



**ACMA**

# AUTOMOTIVE ELECTRONICS

Master Plan Development for Auto Components Industry in India





# **AUTOMOTIVE ELECTRONICS**

**Master Plan Development for  
Auto Components Industry in India**



## Contents

|  |    |
|--|----|
| Foreword .....   | 3  |
| Message from Secretary, Department of Heavy Industry, Government of India..... | 5  |
| Technologies and Segment Scope.....  | 7  |
| Executive Summary.....   | 9  |
| Recommendations for ACMA and Government.....                                   | 11 |
| Global Auto Electronics Market and Megatrends Influencing the Market.....      | 13 |
| Growth Opportunity Analysis – Short and Medium Term Technologies.....          | 15 |
| Action Plans for Indian suppliers – Short and Medium Term Technologies.....    | 17 |
| Sensors and Actuators.....   | 21 |
| OEM Feedback on Suppliers.....   | 23 |
| Key Research Areas for Indian Suppliers – Long Term Technologies.....          | 25 |
| Competencies Required for Auto Electronics Manufacturing and Design.....       | 35 |
| Embedded Engineering Services.....   | 37 |
| Testing Facilities.....  | 39 |
| Software Verification and Validation (V&V).....                                | 41 |
| Case Studies.....  | 43 |
| Summary – Short and Medium Term Technologies.....                              | 47 |



## Foreword

We are happy to bring to you a report on the current and future opportunities in the burgeoning auto electronics market in India for automotive component manufacturing industry in India. Electronics Sector is a critical Sector of the Indian Economy. It is one of the pillars of **“Make in India”** and **“Digital India”** programs of the Government of India (GOI). Keeping in view that the Electronics Manufacturing Sector holds a great potential in the Indian context, and there has been a gap between the achievement and the potential of this sector. The Automotive Component Manufacturers Association of India (ACMA), the apex body representing the interest of the Indian Auto Component Industry in India and supported by Department of Heavy Industry (DHI) commissioned a full-fledged research in its efforts to map the current status and future opportunities for Indian suppliers in the auto electronics market.

Electronics and Information and Communication Technology (ICT) are transforming the idea of mobility. The market for auto electronics is estimated to exceed 200 US\$ billion by 2020. The use of electronics in automobiles is the single largest driver of change in the sector – nearly all automotive innovation arises directly or indirectly from developments in electronics. Most of the solutions designed to lower emissions, improve fuel-efficiency, increase safety and provide convenience services like infotainment for customers are dependent on electronics and associated embedded applications. Currently more than 75% of all electronics used in cars are imported. Concerted efforts from both the Government and the industry are required to propel the Indian auto industry into one of the critical GDP contributors in the near future.

This exhaustive report developed by ACMA’s consulting partner, Frost & Sullivan, on the overall auto electronics industry in India to identify the high growth product markets within the overall auto electronics industry and does a deep dive evaluation of the existing ecosystem for these products. Systems from powertrain, safety, telematics and infotainment are covered as a part of this research. This study would help identify the appropriate initiatives needed for further developing the ecosystem for these high priority products and support suppliers in identifying the right opportunities in the short, medium and long term.

The other objectives being

- Understand the Global Mega Trends that are affecting the automotive electronics Industry
- Understand the emerging automotive trends related to technology (engine, transmission, chassis, safety, and infotainment) at the cluster level only, including regulations
- To outline the market opportunities that exist in the key global automotive regions for Indian suppliers and map the value chain

- To recommend a broad based strategy, policy, capability development approach to grow business opportunities for the industry, ACMA and Government

We would like to place on record our appreciation for Frost & Sullivan for conducting this in-depth study. We are also grateful to our past presidents, ACMA member companies, SIAM and its members, Department of Heavy Industry, Department of Electronics and officials of the Government of India who have shared a wealth of their knowledge for this study.

With best wishes,

Dated: August 16, 2016

Arvind Balaji  
President, ACMA

Ashok K Taneja  
Past President and Chairman, ACMA Committee  
for Knowledge Partner Engagements





गिरीश शंकर, आईएएस  
सचिव  
GIRISH SHANKAR, IAS  
SECRETARY



भारत सरकार  
भारी उद्योग एवं लोक उद्यम मंत्रालय  
भारी उद्योग विभाग  
उद्योग भवन, नई दिल्ली-110 011  
GOVERNMENT OF INDIA  
MINISTRY OF HEAVY INDUSTRIES & PUBLIC ENTERPRISES  
DEPARTMENT OF HEAVY INDUSTRY  
Udyog Bhawan, New Delhi-110 011  
Tel. : 011-23063633, 23061854  
Fax : 011-23062633  
E-mail : shioff@nic.in

### MESSAGE

I am pleased that ACMA is bringing out this publication on "Future of Auto Electronics in India". India is one of the fastest growing Electronics market in the world. The rapid growth in the electronics industry has been mainly on the back of rapid urbanization, increasing disposable incomes and growing consumer base. This creates a unique opportunity for companies in the ESDM (Electronic System Design & Manufacturing) sector to look at India as their next destination to cater to the domestic Indian demand as well as act as an exports hub for the world. The electronics market of India is expected to reach USD 400 billion by 2020. Electronic Manufacturing Services (EMS) industry is expected to be a significant contributor to the entire electronic industry's development and India has Strong design and R&D capabilities in auto electronics and industrial electronics. The Indian government is promoting development of electronics manufacturing clusters throughout the country to provide world class infrastructure and facilities. 65% of the current demand for electronic products is met by imports which presents an opportunity for import substitution.

This is an opportune time for bringing out a detailed report that identifies new market and product opportunities for Indian suppliers for auto electronics. With the forthcoming regulation on safety and emissions, an average Indian car will have more electronics components than ever before. The Automotive Components Manufacturers Association [ACMA] in collaboration with Frost & Sullivan has developed a detailed study to understand the implications of growth in automotive electronics and its impact on the component suppliers and manufacturers in India. This study also sits well with the Prime Minister's "Make in India" initiative through which the government is promoting development of electronics manufacturing clusters throughout the country to provide world class infrastructure and facilities. The study not only looks at opportunities in India but also evaluates the potential to export automotive electronics related manufacturing expertise, developed by Indian component suppliers. Over the past 2-3 years, ACMA has been instrumental in fostering an environment where all small and medium sized component manufacturers in India can come together and work towards developing capabilities in the electronics space.

I believe this study is going to help all stakeholders to plan, prioritize and invest in the appropriate technologies in the future. I would also like to commend ACMA and Frost & Sullivan for their effort in preparing this publication, the findings of which, I am sure, will give future direction to the industry and offer the component manufacturers a roadmap towards technology evolution and further areas of investment.

  
(Girish Shankar)



# Technologies and Segment Scope

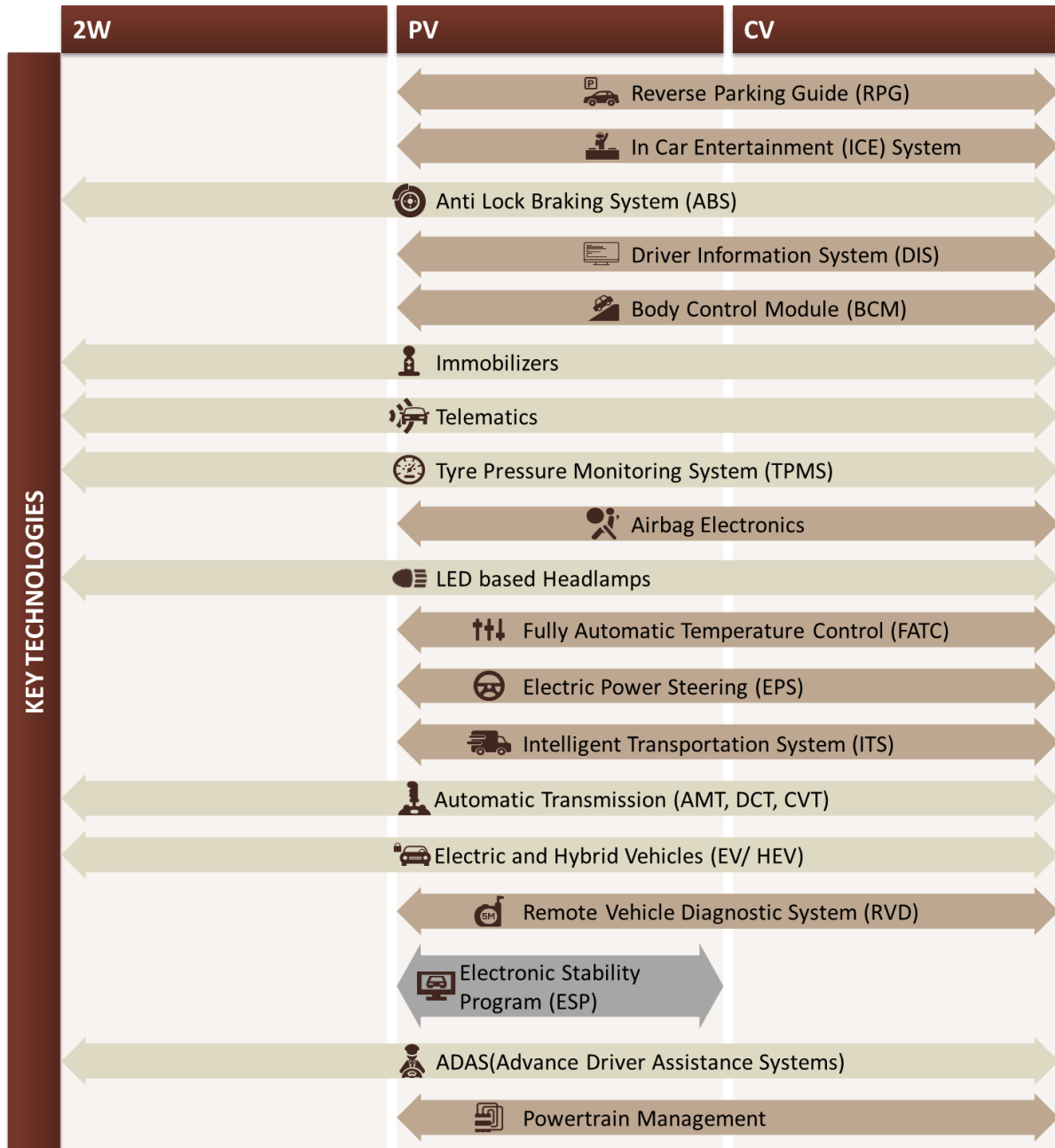
## List of Technologies Considered

| Short Term Technologies<br>(Technologies readily available and could be implemented in 1-3 yrs) | Medium Term Technologies<br>(Technologies available and could be implemented in 3-5 yrs) | Long Term Technologies<br>(Technologies under development) |
|---|--|--|
| Reverse Parking Guide (RPG)   | Telematics   | Intelligent Transportation System (ITS)                    |
| In Car Entertainment (ICE) System   | Tyre Pressure Monitoring System (TPMS)   | Automatic Transmission (AMT, DCT, CVT)                     |
| Anti Lock Braking System (ABS)  | Airbag Electronics   | Electric and Hybrid Vehicles (EV/HEV)                      |
| Driver Information System (DIS)   | LED based Headlamps  | Remote Vehicle Diagnostic System (RVD)                     |
| Body Control Module (BCM)   | Fully Automatic Temperature Control (FATC)   | Electronic Stability Program (ESP)                         |
| Immobilizers  | Electric Power Steering (EPS)  | Advance Driver Assistance Systems (ADAS)                   |
|   |  | Powertrain Management                                      |

## List of Sensors and Actuators Considered

| Sensors   | Actuators                       |
|---|---------------------------------|
| Crank Sensor  | Starter Solenoid Switch         |
| Cam sensor  | AMT Solenoid                    |
| Coolant Temperature Sensor                          | Wastegate Actuators             |
| Accelerator pedal Sensor/ Throttle Position Sensors | Idle Air Control Valve          |
| Manifold Absolute Position Sensor (MAP)             | Canister Purge Solenoid         |
| Air mass flow (HFM)                                 | EGR Valve                       |
| Vehicle Speed Sensor                                | Power Steering Motors           |
| Sensors   | Power Sun roof                  |
| Oxygen Sensor                                       | LED Headlamps Cooling fans      |
| Parking Sensor                                      | Engine Cooling fan              |
| TPMS (Tyre Pressure Monitoring System) sensor       | Electrical Fuel Pump            |
| Wheel Speed Sensor (WSS)                            | Windshield Wipers and Washers   |
| Fuel Level Sensor                                   | Power Door Locks                |
| Ambient Temperature Sensor                          | HVAC Blower                     |
| Air Pressure  | Power Windows                   |
|   | Variable Valve Timing Actuation |
|   | Electronic Throttle Control     |
|   | Dashboard Guages Drivers        |
|   | Idle Speed Controllers          |
|   | Self Adjusting Motors           |
|   | Fuel Injector                   |

## Total Automotive Industry: Technologies and Segment Scope



# Executive Summary

## Key Findings

The overall opportunity available for suppliers in Auto Electronics (all Short, Medium Term Technologies and Sensors) is approximately INR 36,500 Cr by FY2020

### Key Technologies

- **ABS, BCM, and Immobilizer** are the key Short term technologies to be focused
- **Telematics, TPMS, and EPS** are the key Medium term technologies to be focused
- **Parking, Cam, Crank, and Oxygen sensors** are the key sensors to be focused

### Addressable Market (INR Cr):

- Total addressable market for the key sensors considered is expected to be around INR 5,400 Cr by FY2020
- Total addressable market for the key Short term technologies considered is expected to be around **INR 10,500** Cr by FY2020
- Total addressable market for the key Medium term technologies considered is expected to be around **INR 6,400** Cr by FY2020
- Total addressable market for the key sensors considered is expected to be around **INR 5,400 Cr** by FY2020

### Addressable Market (INR Cr):

#### 1-2 Years

- Focus on manufacturing of:
  - Sensors: Ultrasonic, Hall Effect, Piezoelectric
  - Small Control Units and PCB Assemblies
  - Displays

#### 3-4 Years

- Focus on Mechatronics
- Focus on Oxygen Sensors
- Focus on complex ECUs and integration
- Focus on In Vehicle Networking



## Recommendations for ACMA and Government

With the conducive environment made by the GoI to promote auto electronics market in India and the increasing demand for auto electronics we expect more global auto electronics manufacturers to invest in India. India has received investment proposals worth over INR 1.1 trillion (USD 18 billion) in Electronics space since the start of “Make in India” campaign.

In current scenario electronics for Auto application are predominantly imported and there is a constant rise in its trade imbalance. Lack of a component ecosystem is the major hindrance in the growth of indigenous auto electronics market in India. Growth of Auto Electronics in India is possible only when ACMA members and Government take some initiatives with clear focus on long term plans. Government and ACMA should aim at holistic development of the Auto Electronics industry by filling up all the gaps in the electronics ecosystem.

Some initiatives to be followed by ACMA members to develop the Ecosystem for Auto Electronics are:

1. **Focus on becoming end to end service provider** in evolving areas such as ITS, Telematics, and RVD etc.
2. Capability development for **Software Verification and Validation** for developing robust sub-systems across program areas such as safety, powertrain and telematics
3. ACMA membership should **include software engineering service providing** companies such as KPIT, TCS, HCL etc. so that existing members could collaborate on new technology development
4. Existing players in mechanical components may seek to **explore the related product ecosystem in mechatronics** and acquire capabilities / build expertise through **technical tie ups or research partnerships** in the short term
5. **Capability building and investing in technology research in electronics** as automotive electronics is a long term game and expertise on certain systems are built over more than 5 years
6. ACMA members should **focus on Sensors and actuators** which have huge potential in the automotive field as well as have scope of diversification in other fields such as Industrial, Telecommunication and Medical
7. **Organize events and brain storming sessions** around auto electronics that will bring in various stakeholders including the government, software companies, semi-conductor manufacturers & automakers for charting out future roadmap for collaborative development
8. Focus on capability building for **Embedded Engineering Services**

Initiatives to be followed by the Government to develop the Ecosystem for Auto Electronics are:

1. **Set up automotive EMC** (Electronics Manufacturing Cluster) possibly near auto hubs and incentivize manufacturing of sensors, LED clusters, PCBs and LCD Displays etc.
2. **Building of consortia** aimed at fostering the capability development for next generation systems such as autonomous driving, connected mobility etc.
3. Required **frequency Bands be de-licensed** for automotive use on non-exclusive, non-interference basis for public use of RF/ Radar based systems.
4. Manufacture microcontrollers in the country; the setting up of the two **semiconductor fabs** in the country would prove to be a great enabler in this regard.
5. **Set up Testing facilities by government alliance** for comprehensive testing of electronics assemblies/ sub assemblies; **subsidize certification and critical testing** such as EMI/ EMC, ESD
6. Support reputed academic institutions such as IITs/ NITs/ Research Institutes to **introduce auto electronics/ mechatronics related courses** to develop expertise in the field
7. Supplier ecosystem needs to be developed by **providing incentives to small scale industries** aimed at capitalizing on Short and Medium term technology opportunities



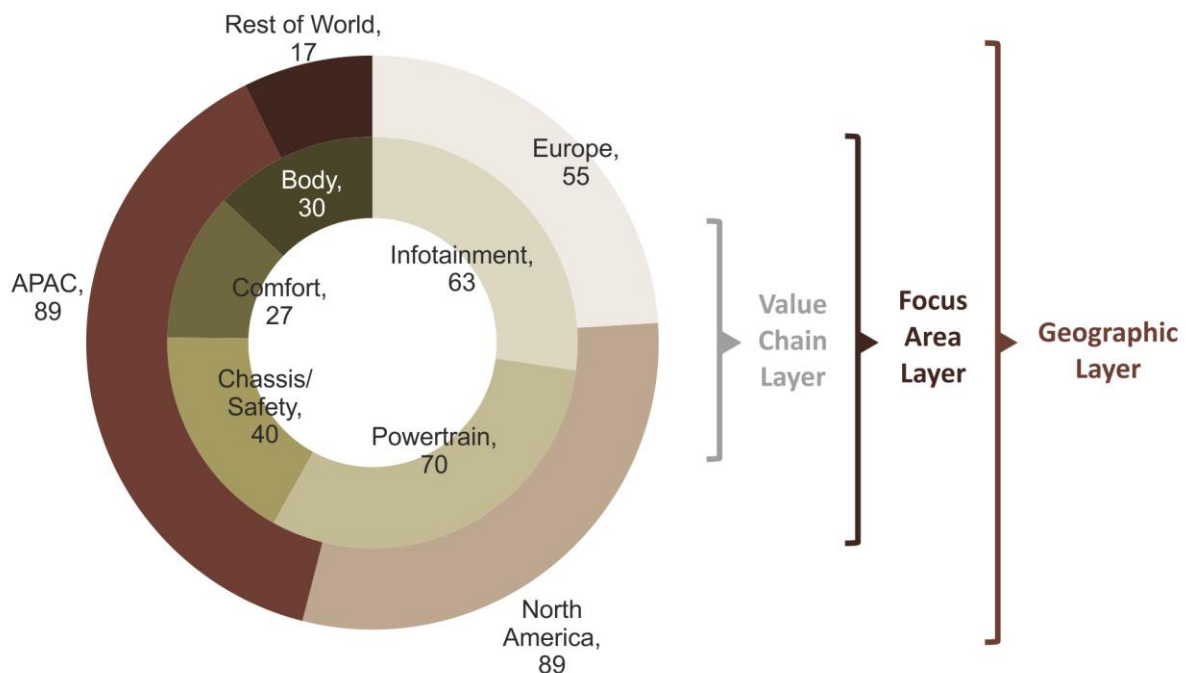
# Global Auto Electronics Market and Megatrends Influencing the Market

Technology development across vehicle segments has seen growth in leaps and bounds primarily in the Passenger Car segment. Usage of electronics content in cars started with the introduction of in car entertainment system, alternators, regulators and other electronics components. Other technological developments in the field of auto electronics were the result of Customer demand and Legislative Pull. Growing electronics content in a car is leading Global Auto Electronics market grow to \$230 billion in 2020; up from \$140 billion in 2010. With growing number of sensors and ECUs installation the overall cost of electronics in a car is expected to reach 30% by 2017 and 45% by 2030.

