ Unavailability of raw material required for MIM may also result in high cost of production among MSMEs .However it can be used an alternative to FFF .	▪ Development of separate training courses for MIM machine operation. ▪ Orientation programs to SMEs/ clusters on long term benefits of the technology through cost-benefit analysis. ▪ Organizations like the Surface Mount Technology Association that focus on extending networks and knowledge base in the form of certification and training.	▪ TC can develop courses and training for creating awareness and capacity building of MSME employees for implementation of the technology. ▪ Consultants/ Subject Matter experts can be engaged by TC to carry out feasibility study at different stages of value chain for implementation of MIM and to study the suitability of FFF Vs MIM for a particular part. ▪ TC can study and establish the method as a suitable alternative for injection moulds

					▪ The TC can develop a separate team or collaborate with a BDS provider (on revenue sharing) to implement these services for MSMEs

For further information, please connect with:

Vivek Agarwal

Partner– Infrastructure, Government and Healthcare (IGH)
KPMG in India
T: +91 98117 05760
E: vivekagarwal1@kpmg.com

Punita Bansal

Associate Director – Infrastructure, Government and Healthcare (IGH)
KPMG in India
T: +91 9910009401
E: punitabansal@kpmg.com