**A Modern Car has:**

- Over a **thousand wires, weighs 45 kilos** and measures a kilometre in length
- An average of 60-100 sensors on board. Because cars are rapidly getting “smarter” the number of sensors is projected to reach as many as **200 sensors per car**
- Around **100 ECUs** that control the electronics

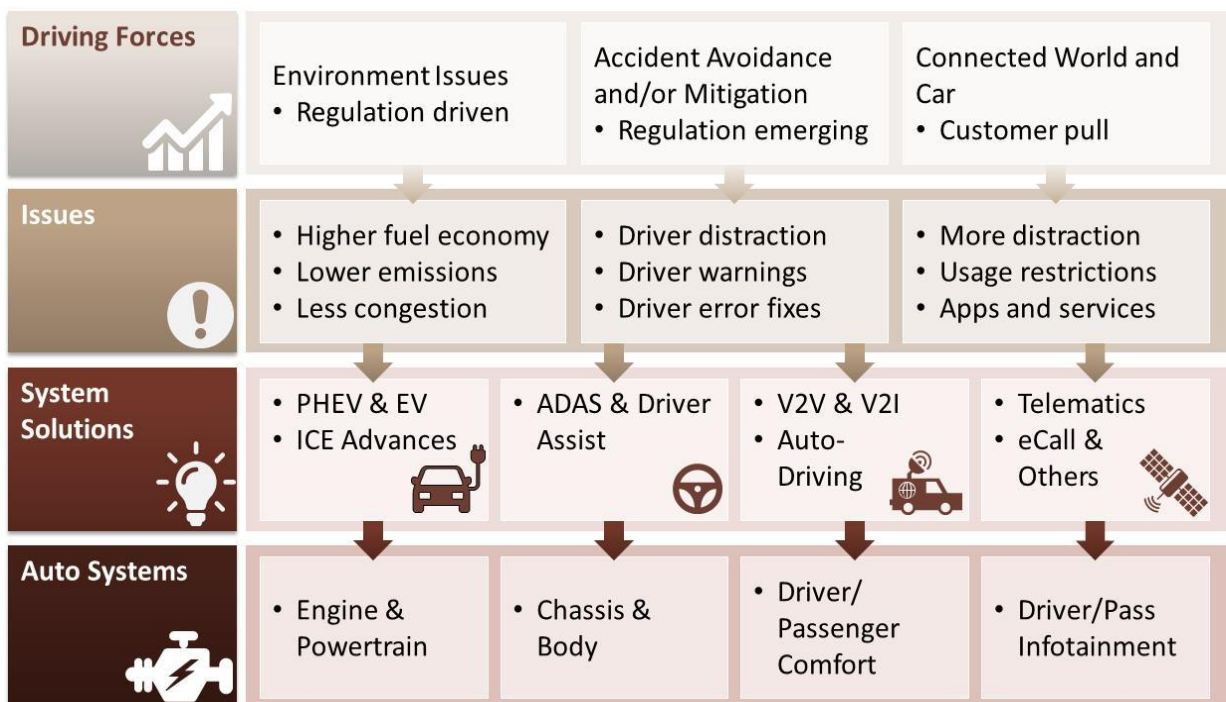
With highly dynamic market scenarios the Asia Pacific market is expected to drive the growth of Auto Electronics worldwide. Government mandate on emission norms and safety norms are the major thrust for the growth of electronics content in Powertrain and Safety programs worldwide.



Introduction of electronic substitutes in vehicles with gradual phase out of mechanical components has fueled the growth of auto electronics market. Legislative and Customer Pull are leading to the advent of new technologies across vehicle segments (PV, CV, and 2W) such as ABS, Rear lighting control, Active Suspension and others. Ninety per cent of innovations in the modern car are based on new developments in electronics. Some of the key technologies expected to be focused by OEMs as well as suppliers across vehicle segments are:

|                               |                                    |                            |
|-------------------------------|------------------------------------|----------------------------|
| Radar                         | Touch Screen Displays              | Digital Instrument Cluster |
| Body Processor                | Rear Lighting Control              | Angle Sensor               |
| ABS                           | Digital Speaker                    | Active Suspension          |
| Collision Avoidance System    | Traction Control Active Suspension | Fuses and Relays           |
| Compressor                    | ESP                                | Vehicle Computer           |
| GPS                           | Immobilizer                        | Seat Adjustment            |
| Regulated Catalytic Converter | Digital Radio                      | V-V/V-X                    |
| Front Lighting Control        | Roof Module                        |                            |
| Engine Management             | Active Suspension                  |                            |

Mega trends such as Urbanization, Connectivity, Emission reduction norms, increase in Active Safety features penetration, and others are driving the growth of technological development in vehicles. These megatrends will eventually accelerate the rise of new technologies across vehicle segments and across program areas.



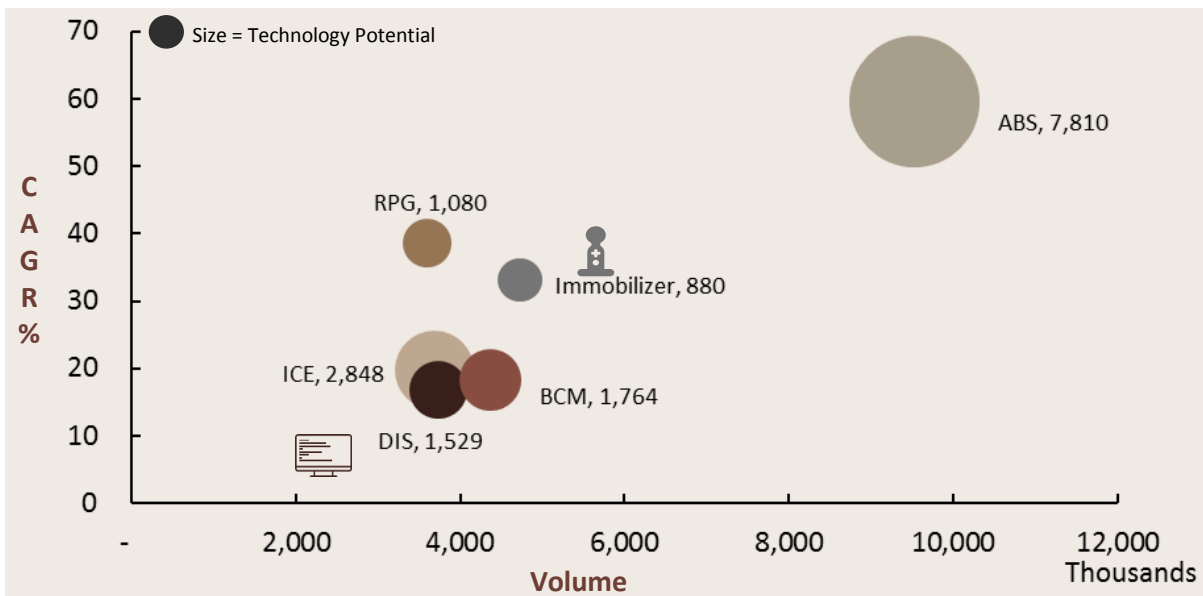
# Growth Opportunity Analysis – Short and Medium Term Technologies

Auto electronics industry in India is currently at a nascent stage and is dominated by the global suppliers. On an average around 65-70% of auto electronics requirements of OEMs in India is met through imports. Product conceptualization and designing of electronic components is primarily done by the OEMs internally while the child parts are mostly imported. Majority of the Indian suppliers are currently assembling imported parts.

To reduce import burden and boost indigenous manufacturing of auto electronics components, comprehensive ecosystem assessment of certain automotive technologies based on their current and future potential is done and they are classified into three categories (Short, Medium, and Long term) as indicated in the chart.

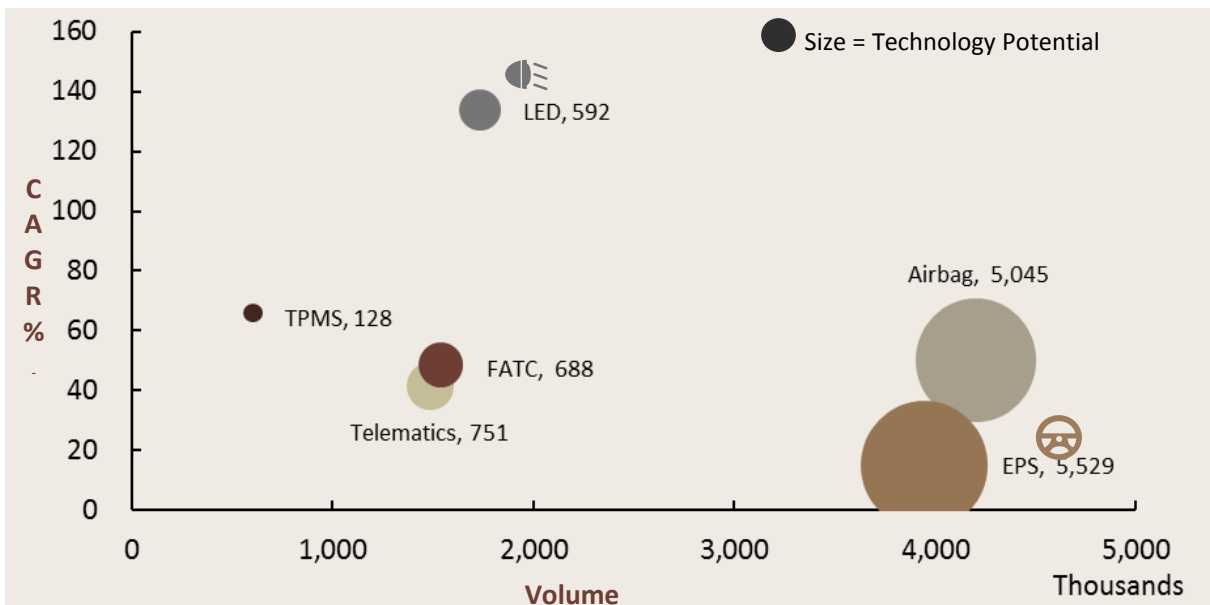
## Short Term Technologies

Short term technologies ABS, RPG, Immobilizer, ICE, BCM, and DIS technologies as compare to Medium and Long term technologies have relatively high penetration across vehicle segments and are expected to generate revenue of INR 16,000 Cr by FY 2020. Know-how for these technologies is readily in the Indian market and some of the Indian suppliers are already developing these systems either in collaboration with a global player or on their own. With ABS expected to become mandatory for PV, 2W segment and the current mandate for Trucks N3 category (above 12 tonnes Gross Vehicle Weight) and buses in the M3 category (above 5 tonnes GVW and carrying nine passengers), it is expected to dominate the short term technology market by generating INR 7,801 Crs by FY2020



**Medium Term Technologies**

Medium term technologies Airbag, LED, EPS, FATC, Telematics, and TPMS are expected to generate revenue of INR 13,000 Cr by FY 2020. Medium term technologies have low penetrations in the current market and are suggested to be targeted by suppliers who have strong financial background and can make huge investment in developing these technologies. Airbag and EPS are expected to dominate the medium term technology market by generating INR 5,045 Crs and INR 5,529 Crs revenue respectively by FY2020.



Note: Potential represents summation of all vehicle categories

Source: Frost & Sullivan analysis

## Action Plans for Indian suppliers – Short and Medium Term Technologies

All the Short and Medium term technologies have varied levels of developed/ undeveloped ecosystem. Here we break down all the technologies into major sub components and based on the Design and Manufacturing capabilities of Indian suppliers we categorize action plans for them. Categorization is broadly done into five key actions; Develop Indigenously, Import and Integrate, Import and Value Addition, Technical Tie ups, and Value Added Service.

Sub Components which are relatively easy to design and manufacture are supposed to be “developed indigenously” by Indian suppliers. Sub components for which technical knowhow is very restricted and there are constraints in domestic manufacturing are supposed to be “Import and Integrate” by Indian suppliers.

Similarly for other categories too we recommend plan of actions for Indian suppliers which are depicted in the table below:

|                         |   | FY 2016   |   | FY 2020   |   | CAGR  |     |
|-------------------------|---|---|---|---|---|---|-----|
|                         |   | XXX   | XXX   | XXX   | XXX   | XXX   | XXX |
| Key Actions             | Technologies/ System <small>(Note: All Revenues in INR Cr)</small>  |   |   |   |   |   |     |
|                         | RPG   | ICE   | ABS   | DIS   | BCM   | Immobilizer   |     |
|                         | 292.9<br>1,080.4<br>38.6%   | 1,387.9<br>2,847.9<br>19.7%   | 1,203.3<br>7,809.7<br>59.6%   | 818.9<br>1,528.7<br>16.9%   | 901.3<br>1,764.4<br>18.3%   | 280.7<br>879.9<br>33.1%   |     |
| Develop Indigenously    | <ul style="list-style-type: none"> <li>• Ultrasonic Sensors</li> <li>• Controllers</li> <li>• Displays</li> </ul> | <ul style="list-style-type: none"> <li>• Speakers</li> </ul>                                | <ul style="list-style-type: none"> <li>• Wheel Speed Sensor</li> </ul>            | <ul style="list-style-type: none"> <li>• Instrument Cluster</li> <li>• Displays</li> </ul>        | <ul style="list-style-type: none"> <li>• BCM</li> </ul>   | <ul style="list-style-type: none"> <li>• RF Based Controller</li> <li>• Transponder Based Controller</li> </ul> |     |
| Import and Integrate    |   |   |   |   |   | <ul style="list-style-type: none"> <li>• Transponder Chip</li> </ul>  |     |
| Import & Value Addition | <ul style="list-style-type: none"> <li>• Camera</li> </ul>  |   |   |   |   |   |     |
| Technical Tie Ups       |   | <ul style="list-style-type: none"> <li>• Head Unit</li> <li>• Rear Seat Displays</li> </ul> | <ul style="list-style-type: none"> <li>• ECU</li> <li>• Modulator Unit</li> </ul> |   | <ul style="list-style-type: none"> <li>• High End BCM (Integration of Safety and Security)</li> </ul> |   |     |
| Value Added Service     |   |   |   | <ul style="list-style-type: none"> <li>• In Vehicle Networking, Communication Protocol</li> </ul> |   |   |     |

Source: Frost & Sullivan analysis

| Key Actions             | Technologies/ System <span style="float: right;">(Note: All Revenues in INR Cr)</span> |                                |                                |  |                                   |  |
|-------------------------|--|--------------------------------|--------------------------------|--|-----------------------------------|--|
|                         | Telematics   | TPMS                           | LED                            | FATC   | EPS                               | Airbag Electronics                       |
|                         | 187.8<br>750.6<br>41.4%  | 16.9<br>128.4<br>66.0%         | 19.8<br>592.1<br>133.8%        | 141.4<br>687.9<br>48.5%                              | 3,142.5<br>5,529.1<br>15.2%       | 994.7<br>5,045.2<br>50.1%                |
| Develop Indigenous      | • Telematics Box   | • Display Unit<br>• Controller | • Housing including Heat Sinks | • Temperature Sensors (Ambient, Sun, Humidity, Duct) | • Motor<br>• Reduction Gear       |  |
| Import and Integrate    |  |                                |                                |  | • Torque Sensor<br>• Angle Sensor | • Airbag Control Unit<br>• Crash Sensors |
| Import & Value Addition | • Telematics Box   | • Tire Pressure Sensors        | • Optics<br>• LED Lighting     | • Controllers  | • ECU                             | • Airbag Module                          |
| Technical Tie Ups       |  |                                |                                |  |                                   |  |
| Value Added Service     | • Mobile Communication<br>• Fleet Management   |                                |                                |  |                                   |  |

Source: Frost & Sullivan analysis

## Market Roadmap for Short and Medium Term Technologies

Based on the sub component level breakup of the technologies and complexity in design and manufacturing we suggest market entry roadmap for Indian suppliers. We broadly suggest three roadmaps;

- a) Become Tier-1 supplier (where the technical know-how is readily available and system manufacturing is already being done by some of the players in India)
- b) Become Tier-2 supplier (where the technical knowhow is limited and sub components are procured by the Tier-1 suppliers for complete system manufacturing)
- c) Become aftermarket supplier (where aftermarket penetration of the product is high)

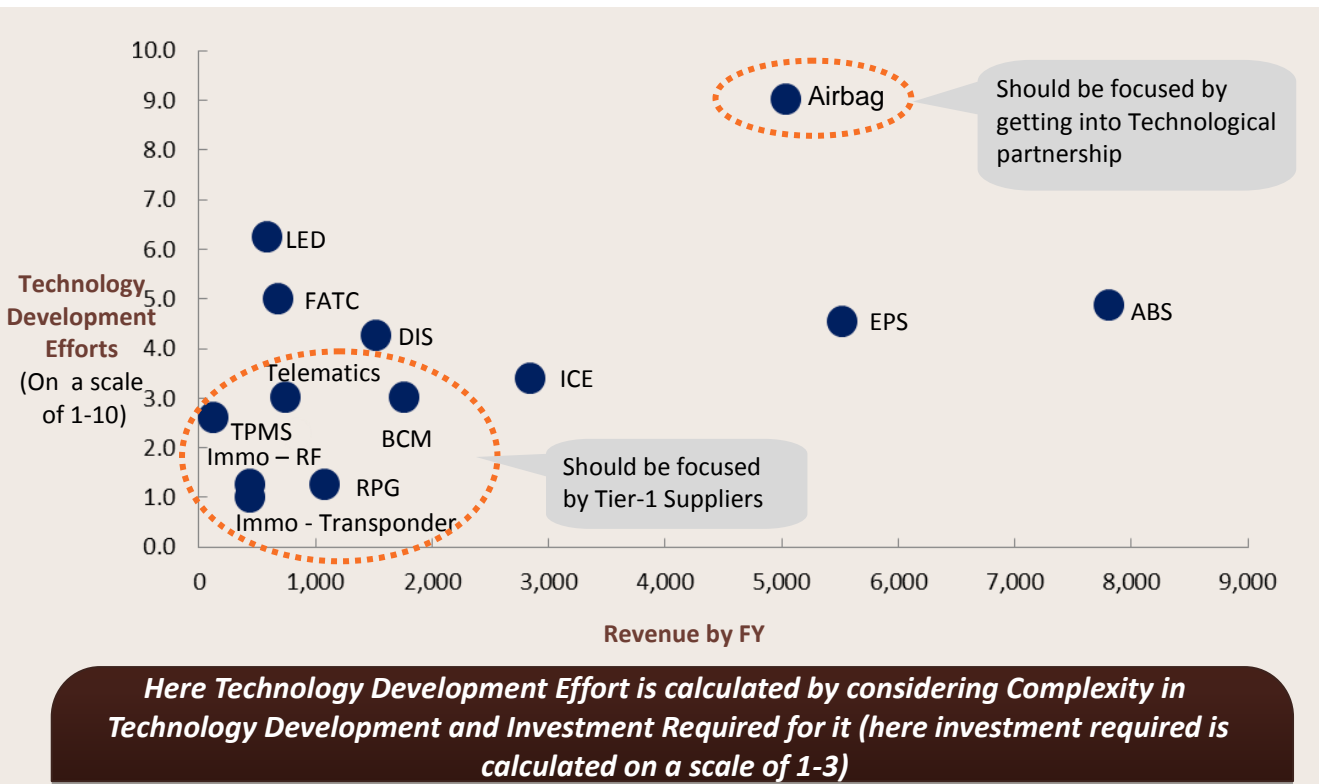
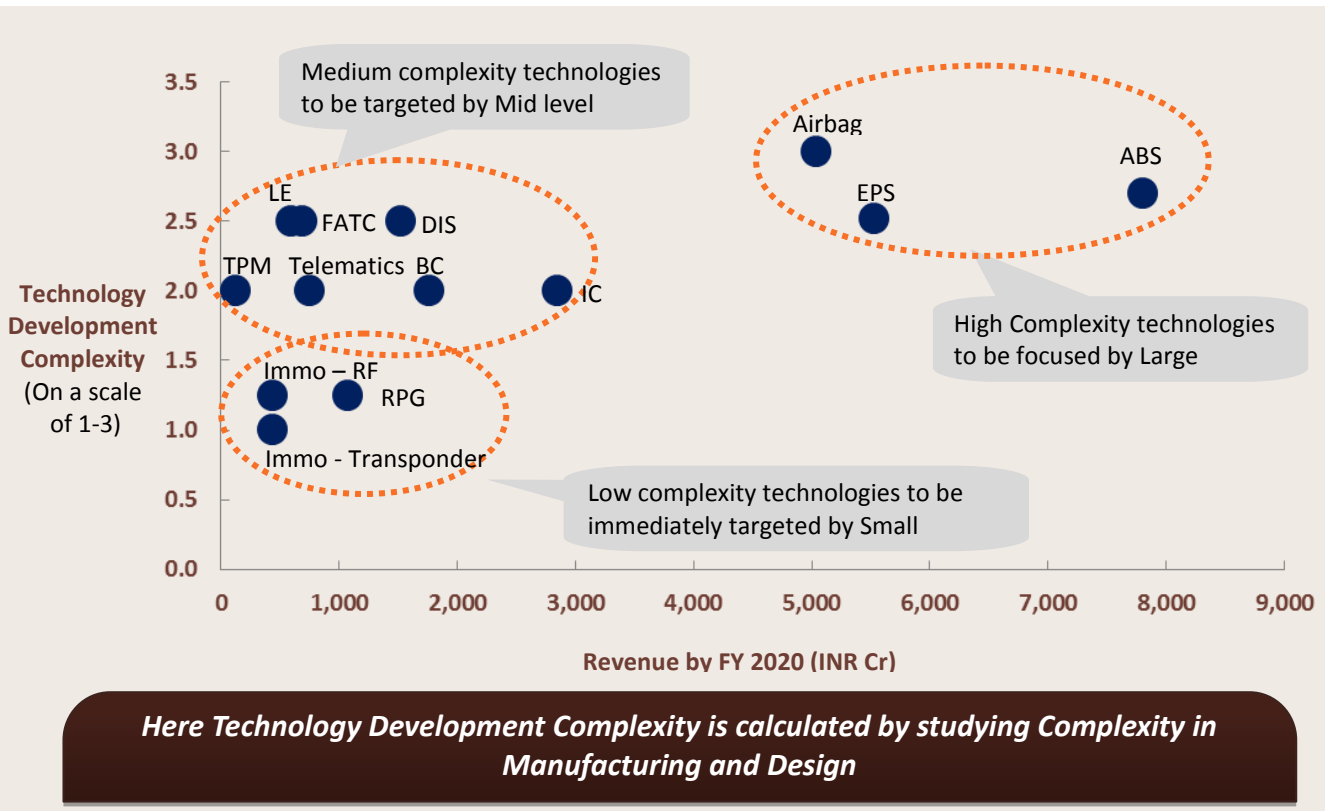
| Key Technologies   | Tier 1<br>(Complete System)         | Tier 2<br>(Sub Components)          | Aftermarket<br>Supplier             |
|--|-------------------------------------|-------------------------------------|-------------------------------------|
|  Reverse Parking Guide (RPG)                | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | <input checked="" type="checkbox"/> |
|  In Car Entertainment (ICE) System          | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
|  Anti Lock Braking System (ABS)             | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/>            |
|  Driver Information System (DIS)            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
|  Body Control Module (BCM)                  | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            |
|  Immobilizers                               | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
|  Telematics                                 | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
|  Tyre Pressure Monitoring System (TPMS)     | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
|  Airbag Electronics                         | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input type="checkbox"/>            |
|  LED based Headlamps                        | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/>            |
|  Fully Automatic Temperature Control (FATC) | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/>            |
|  Electric Power Steering (EPS)            | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/>            |
|  Intelligent Transportation System (ITS)  | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
|  Automated Transmission (AT)              | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input type="checkbox"/>            |
|  Electric Vehicles (EV)                   | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input type="checkbox"/>            |
|  Remote Vehicle Diagnostic System (RVD)   | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/>            |
|  Electronic Stability Program (ESP)       | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/>            |
|  ADAS(Advance Driver Assistance Systems)  | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input type="checkbox"/>            |
|  Powertrain Management                    | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/>            |

Source: Frost & Sullivan analysis

Technologies such as RF, Transponder based immobilizer and RPG system already have good penetration in the Indian market, the technical know-how for these technologies is also readily available, hence these technologies could be immediately targeted by Small suppliers.

Technologies such as TPMS, LED, FATC, Telematics, BCM, and ICE have medium complexity in the manufacturing and design and also the revenue generation is less, these technologies could be targeted by Mid-level suppliers.

Indian suppliers have very limited knowledge on Airbag electronics, ABS, and EPS thus these technologies should be focused by large suppliers, who could make huge investment in building up the technical know-how of these technologies.



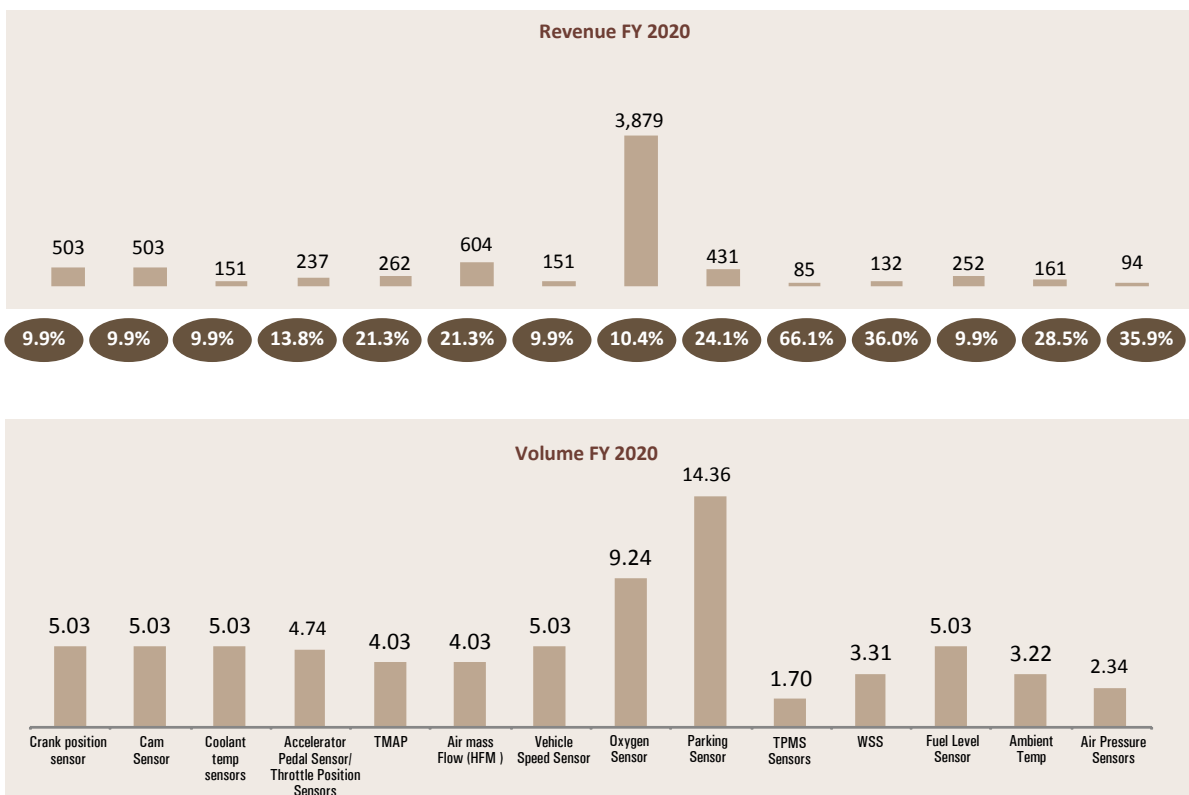


## Sensors and Actuators

Driven by wireless sensing applications and growing embedded controls, sensors and actuators are expected to grow at a rapid rate. Modern-day vehicles are equipped with new technologies which in turn are leading to the growth of Sensors and Actuators market. A Sensor and an actuator integrated with a microcontroller improves the reliability and durability of the entire system. Automakers (Indian and Global) are making India as an export hub and also ramping up the production capacities, this in turn is driving the auto components market.

The charts below illustrate some of the key powertrain, temperature, level, and pressure sensors market in the Indian automotive market (chart 1) and some of the key actuators (chart 2). With growing demand for Powertrain management system crank and cam position sensors should be targeted by the Indian suppliers. Indian supplier’s focus on auto component manufacturing and sourcing to other countries is expected to drive the actuators market. Solenoid and Piezo Actuators to drive the overall Actuators market and could be targeted by the Indian suppliers.

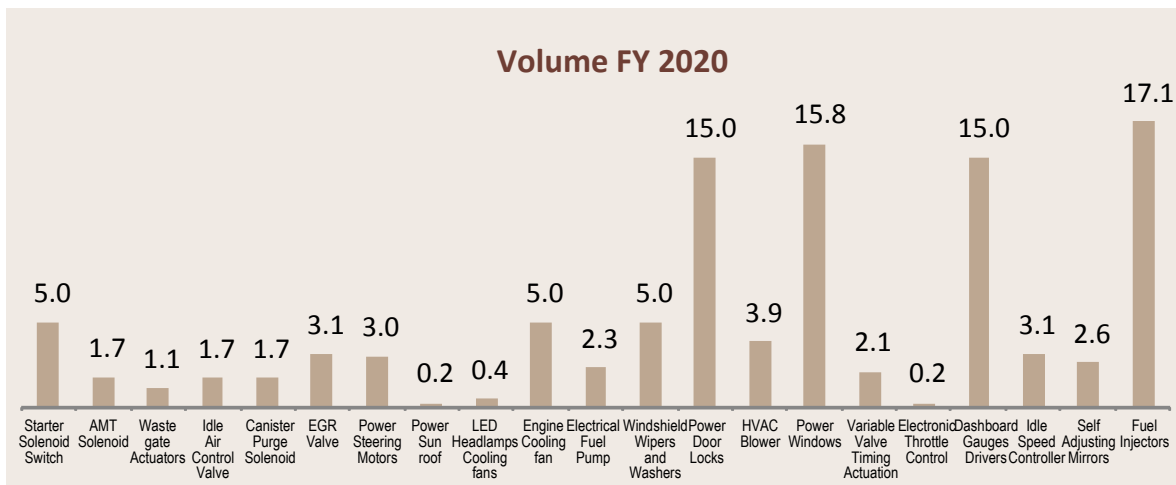
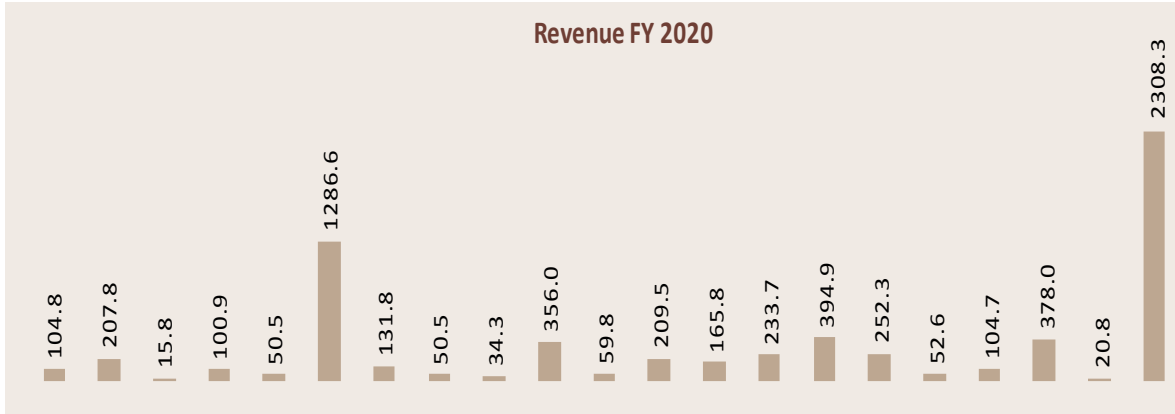
**Key Sensors Revenue (INR Cr) and Volume (Mn Units) FY 2020**



Note: 2 (for PV) Oxygen Sensors, 4 Parking Sensors, and 4 TPMS sensors are required in a vehicle

Source: Frost & Sullivan analysis

**Key Actuators Revenue (INR Cr) and Volume (Mn Units) FY 2020**



Source: Frost & Sullivan analysis

## OEM Feedback on Suppliers

Burgeoning cost pressure on OEMs is compelling them to increase the localization content in cars. OEMs are focusing on procuring components from domestic suppliers to avoid high import duties, and reduce logistics costs at the same time. OEMs are willing to work with Indian suppliers on auto electronics and want suppliers to develop solutions to showcase as well as improve system level understanding.

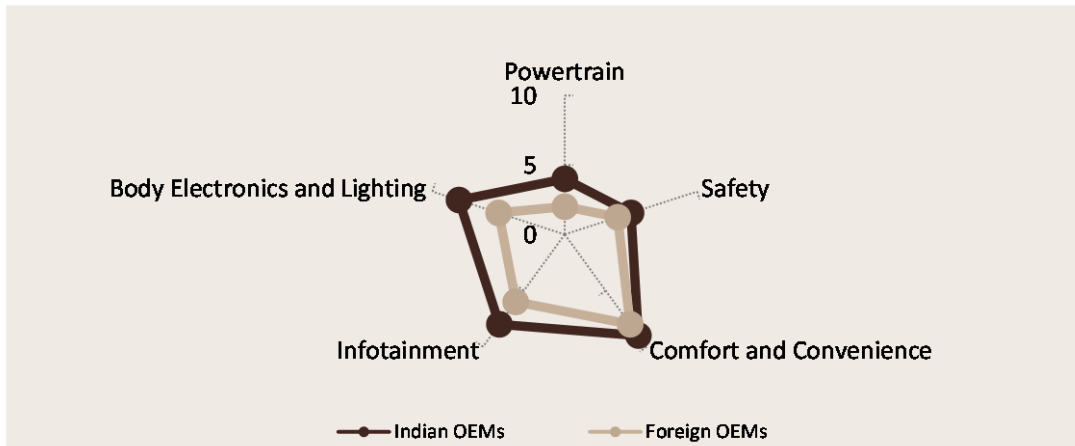
### Feedback of Vehicle manufacturers on Indian suppliers:

- OEMs operating in India are more than willing to work with Indian suppliers in the area of automotive electronics. Indian OEMs (Tata, Mahindra, Ashok Leyland) have shown the highest interest in working with Indian suppliers
- OEMs want suppliers to showcase solutions and **come up with new systems that show improvement on different parameters such as design**, efficiency, cost etc. over existing systems
- Number of Indian and multinational OEMs have opined that Indian suppliers need to improve upon **overall system level understanding** and expect them to have expertise that goes beyond subcomponents
- Non-safety critical program areas such as **comfort and convenience, infotainment** are two program areas where there exists maximum willingness to work with Indian suppliers
- **Quality and reliability** are **two concern areas** for working with new suppliers for automotive electronics according to OEMs as even small issues may lead to recalls and can affect brand reputation
- Future Indian suppliers have to showcase superior reliability through **rigorous testing and validation**

### OEM Willingness to work with Indian Suppliers:

Indian OEMs (Bajaj Auto, Mahindra and Mahindra, Tata Motors, and Others) have high willingness to work with Indian suppliers over Foreign OEMs (Maruti Suzuki, Honda Cars, Hyundai, and Others). Foreign OEMs have set suppliers routed from their parent company; they preferably opt for the same suppliers, leaving very less chance for any new Indian supplier's entry into their value chain.

Indian OEM's willingness to work with Indian suppliers is comparatively high on less critical program areas such as Infotainment, Comfort & Convenience, and Body Electronics over other critical program areas such as Powertrain and Safety due to high level of complexity in manufacturing and design of these domain components.

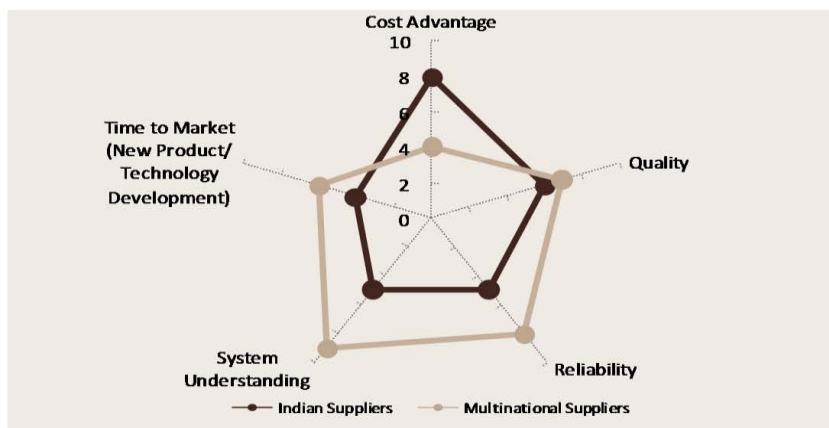


Source: Frost & Sullivan analysis

| Indian OEMs           | Foreign OEMs          |
|-----------------------|-----------------------|
| Mahindra and Mahindra | Maruti Suzuki         |
| Tata Motors           | Hyundai               |
| Ashok Leyland         | Honda Cars            |
| Bajaj and others      | Nissan                |
|                       | Volkswagen and others |

### OEM Perception of Vendor Capabilities:

As India ranks up in the preference list of multinational players to set up state-of-the-art manufacturing facility, opportunities for multinational as well as Indian suppliers also increases in turn. Sensing the opportunities in Indian market, Multinational suppliers are expanding their presence further by getting into JV, technological partnerships, or by Mergers and Acquisitions. Multinational suppliers have an edge over Indian suppliers on most of the parameters such as Quality, Reliability, System Understanding, and Time to Market due to their global presence whereas Indian suppliers on the other hand lead in terms of Cost advantage over Multinational suppliers. Indian suppliers are perceived as strong players in the forging and machining of components over auto electronics understanding



Source: Frost & Sullivan analysis

# Key Research Areas for Indian Suppliers – Long Term Technologies

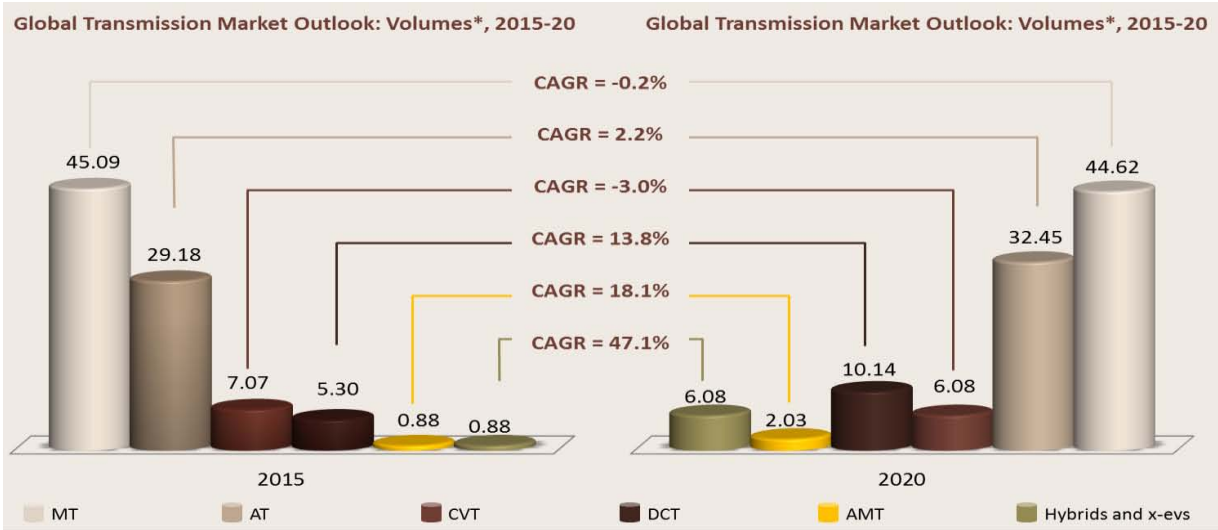
## Key Research Areas for Indian Suppliers in ITS

Intelligent Transportation System is the application of advanced information and communications technology to surface transportation in order to achieve enhanced safety and mobility while reducing the environmental impact of transportation. Indian suppliers as explained below can focus on certain research areas such as Wireless communication, Computational technologies, Sensing technologies, Video vehicle detection, and Probe & smart vehicles.

- **Wireless communications** - GPS, DSRC (Dedicated Short Range Communications), Wi-fi, Mobile communication
- **Computational technologies** - Microprocessor modules with hardware memory management and Real-Time Operating Systems. Software applications including model-based process control, artificial intelligence, and ubiquitous computing.
- **Sensing technologies** - State-of-the-art microchip, RFID (Radio Frequency Identification), and inexpensive intelligent beacon sensing technologies. Infrastructure sensors are indestructible devices that are installed or embedded in the road or surrounding the road
- **Video vehicle detection** - Traffic flow measurement and automatic incident detection using video cameras
- **Probe & smart vehicles** - "Floating car" or "probe" data collection for obtaining travel time and speed data for vehicles traveling along streets, highways, freeways, and other transportation routes.

## Global Transmission Outlook

To curb global warming and improve fuel efficiency, OEMs as well as suppliers are working on the transmission system, and as a result diversification in transmission types is growing. As depicted in the chart below AMT is expected to gain momentum globally due to increased demand from markets like India & China. Most global suppliers are likely to set up local manufacturing units for AMTs in India in the next few years. Global AMT market is expected to increase from 0.88 Mn Units to 2.03 Mn Units by the year 2020. On the other hand, Hybrids and xEV are also expected to gain traction in the market; it is expected to grow at a CAGR of 47.1% by the year 2020.



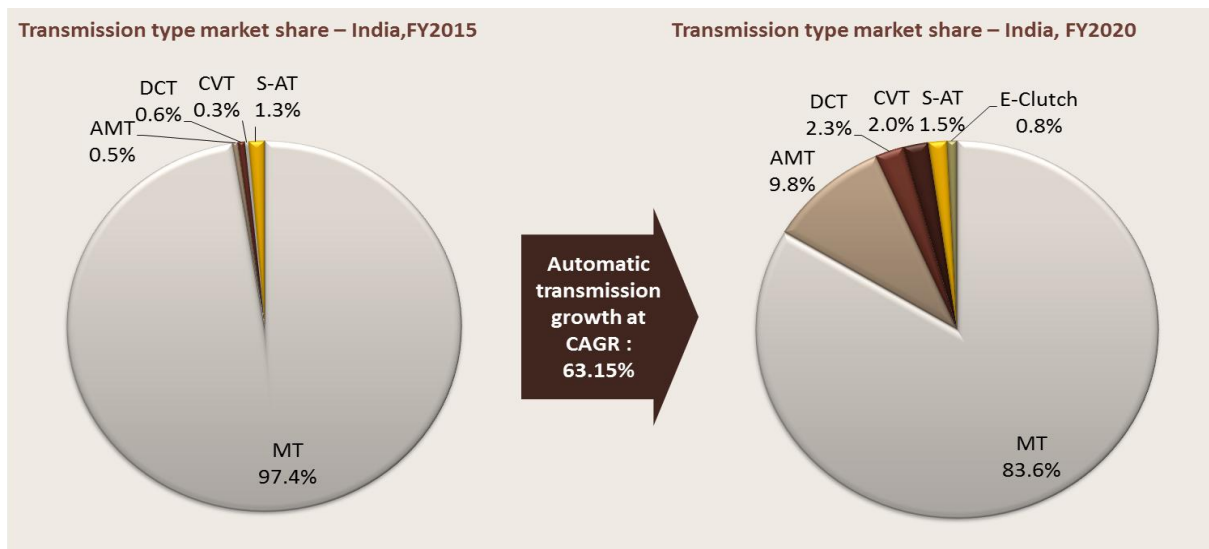
Note: All figures are rounded. The base year is 2015. Source: Frost & Sullivan

\*Volumes in million units

Note: Only PV Volumes considered

## Growth of Automatic Transmission in India

Figure illustrates the current and expected share of transmission in the Indian market, by 2020 AMT is expected to be the biggest gainer with market share growing from current 0.5% to ~10% followed by DCT from current 0.6% to 2.3% and CVT from current 0.3% to 2.0%. AMT penetration is expected to increase AMT & DCT poised to gain market share whereas stepped-AT to show weaker growth despite growth on overall numbers.



Source: Frost & Sullivan analysis

## Key Research Areas for Indian Suppliers in AT

Transmission and Clutch actuators should remain the focus areas for Indian suppliers while long term partnerships on AMT ECUs could be forged with research companies. 2W AMT to be attractive in the short term in India.

### Program Select Lever

- Used for selecting various drive modes, such as Neutral, Park, Drive.
- This selector is also used for manually shifting the gears

### Transmission Control Unit

Electronic control module which provides command for shifting → to both **clutch and transmission actuator** based on

|                      |                |
|----------------------|----------------|
| Gas pedal position   | Ignition       |
| Brake pedal position | Engine speed   |
| Clutch position      | Load condition |
| Shifter position     |                |

### Sub components (Typical)

Microprocessor: Usually 32-bit Microcontroller  
Sensors: 4x position, 4x speed, 1x temperature.  
2x pressure

### Actuators

#### Transmission Actuator

- Actuates different gears as per input from transmission control unit
- Fully automated or manual override modes are available

#### Clutch Actuators

- Activates/deactivates clutch, as per input from transmission control unit

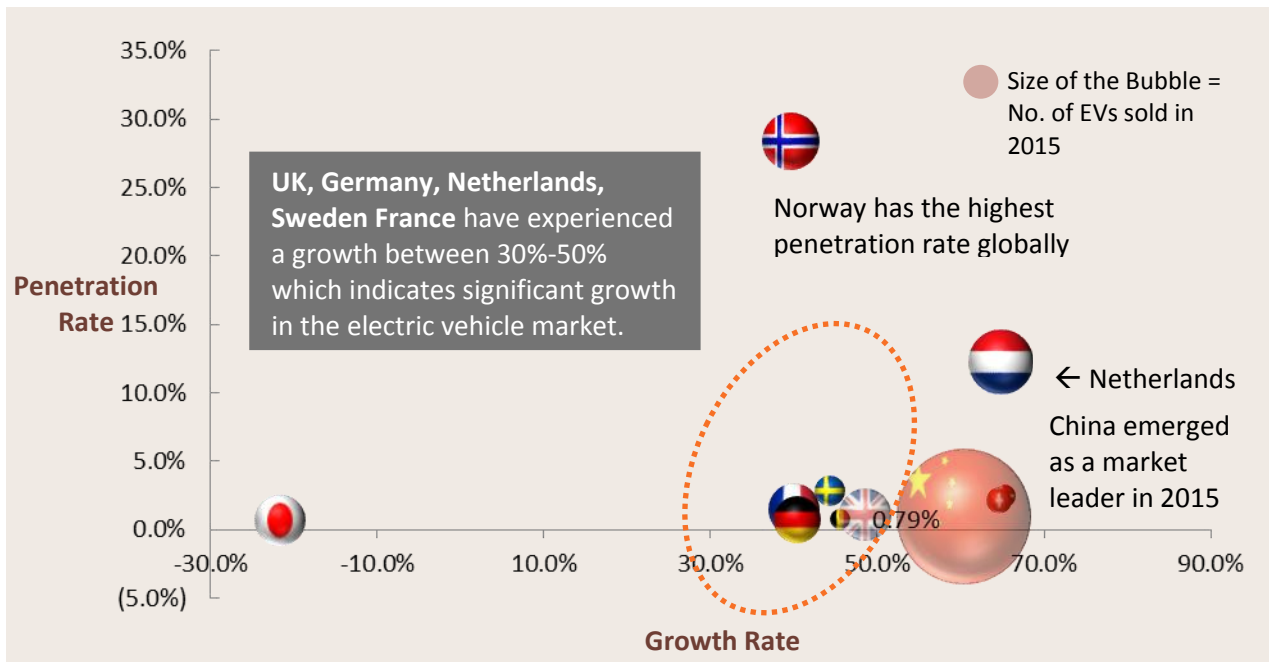
### Sub components (Typical)

- Actuator solenoids : 11 solenoids

## Electric Vehicles (EV) Growth Analysis

As depicted in the chart below, China has emerged as a leader in EV sales in 2015 recording a growth over 60%, whereas Norway has the highest penetration rate globally. UK, Germany, Netherlands, Sweden France have experienced a growth between 30%-50% which indicates significant growth in the electric vehicle market.

### Electric Vehicle Growth Analysis by Country 2015



Total EV Market: Growth Analysis by Country, Global, 2015

Source: Frost & Sullivan analysis

## India's Connected 2 Wheeler

Ather's S340 e-scooter marks foray of connected vehicle technology into Indian 2 wheeler industry. Their e-scooter S340 is a cloud-based connected vehicle. The S340 comes with touchscreen dashboard and integrates cloud based data to help personalize the consumer ride experience. There is a S340 Mobile App as well which keeps the rider connected with the vehicle, to configure ride and profile preferences and sync navigation routes remotely.

Some of the key features of e-scooter are:

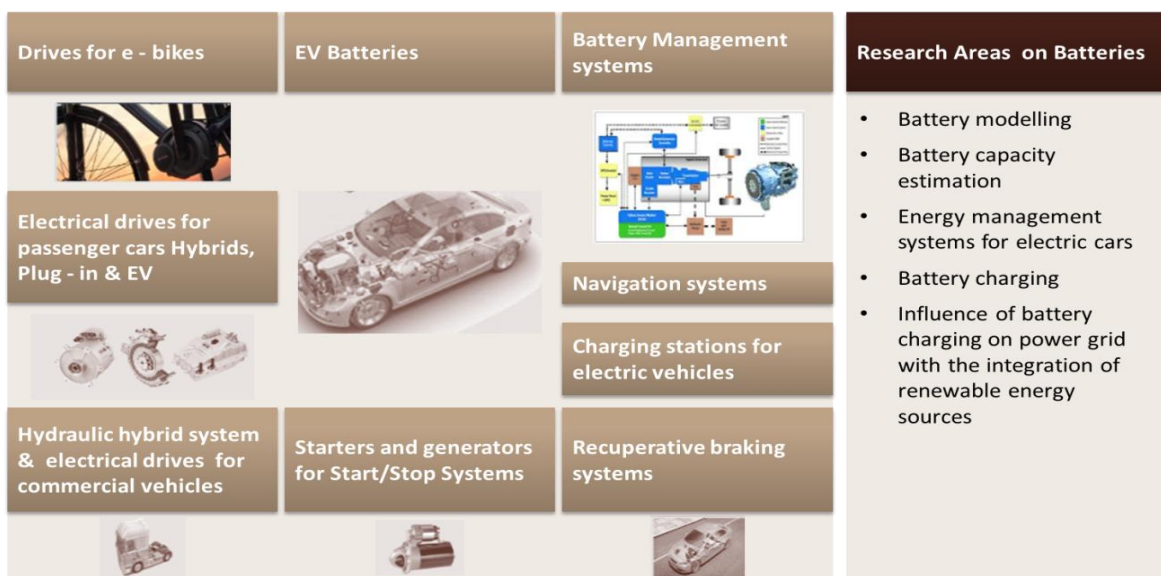
- 200 mm Front & Rear Disc Brakes
- On board navigation
- 3kW/ 5kW motor
- **0-60 kmph: 11 Sec**
- **Top Speed:72 kmph**
- **Range per full charge:60 km**
- **Fast Charging:80% in 50 minutes**
- Predictive analytics and aggregation of ride statistics enable customized recommendations.





## Key Research Areas for Indian Suppliers in EV

Thrust on green vehicles is expected to increase across the globe due to multiple initiatives taken by the Governments and OEMs to counter environmental issues rising at an alarming rate and also to solve rising fuel consumption and costs. To promote low carbon transport in India the National Electric Mobility Mission Plan (NEMMP 2020) was released by the Ministry of Heavy Industry and Public Enterprises. Recognizing the growing demand for Electric Vehicles, OEMs are gearing up with plans to include more and more number of Electric Vehicles in their product portfolio Indian suppliers could focus on Battery Management in the EV market. It is expected to emerge as a major scope for technology development. The key research areas include Battery Modelling, Battery Capacity Estimation, Energy management systems for electric cars, Battery charging, Influence of battery charging on power grid with the integration of renewable energy sources.



Source: Frost & Sullivan analysis

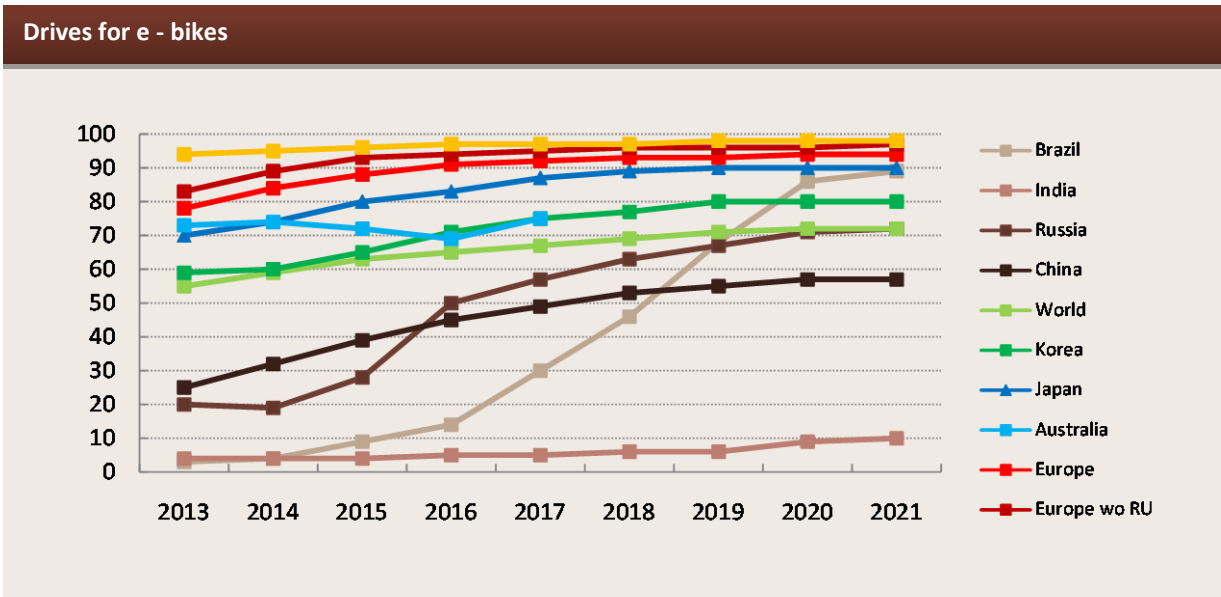
## Key Research Areas for Indian Suppliers in Remote Vehicle Diagnostics (RVD) System

Remote Vehicle diagnostics is the ability to remotely examine automotive fault codes and wirelessly communicate data to a server, where the information is stored, analysed and managed. Indian suppliers could focus on the competencies development for managing complete diagnostic centres - Web server, Data base, Vehicle specific details.

- Passive & periodic Diagnostics
- Facility of Vehicle initiated Fault notifications
- High end systems including Prognostics
- ECU re-programming for remote code updates
- Remote management of vehicle recalls
- End to end service providing

## Worldwide Electronic Stability Program (ESP) Penetration

Increasing road fatalities and accidents has led to the demand for advanced safety and driver assistance systems worldwide. With very low penetration (4-5%) today, ESP has a huge potential in India in the next few years as government may mandate the use of this technology like in Europe and NA. The chart below illustrates worldwide penetration rates for PCs and LCVs <6T.

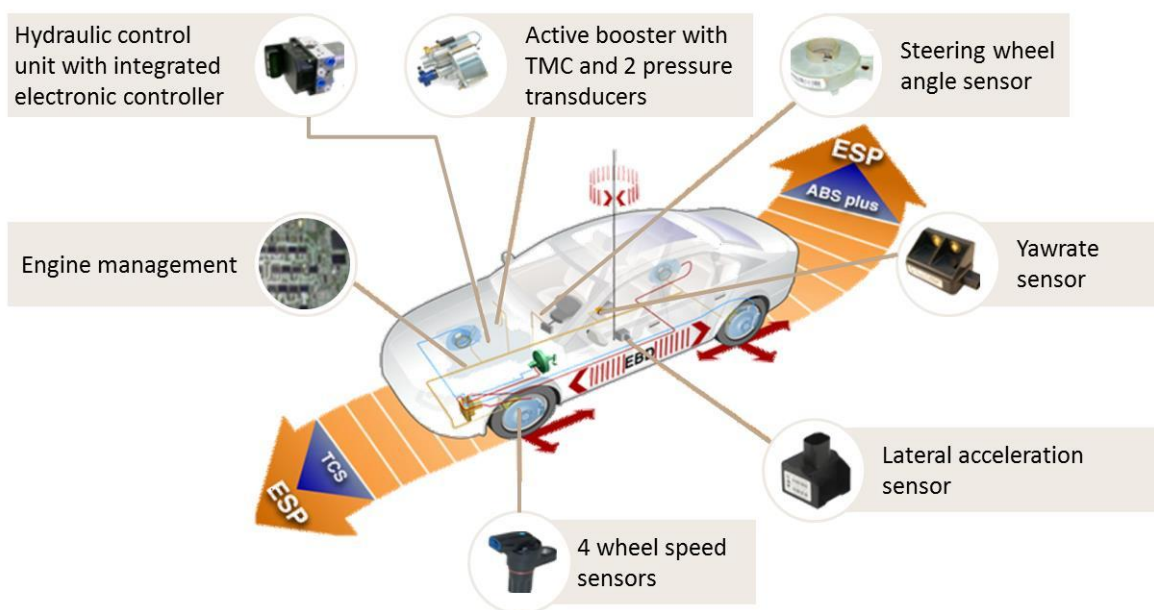


Based on production of passenger cars and LCV < 6t

Source: Frost & Sullivan analysis, Bosch

## Key Research Areas for Indian Suppliers in ESP

One of the major reasons behind road accidents is vehicle skidding, and the solution to this problem is ESP. ESP protects the car with a number of systems along with an Antilock Braking System and Traction Control System. With growing demand for safer vehicles to prevent skidding, OEMs are expected to install ESP in upcoming cars in the near future. In present scenario Indian suppliers do not have the capabilities for complete ESP system development, but with the expected growth of ESP system in the Passenger Vehicle segment the Indian suppliers should focus on manufacturing sensors and actuators for ESP while long term focus should be on ECU development for ESP.



Source: Frost & Sullivan analysis

## Key Research Areas for Indian Suppliers in ADAS

ADAS are multiple safety systems aimed at increasing car and road safety. Depending upon the driving culture in India, suppliers have to work on dedicated ADAS for Indian Automotive market.

Government has de-licenced use of devices or wireless microphones in the frequency bands of 36-38 MHz, 433-434.79 MHz, 302-351 kHz and 76-77 GHz. De-licensing of these low frequency bands has enabled the vehicle manufacturers to use this frequency through radar-based system and focus on selective ADAS features development.

Indian suppliers should focus on the development of sensors and actuators primarily; Systems Integration, Validation and Communication Architecture to be focussed in partnership with established global player.

**Technology inside car**

- Components/sensors, actuators
- Sensor optimization (cost, resolution, form factor, lifetime)
- Road condition sensors
- HAD certified sensors
- Embedded laser scanner

**System integration & communication architecture**

- Development of centralized and decentralized architecture for real time assessment and actuation at low power and low computational efforts with redundancy
- Vehicle – VRU communication
- Data integrity
- Negotiation between cars & cars and others
- Embedded HW system architecture

**System design**

- Improve adequacy and efficiency of reliability/robustness test strategies (physics of failure, combined loads)
- Comprehensive understanding of failure mechanisms
- Implementation of virtual techniques (testing, FMEA prototyping)
- Validation technology
- Data base for use cases

**Standardization**

- Vehicle certification (market access, UNECE)
- Traffic signs (signalization)
- Car 2X signals
- Vehicle functions (steering and lighting system)

**System integration and validation**

- Sensor fusion, environment models
- Logistics for lifelong maintenance
- AUTOSAR for HAD
- Traffic scene interpretation
- Design of tests
- Sensor stimuli
- Test (simulation) system

## Key Research Areas for Indian Suppliers in Powertrain

Powertrain being one of the most critical program area has very limited scope of opportunities left for Indian suppliers. Power train management revolves around one major goal: improving efficiency in ways that maximize driving performance while minimizing emissions. However, in the long run Indian suppliers can focus on Engine Management and Emission Control System.

### A) Engine Management system:

- **Microprocessor :**
  - Increasing Computing capabilities
  - Integration of enhanced signal processing and real-time control into single-chip systems
- **Sensor:**
  - Integration of sensor cells with signal conditioning to produce “active sensing” device
- **Power control Integrated circuits :**
  - Increase power IC content to broaden the variety of choices for consumers and accommodate the increasing demand for higher fuel efficiency as well as optimized performance

### Emission control systems:

- **EGR systems :**
  - This involves recirculating a controllable proportion of the engine's exhaust back into the intake air.
  - Electronic Component – EGR Controller – Solenoid
- **SCR System :**
  - This system uses a urea based diesel exhaust fluid (DEF) and a catalytic converter to significantly reduce oxides of nitrogen (NOx) emissions
  - Electronic component- DCU (Dosing Control Unit),- Urea Level Sensor,- Urea Quality Sensor
- **Alternate fuel :**
  - Cleaner fuels with reduced sulphur content contribute significantly to lower emissions.
  - Growing interest in CNG/LPG/LNG
  - Other alternative fuels being tested or used on a limited basis include Biodiesel, Methanol and Ethanol, Hydrogen and Electricity.



## Competencies Required for Auto Electronics Manufacturing and Design

Indian suppliers have strong hold on the hardware manufacturing/ forging/ machining of the components, but are relatively new in the field of auto electronics design and manufacturing. Due to the lack of technical know-how and unavailability of infrastructure support for Auto electronics manufacturing, most of the demand in India is predominantly met through imports from China, Korea, Taiwan or some other global destination. To seize the growing opportunities in the auto electronics manufacturing and design suppliers can focus on developing capabilities in the below mentioned areas:

### Capabilities required for Manufacturing:

- PCB Manufacturing Techniques
- SMT (Surface Mount Technology) based automated production lines
- ESD (Electrostatic Discharge) precautions in handling electronic components
- In circuit testing techniques
- PLC (Programmable Logic Controllers) based automated techniques

### Capabilities required for Design:

- Hardware design and testing methods and integration with the software
- In vehicle Networking - Implementation and testing of CAN/ LIN/FlexRay/MOST network
- Verification of analog, radio frequency, communication, digital or control electronic circuits, subsystems and systems (e.g., hardware, software, hybrid); applications development (software, security and programming)
- Software life-cycle process including specification, design, implementation, change control, and testing
- Proficiency in use of LabVIEW and MATLAB, Simulink tools for design and simulation of interfacing systems
- Micro-controller based embedded controller systems in the field of automotive control
- Sensors and Interfacing
- Environmental factors & protection
- Vehicle systems engineering, including how combinations of electronics and mechanical design are used to jointly achieve safety objectives
- Cyber security of automotive electronic control systems
- Existing relevant design and testing standards (SAE, ISO, IEEE, etc.)
- Vehicle design and testing methods





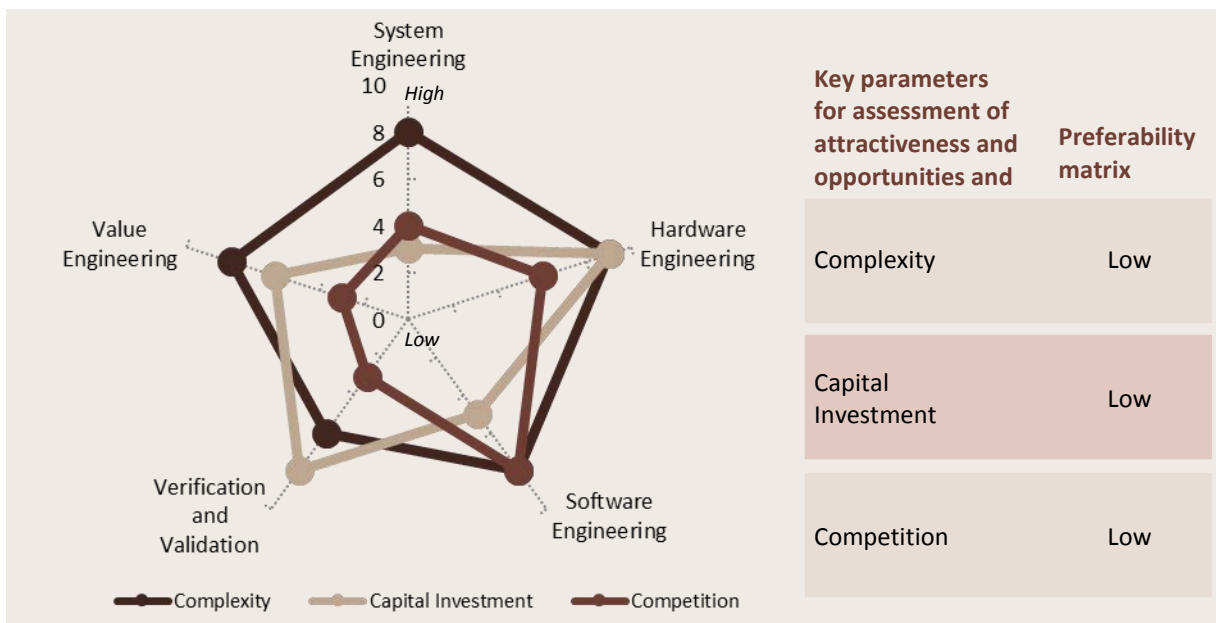
## Embedded Engineering Services

Indian automotive industry due to the legislative and customer pull is witnessing proliferating need for electronics and embedded engineering services across all vehicle segments. Embedded System is a combination of hardware and software, specifically designed for a particular function. Embedded product lifecycle services include the following activities:

- System Engineering
- Hardware Engineering
- Software Engineering
- Verification and Validation
- Value Engineering

Out of the above mentioned activities System and Value Engineering with lower capital investments requirement and lower competition offers Indian suppliers excellent growth opportunities in embedded systems space.

### Embedded System Activities – Overall Attractiveness and opportunities assessment



Source: Frost & Sullivan analysis

**Challenges faced by the suppliers in Embedded Engineering services are:**

- **Adaptability:** Responding to customer needs rapidly, adopting new technologies and standards
- **Cost Control:** Rising cost of creating tools and supporting multiple customers
- **Product Lifecycle:** Shorter shelf life of products and technologies causing serious engineering and technologies disruptions
- **Time to Market:** Enormous pressure on time to market for all products

**Focus area for Indian Suppliers:**

End-to-End system development, Multiple domain expertise, and Low engineering costs are the major areas to be focused by Indian suppliers in Embedded Engineering Services.

- **End-to-End System Development:** System capability ranging from sensing technology to embedded firmware, software, and hardware design and development.  
*For Example: Telematics, ITS, RVD, TPMS*
- **Multiple Domain Expertise:** Diverse expertise across various automotive systems to leverage and apply for greater resource utilization and value addition.  
*For Example: ABS (Brake Systems), DIS (Vehicle Control Systems), BCM (Body Control Systems)*
- **Low Engineering Costs:** Continuous productivity improvement, improving and virtualizing lab resources, and expertise in design implementation.  
*For Example: RPG, Immobilizer*

## Testing Facilities

Increase in electrical and electronics content in a vehicle increases the possibility of these components being exposed to some external sources of energy causing interferences with other electronic or electrical equipment thus resulting in unanticipated changes in the system operation.

### Critical Tests Required for Electronic Systems:

Three categories of tests primarily required for any electrical/ electronic system are EMI/ EMC, Reliability, and Durability Tests. EMI/EMC and Reliability Test facilities are available at ARAI (Pune), iCAT (Manesar), and VRDE (Ahmednagar) while the Durability Tests are primarily done by the Component Manufacturers/OEMs.

- **Types of EMI/ EMC Tests:**

Radiated Emission, Radiated Immunity, Conducted Emissions, Conducted Immunity, Transient Voltage, Electrostatic Discharge (ESD), EMI Scanning

- **Types of Reliability Tests:**

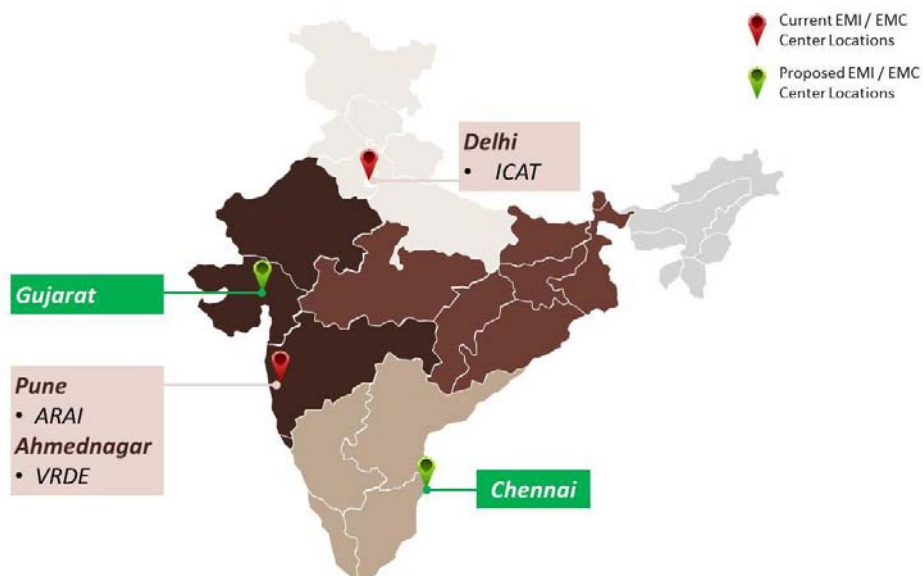
Combine Temperature and Vibration, Cyclic Temperature and Humidity, Altitude Tests, Water Spray Test, Dust Test, Thermal Shocks

- **Types of Durability Tests:**

Service Life Test, Endurance Test

### Current EMI/ EMC Testing Facilities:

As part of NATRIP test centers at GARC Chennai, iCAT Manesar, VRDE Ahmednagar, and ARAI Pune have been finalized to set up the test facilities.



Source: Frost & Sullivan Analysis



## Software Verification and Validation (V&V)

Indian automotive industry is witnessing a major transformation of replacing mechanical components with electronics and software in all the program areas be it Powertrain, Safety, Body Electronics, or Lighting Systems. Around 80-90% of the innovations in the Indian automotive industry are software controlled innovations. Software systems are believed to account for up to 30-40% of the vehicle's manufacturing cost. With this influx of electronics and software content in a vehicle the software quality levels has become the major area of concern for vehicle manufacturers. To mitigate the risks associated electronics and software intensive systems the need for software verification and validation has evolved.

**Software Verification:** Process of evaluating the intermediary work products of a software development lifecycle to check the right track of creating the final product

**Software Validation:** Process of evaluating the final product to check whether the software meets the business needs

Steps involved in software verification and validation activities are as follows:

- Developing test strategies
- Developing validation and verification plans and scripts for vehicle subsystems
- Ensuring testability of software requirement with formal techniques
- Static code checks & analysis using tools like RTRT, Polyspace, QAC & PC-Lint
- Test suite generation using scripts and modeling tools like Labview
- Automated/ Manual Test execution and fault tracing
- Defect identification and verification
- Validation on vehicle simulators/ labcars
- Validation of automotive software at various levels of testing starting from unit level until system testing

Typical Tools used for software verification and validations are:

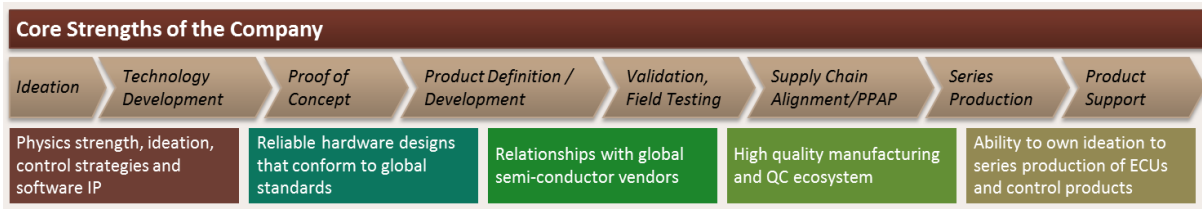
- a) Visual Test: Regression Testing Tool for GUI
- b) Labview, Test Stand: Test suite development
- c) INCA, Labcar, MDA, CANalyzer: Automotive Unit Integration and System Testing
- d) Perl, Tcl, Python: Test scripting languages
- e) Trace32, iONE, GDB, BDI: Debuggers



# Case Studies

## SEDEMAC Case Study

|  |   |  |   |
|--|---|--|---|
| <b>Foundation:</b><br>2008                       | <b>Legal Form:</b><br>Private Limited   | <b>Founders:</b><br>Mr. Shashikanth Suryanarayan<br>Mr. Pushkaraj Panse<br>Mr. Amit Dixit<br>Mr. Manish Sharma | <b>Corporate and Tech Centre:</b><br>Pune |
| <b>Market:</b><br>Two Wheelers<br>Diesel Gensets | <b>Customers:</b><br>Bajaj, TVS, Mahindra, Hero<br>Powerol, Koel Green, Leypower, Tafe,<br>Cooper Corp, Cummins, Eicher | <b>Products</b><br>Two Wheeler Controls<br>Genset Controls   |   |



**SEDEMAC** raised funding close to \$7.5 million (about INR 50 Cr.) from Nilekani and existing investor Nexus Venture Partners. Intent of this funding is to invest in control solutions for the PV and CV segments.

The **SEDEMAC** team plans to invest the funds to scale up and expand into the global market including China and the

### Product Range

- Novel spark timing solution
- Delivers “best possible” fuel economy
- Throttle position sensor eliminated
- Forward-looking solution: Algorithm applicable to future control technologies ISG, AMT, EFI, etc.
- Implemented on 2 Million + vehicles (as on Jun ‘15); ZERO Failures
- Estimated 20 Million Kg CO<sub>2</sub> saved

## KPIT Case Study

### Company Overview

- Headquartered in India
- Listed on NSE and BSE INR 3,000 Cr. Revenues
- 10,000+ Employees worldwide
- 60+ Patents filed in less than 5 years
- 32% CAGR growth recorded from FY12-FY15 for Business in India
- Winner of 9 Innovation Awards in last 3 years

### Business IT

- Domain-led ERP, Surround ERP, Big Data, Analytics, Cloud, Warranty, PLM, Enterprise Cost Management

### Engineering

- Powertrain, Safety, Infotainment, Diagnostics, Telematics, In-Vehicle Networking, MEDS, Body and Chassis, IoT, Products & Platforms

| Tools                                 | Platforms                               | Products                                  |
|---------------------------------------|---|---|
| K-SAR - R4.0.3 solutions              | KIVI – In-Vehicle infotainment          | Battery Management Systems                |
| Vehicle Diagnostics tools             | KONNECT- Connectivity                   | Intelligent Transport System              |
| Medini – Functional safety tool chain | KPIoT – Big Data and Analytics Platform | Revalo – Plug in parallel Hybrid solution |

### Largest Transportation Technology company to provide **Device + System Integration + Backend IT operations + On Ground Support**

- India’s 1<sup>st</sup> and largest UBS II compliant ARAI approved ITS
- In ITS and UBS-II specifications due to ability to build robust products with military grade specs
- Pan India implementation for NHAI including patrol vans, ambulances and toll trucks
- Major Users of OBITS: CSTC (Kolkata), APSRTC (Hyderabad), PRTC (Puducherry), NMMT (New Mumbai), TMT (Thane), KDMT, SMT (Solapur), HRTC (Himachal), KSRTC (Kerala), ASTC (Assam), MBMT
- 4000+ ITS Systems manufactured and installed on various vehicles; 3000+ UBS-2 Compliant Systems on road
- Recommended National level ITS Architecture and Standardization guidelines to institutes like BIS and ASRTU



### KPIT's Electric Bus Solution

- Indigenously Developed
  - IP is owned by KPIT
  - Designed specifically for Indian conditions
  - Over 5 years of experience in hybrid and electric technologies
  - More than 22 patents in the field of hybrids
  - MoU with CIRT for road testing and validation
  - Versatile system, variety of buses
- 
- **Certified by ARAI** (Homologation completed)
  - Applicable on a **wide range of vehicles**
  - Technology showcased to the **Prime Minister of Malaysia** for adoption on fleet of **Malaysian Royal Police** (discussion in process)
  - Numerous **Innovation Awards**
- 
- An intelligent, plug-in, parallel hybrid solution, developed by KPIT and Bharat Forge Limited
  - Both KIVI and Konnect have been sourced for production by Global OEMs and the platforms are expected to be part of models rolled out in 2017
  - Certified by ARAI for JnNURM-II specifications



# Summary – Short and Medium Term Technologies

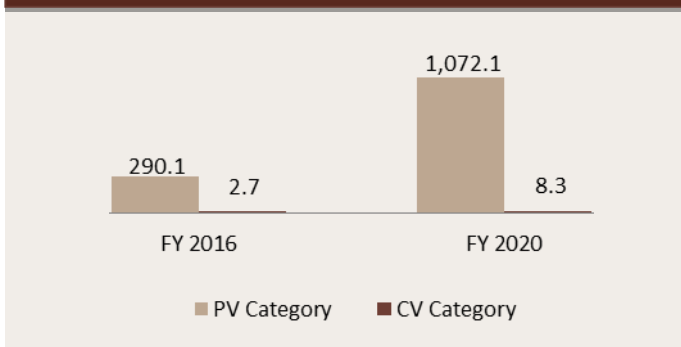
## RPG Summary

**RPG:** It helps the driver sense when objects are in the vehicle's "blind spot," through a audio warning or a visual display. In basic system sensors mounted on the bumper detects the distance of obstacles from the extremities of the car and give an audible beep depending on the distance of the obstacle. A step up, a rear facing camera with a wide angle lens, mounted high and pointing slightly downward, give a broad field-of-view around the back of the car. Increase in demand for assistance in parking is driving the RPG market, it is expected to grow from INR 293 Cr to INR 1,080 Cr at a CAGR of 38.6% over next four years

### Major Components and Share by Value (%)

- Ultrasonic Sensors: 20%
- Controllers: 20%
- Displays: 35%
- Cameras: 25%

Current Market and Forecast (INR Cr)



**Market Trends**

- CCD (Capacitor Coupled Devices) camera preferred for Passenger Vehicle application
- Bumper mounted, water resistant, and vibration resistant sensors used for the PV application
- Controllers suitable for mounting on body
- Integrated Controllers and Buzzers are being used
- Colored LCDs with mirror finish used as a part of Rear view mirror for Camera based RPG
- LEDs displaying distance used for Ultrasonic based RPG

**Key Players**

- Interface Microsystems
- Autocop
- Xenos Technologies

**Technology Evolution**

Ultrasonic → Camera → Park Assist → Automated Parking

**Opportunity Analysis and Recommendations****Short Term**

- Focus on manufacturing Ultrasonic sensor based RPG for aftermarket/ OEM
- Focus on developing LED displays for the RPG

**Medium Term**

- Develop integrated solutions with Camera, Ultrasonic sensors, and LCD displays integrated in rear view camera

**Long Term**

- Build expertise on the development of Park Assist and Automated Parking System

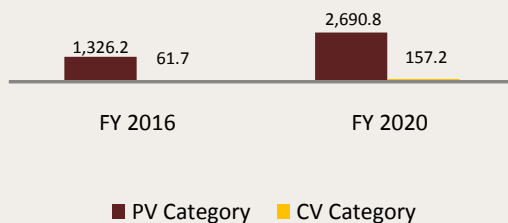
## ICE System Summary

**ICE System:** It is integrated infotainment systems in automobiles that deliver entertainment and information content. Typical tasks that can be performed with an In car entertainment system include managing and playing audio content, utilizing navigation for driving, delivering rear-seat entertainment such as movies, games, social networking, etc. Increasing demand for Comfort and Convenience is driving the growth of ICE system in vehicles; it is expected to grow from INR 1,388 Cr to INR 2,848 Cr at a CAGR of 19.7% over next four years.

### Major Components and Share by Value (%)

- Car Radio/ Head Unit: 60%
- Speakers: 40%

### Current Market and Forecast (INR Cr)

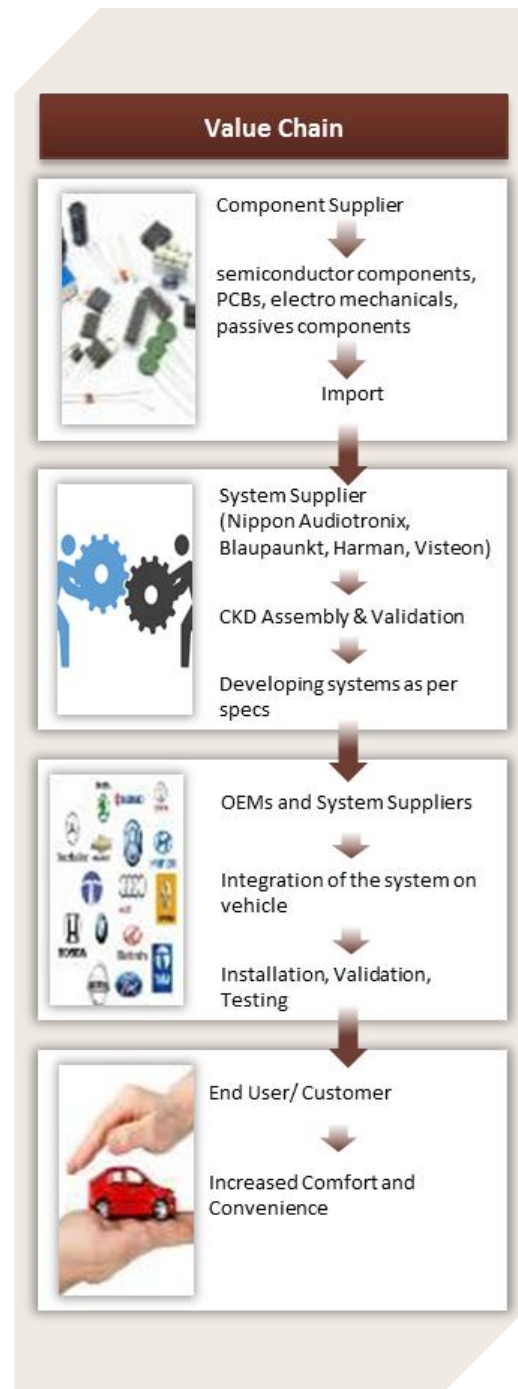


### Market Trends

- Integrated Head units for Passenger Vehicle applications are expected to grow
- For CV trends is shifting from Standalone units to integrated units
- ICEs with touchscreen having additional features as navigation etc are being increasingly used for high end vehicles

### Key Players

- Nippon Audiotronix Ltd
- Blaupunkt
- Alpine
- Pioneer



## Opportunity Analysis and Recommendations

### Short Term

- Focus on design and development of Single Din/ 2 Din Audio System for low end vehicles
- Focus on integration of Bluetooth Connectivity, Steering mounted controls into the ICE system

### Medium Term

- Focus on development of systems integrated with dashboards in consultation with OEMs for improved aesthetics and haptic
- Build expertise for improved vehicle acoustics

### Long Term

- Build expertise on the development of Park Assist and Automated Parking System

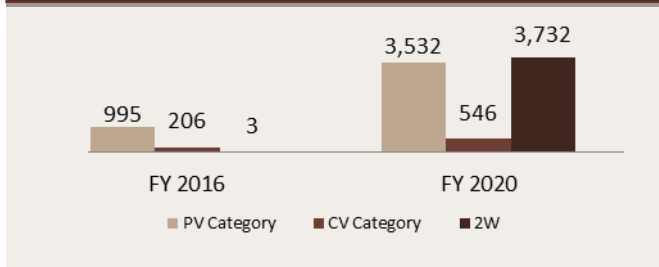
## ABS Summary

ABS is an automobile safety system that allows the wheels on a motor vehicle to maintain tractive contact with the road surface according to driver inputs while braking, preventing the wheels from locking up and avoiding uncontrolled skidding. Government mandate on ABS for PV, CV and 2W segment to drive the overall ABS market, it is expected to grow from INR 1,203 Cr to INR 7,810 Cr at a CAGR of 59.6% over next four years.

### Major Components and Share by Value (%)

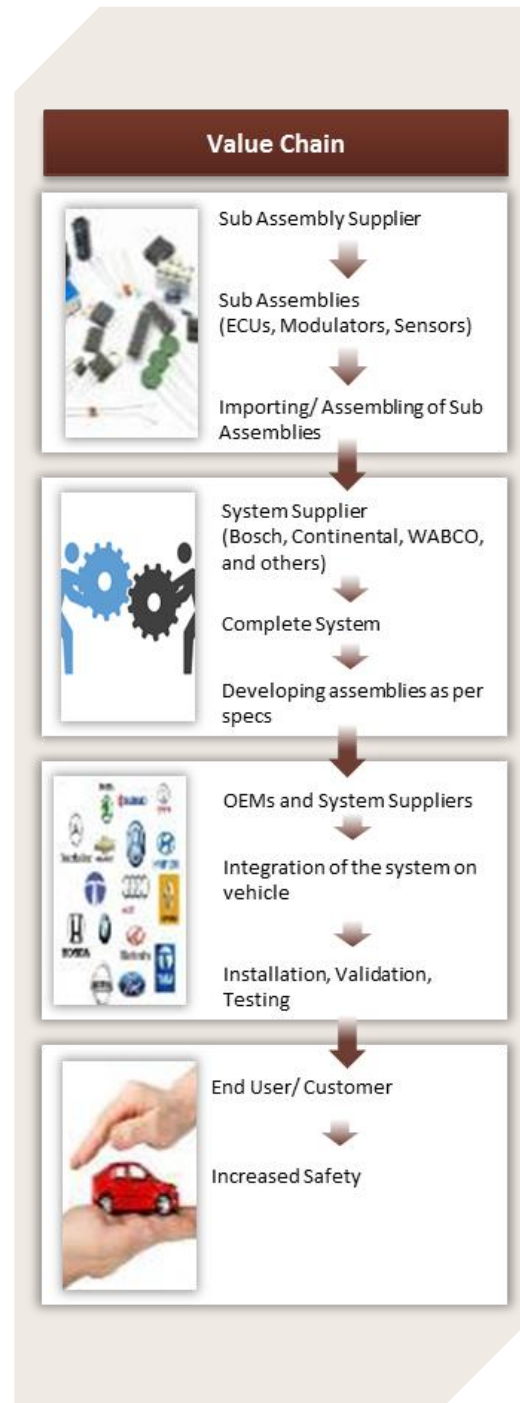
- ECU (40%)
- Wheel Speed Sensors (30%)
- Modulator Unit (Hydraulic/Pneumatic) (30%)

Current Market and Forecast (INR Cr)



### Market Trends

- Body Mounted ECUs used for Passenger Vehicle applications
- Chassis mounted ECUs used for Commercial Vehicle applications
- Hydraulic modulator units used for Passenger Vehicle applications
- Pneumatic modulator units used for high tonnage CV applications
- For low tonnage CV applications Hydraulic units are used
- Contact less/ Hall effect sensors are expected to grow in near future



**Key Players**

- Bosch
- Continental
- WABCO

**Technology Evolution**

ABS → TCS → ESP

**Opportunity Analysis and Recommendations****Short Term**

- Build expertise to manufacture Wheel Speed Sensor.
- Focus on Contact less sensors manufacturing.
- Focus on setting up PCB manufacturing/ assembly facilities.

**Medium Term**

- Enhance capabilities/ capacities for Design and Manufacturing of Modulator Valves
- Develop capabilities for Integration of Modulator Valves with the ECUs

**Long Term**

- Focus on design and development of Body Mounted and Chassis mounted ECUs by getting into technological partnership with the established players.



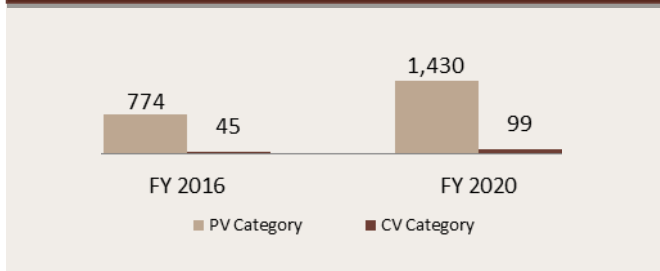
## DIS Summary

DIS: The display of the driver information system (DIS) brings together a wide range of different information items in the center of the cockpit and permanently indicates the vehicle’s current operating status. It is intuitively laid out, user-friendly, and allows the driver to stay focused on the road. Increasing human machine interface is leading to the growth of the DIS market; it is expected to grow from INR 819 Cr to INR 1,529 Cr at a CAGR of 16.9% over next four years

### Major Components and Share by Value (%)

- Instrument Clusters: 60%
- Displays: 40%

Current Market and Forecast (INR Cr)



### Market Trends

- Instrument clusters with 3D dials preferred
- Stepper motor-driven clusters are being used predominantly
- Increasing penetration of digital Instrument Clusters
- Increased number of telltales
- TFT Displays
- Colored LCD displays
- Integrated displays



**Key Players**

- Magneti Marelli
- Visteon
- Varroc
- Denso
- Continental
- Delphi
- JNS Instruments

**Technology Evolution****Current Clusters**

(Analog, Digital, Hybrid) → Reconfigurable Clusters → HuD

**Opportunity Analysis and Recommendations****Short Term**

- Develop Digital instrument clusters for 2W and 3W vehicle segment
- Focus on development of Stylized clusters with aesthetic appeal
- Build expertise to develop Integrated Clusters capable of displaying various vehicle parameters such as Fuel efficiency, Diagnostics, and Engine running conditions

**Medium Term**

- Enhance capabilities and capacities for Stepper motor driven clusters across all segment vehicles
- Develop expertise on improving protection levels to IP65 and above
- Focus on developing CAN compatible clusters for high end vehicles

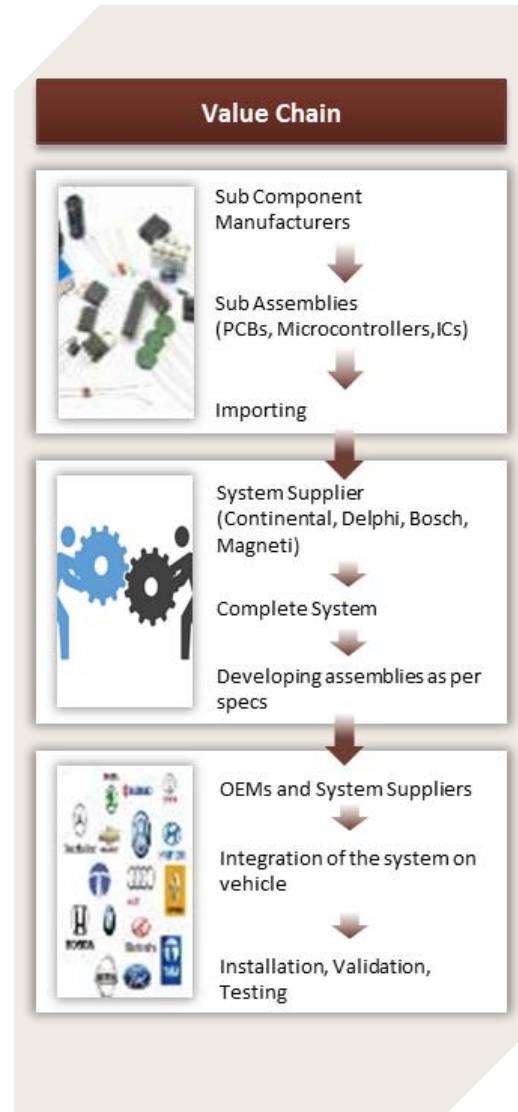
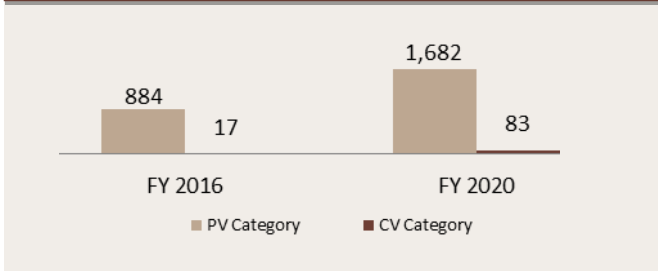
**Long Term**

- Focus on Full TFT/ Reconfigurable Clusters by getting into Technological Partnership/ JV with established players
- Build HuD (Head up Displays) development capabilities for high end vehicles

## BCM Summary

**Body Control Modules (BCMs):** An electronic control unit responsible for monitoring and controlling various electronic accessories in a vehicle's body. The BCM communicates with other on-board computers via the car's vehicle bus, and control load drivers – actuating relays that in turn perform actions in the vehicle such as operating power windows, power mirrors, central locking etc. Increasing demand for in-vehicle communication system, infotainment features, safety features, comfort, etc is expected to increase BCM market from INR 901 Cr to INR 1,764 Cr at a CAGR of 18.3% over next four years.

Current Market and Forecast (INR Cr)



## Market Trends

- Increasing options and utilities is giving room to more control functions in a BCM pushing OEMs to constantly work on increasing functionality
- Although there is a high level of local value addition with regard to product manufacturing, there is a lot of import dependence with regard to components

**Key Players**

- Continental
- Delphi
- Bosch
- Magneti Marelli

**Technology Evolution**

Entry Level BCMS → High End BCMS → Central Gateway +  
In Vehicle Networking

**Opportunity Analysis and Recommendations****Short Term**

- Develop BCMS to replace individual controllers for low end cars
- Design and develop BCMS indigenously for mid segment cars

**Medium Term**

- Enhance the existing capabilities of BCM designing for high end cars
- Develop BCMS with Gateway and Networking functionality

**Long Term**

- Develop Modular BCMS for platform based approach to reduce cost and lead time
- For CV segment develop BCMS suitable for Chassis mounting

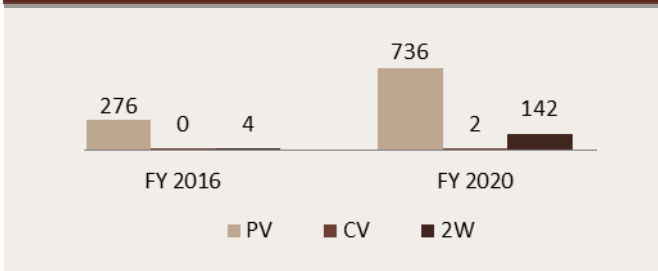
## Immobilizer Summary

**Immobilizer:** It is an electronic anti-theft device. It is activated when the ignition key is removed and works in tandem with the engine control unit to prevent unauthorized starting of the engine as far as is possible. Government mandate on immobilizer would drive the immobilizer market and it is expected to grow from INR 281 Cr to INR 880 Cr at a CAGR of 33.1% over next four years.

### Major Components and Share by Value (%)

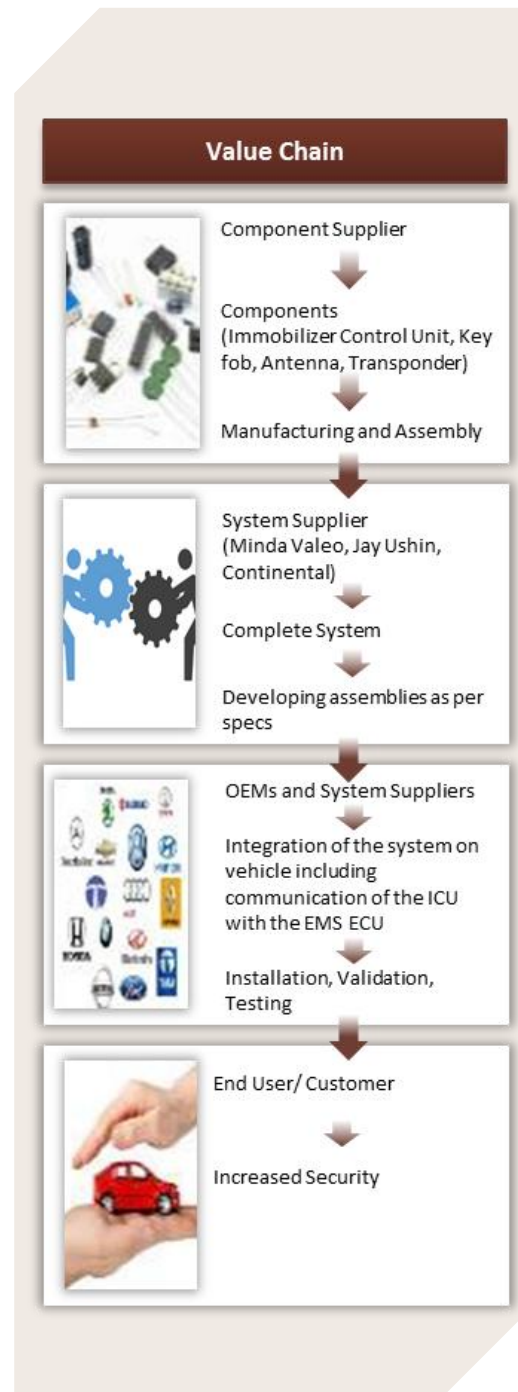
- RF Based Controller
- Transponder Based Controller

Current Market and Forecast (INR Cr)



### Market Trends

- RF-based Immobilizers are predominantly fitted in all the low-end cars
- Immobilizers for certain high-end cars are imported from countries like Taiwan, Korea, and Japan



**Key Players**

- Delphi
- Continental
- Minda Valeo
- Jay Ushin
- Omron

**Opportunity Analysis and Recommendations****Short Term**

- Develop capacities for RF based Immobilizer for Passenger Car and Small Commercial Vehicle Segments with basic fuel cut-off and starter relay cut-off system (regulation to mandate Immobilizer expected)
- Focus on Integration of RKE with the Immobilizer

**Medium Term**

- Develop Transponder based Immobilizers with integrated antennas and control units
- Focus on system integration of the Immobilizer Control Unit with the EMS ECU and the Vehicle Alarm System

**Long Term**

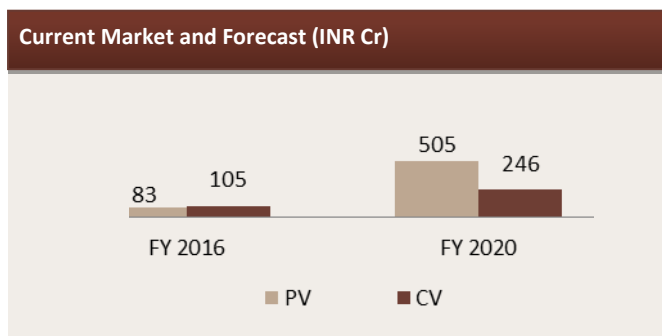
- Develop expertise on integration of the immobilizer control unit in the BCM
- Develop capabilities for interfacing Immobilizer functions in the EMS ECU with encrypted signals to enhance vehicle security level (Thatcham rating)

## Telematics Summary

Telematics is a general term that refers to any device that merges telecommunications and informatics. Telematics includes anything from GPS systems to navigation systems. Increase in telematics application in the commercial vehicle category is expected to drive the Telematics market from INR 188 Cr to INR 751 Cr at a CAGR of 41.4% over next four years.

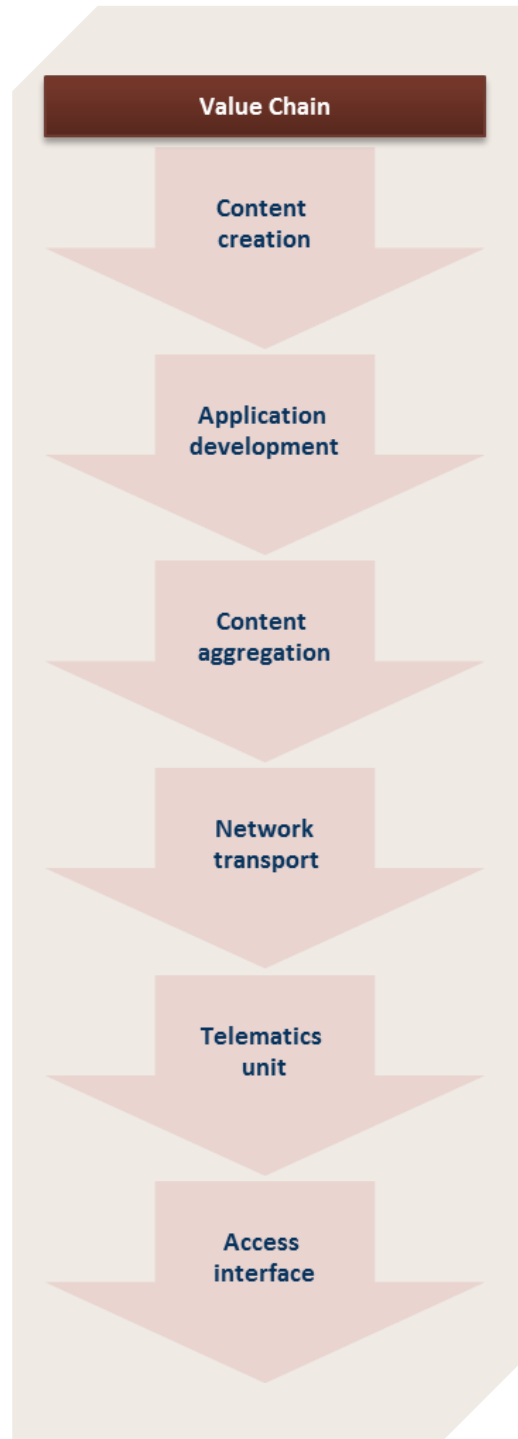
### Major Components and Share by Value (%)

- Telematics Box: 70%
- Service Packages: 30%



### Market Trends

- Telematics Boxes are generally either imported or assembled with GPS and GSM modules
- More than 85% of all telematics boxes are imported as major components in GPS and GSM modules are getting imported from other countries like Thailand, China.
- Many local players import and assemble telematics boxes after importing major components



**Key Players**

- Bosch
- Pricol
- Magneti Marelli
- Trimble
- Continental
- WABCO

**Opportunity Analysis and Recommendations****Short Term**

- Focus on the assembly / assembly of telematics boxes
- All components are already widely available in the import market
- Focus on 3G / 4G communication protocol as this is the way forward for the industry

**Medium Term**

- Tie up with small software companies in service business and develop unique product solutions specific to the Indian market like fuel pilferage monitoring, driver behavior monitoring, etc.

**Long Term**

- Tie up with Telecom operators and become one-stop-shop solution providers for Telematics and be present across the value chain
- Focus on innovative business models for various fleet operators based on end-user requirements

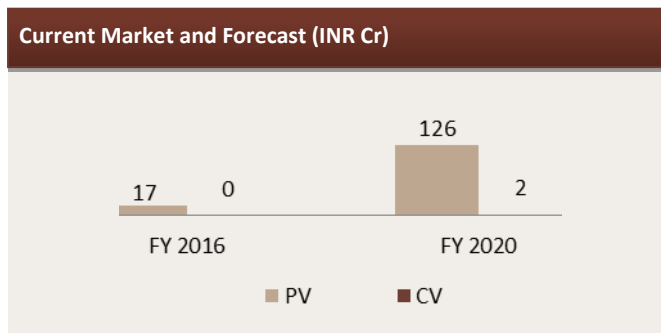


## TPMS Summary

**TPMS:** It is an electronic system designed to monitor the air pressure inside the pneumatic tires on various types of vehicles. TPMS report real-time tire-pressure information to the driver of the vehicle, either via a gauge, a pictogram display, or a simple low-pressure warning light. Demand for better fuel efficiency and Safety are leading the TPMS market, it is expected to grow from INR 17 Cr to INR 128 Cr at a CAGR of 66.0% over next four years.

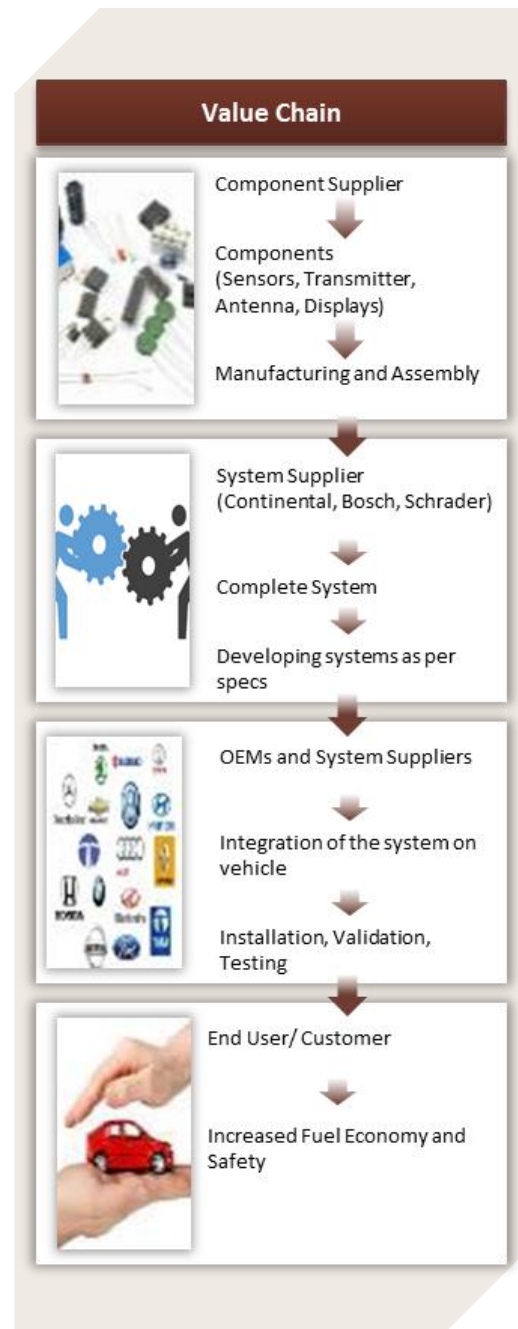
### Major Components and Share by Value (%)

- Tire Pressure Sensor: 30%
- Display Unit: 30%
- Controller: 40%



### Market Trends

- Snap-in Valve Sensors or the Snap-in Valve battery less sensor are currently being used as Tire Pressure Sensors
- Indirect TPMS being predominantly used in the aftermarket for PV category
- TPMS penetration is high in the aftermarket primarily



**Key Players**

- Continental
- Schrader
- Pacific Industrial
- Steelmate
- TRW
- Blaupunkt

**Opportunity Analysis and Recommendations****Short Term**

- Focus on the aftermarket with the basic TPMS module
- Develop expertise on development of Direct TPMS Module for the OEM market by technological partnership with the established global players

**Medium Term**

- Focus on manufacturing/ integration of the TPMS with other vehicle electronics such as integration of Receiver with the RKE module or the BCM module
- Focus on developing LCD multi-color display

**Long Term**

- Focus on development of robust Indirect TPMS module
- Build expertise to integrate the TPMS display into DIS by technological partnership with DIS manufacturers

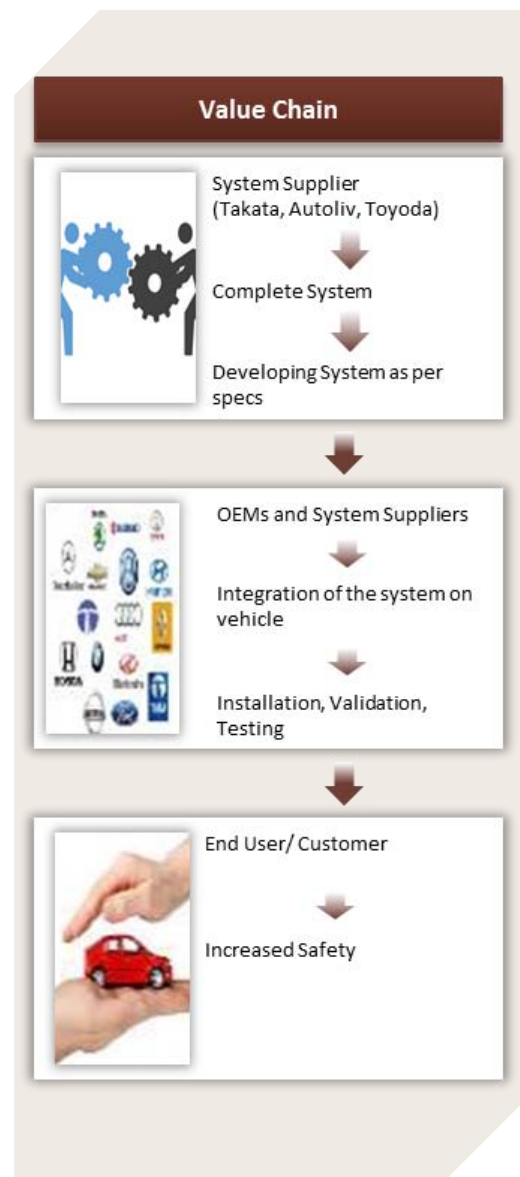
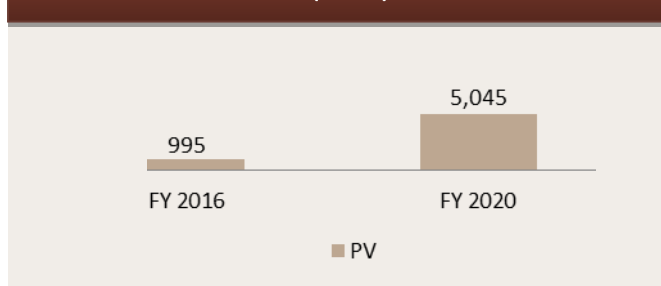
## Airbag Electronics Summary

**Airbag:** It is a supplementary Restraint System for driver and/or passenger safety in case of a crash. A thin nylon bag in the steering wheel/ above glove compartment inflates in the event of an impact and prevents the driver/ passenger from hitting the steering wheel/ dashboard. Mandatory crash tests for new models sold in India from October 2017 under the Road Transport and Safety Bill to drive the overall Airbag market, it is expected to grow from INR 995 Cr to INR 5,045 Cr at a CAGR of 50.1% over next four years.

### Major Components and Share by Value (%)

- Airbag Module: 40%
- Airbag Control Unit: 45%
- Crash Sensors: 15%

Current Market and Forecast (INR Cr)



### Market Trends

- Players such as Takata and Autoliv do the integration of Airbag Inflator Unit and Airbag in a module called as Airbag Module in their manufacturing plant in India
- Electromechanical crash Sensors and Airbag control Unit are imported by the suppliers

**Key Players**

- Takata Corp
- Autoliv Inc
- Rane TRW Steering Systems Private limited
- Toyoda Gosei Co

**Opportunity Analysis and Recommendations****Short Term**

- Build expertise to manufacture Airbag Module components (Inflator and Airbag) domestically
- Focus on manufacturing of Crash Sensors by doing Technical tie up with the established players

**Medium Term**

- Build expertise for development of Airbag Control Units in coordination with the Airbag manufacturers
- Build expertise on the integration of multiple airbags on vehicles

**Long Term**

- Focus on manufacturing of complete system by getting into Technical tie-up/ JV with Global players with strong hold in the market
- Build expertise on Testing and Validation of the system

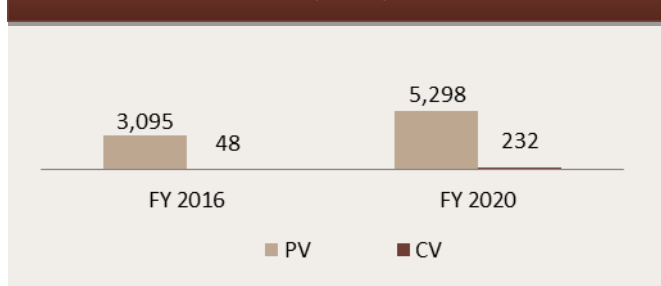
## EPS Summary

In the Electric Power Steering System, the electric motor (“E-motor”) is attached directly to the steering gearbox without a hydraulic system. Sensors detect the motion of the steering column and a processor module applies assistive power via an electric motor. This allows varying amounts of assistance depending on driving conditions. Increase in EPS penetration in the Passenger Car segment is expected to drive the EPS market from INR 3,143 Cr to INR 5,529 Cr at a CAGR of 15.2% over next four years.

### Major Components and Share by Value (%)

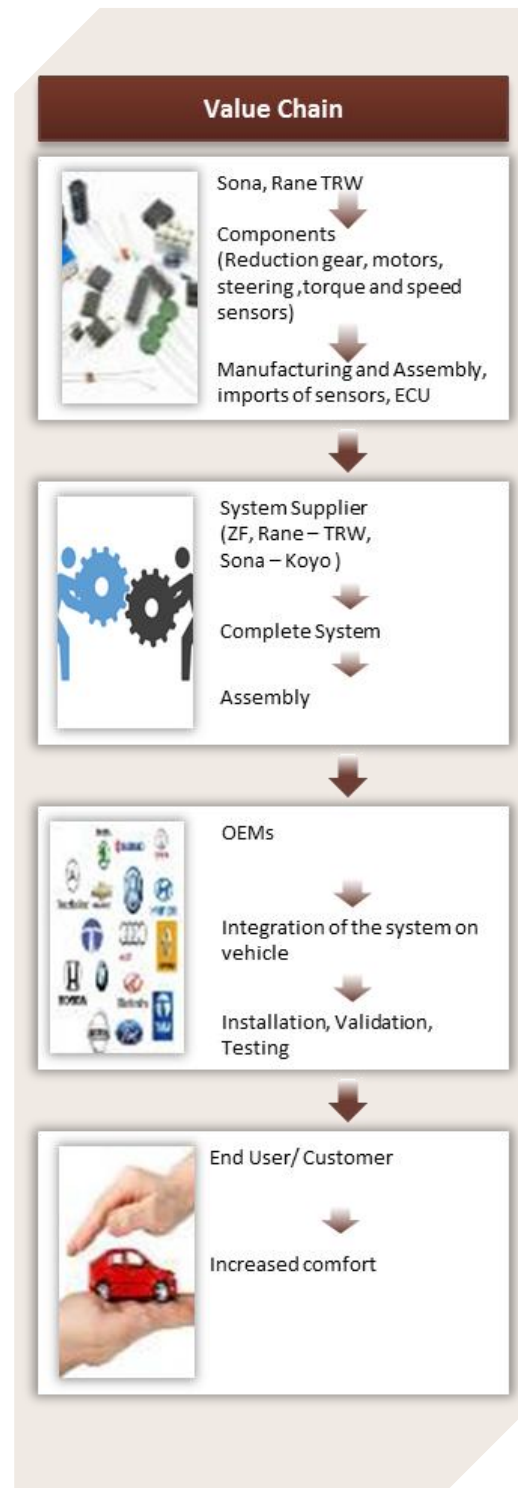
- Power Steering Motor: 30%
- Reduction Gear: 15%
- ECU: 40%
- Torque and Angle Sensor: 15%

Current Market and Forecast (INR Cr)



### Market Trends

- Almost 100% of EPS manufacturers for EPS in India assemble mechanical components of EPS
- All the sensors, ECUs and actuators are either imported or supplied by the OEMs to the Tier 1 for assembly
- EPS market is primarily driven by the Passenger Car Segment



**Key Players**

- Rane TRW Steering Systems
- Sona Koyo
- Showa India
- Mando India

**Opportunity Analysis and Recommendations****Short Term**

- Focus on technical tie-ups to manufacture the actuator for EPS which is bidirectional brushless motor
- Focus on manufacturing of reduction gears, not all reduction gears are domestically manufactured

**Medium Term**

- Build expertise to manufacture sensors for EPS application
  - Torque Sensor
  - Steering angle sensor
  - Speed Sensor

**Long Term**

- Build expertise to integrate motor with the ECU or Torque Sensor with the ECU
- Capability building toward understanding ECU specification for EPS

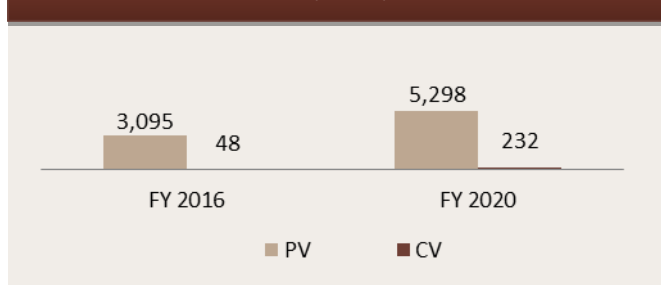
## LED Summary

A light-emitting diode (LED) is an electronic device that emits light when electrical current passes through it. Early LEDs produced only red light, but modern LEDs can produce several colors, including red, green, and blue (RGB) light. Recent advances in LED technology have made it possible for LEDs to produce white light, as well. Increasing energy efficiency awareness and growing Green energy drive is leading to the increase in LED market, it is expected to grow from INR 20 Cr to INR 592 Cr at a CAGR of 133.8% over next four ye

### Major Components and Share by Value (%)

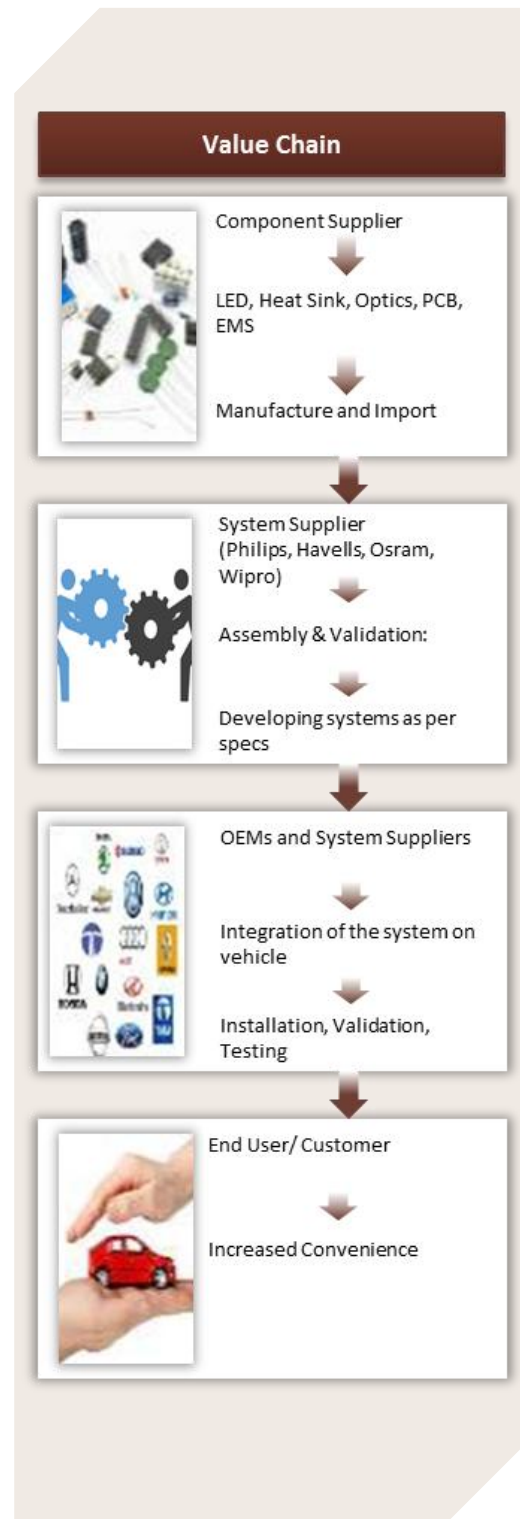
- LED: 50%
- Driver circuit: 15%
- Heat sink: 20%
- Thermal interface material: 15%

Current Market and Forecast (INR Cr)



### Market Trends

- Heat sink and drivers are manufactured in India and are also imported from China
- Light source with lens, reflector, and chip is entirely imported
- LED Lightings are Imported to India



**Key Players**

- Rane TRW Steering Systems
- Sona Koyo
- Showa India
- Mando India

**Opportunity Analysis and Recommendations****Short Term**

- Design activity of driver circuits, heat sink, and LED
- Focus more on assembly of Housing by integrating heat sink and thermal interface material

**Medium Term**

- Set up manufacturing units for heat sink, housings, driver, etc.
- Setting up EMS for LEDs, there are companies like Instapower, Promptec, VIN but the growth of the market would need more suppliers for EMS

**Long Term**

- LED chips being the most expensive component in the product, there arises a need for setting up LED wafer fabs in the country
- LED wafer fabs, along with the testing facilities, will not only prevent the import of sub-standard light fittings but also increase the local value addition
- Alternatively, with rest of the components manufactured, LEDs could be imported & assembled locally and sold with OEMs & aftermarket

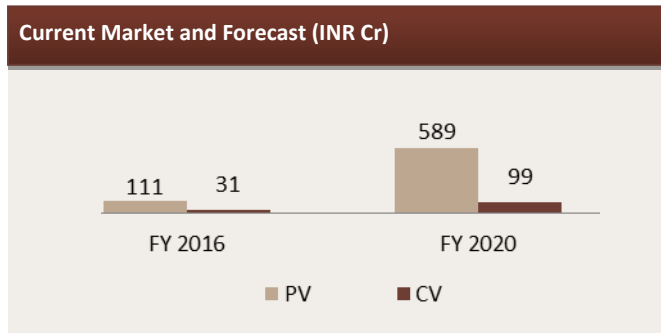


## FATC Summary

Fully Automatic Temperature Control (FATC) is the ability to monitor and control the cabin temperature at user-specified value without manual interventions. Growing demand for in-car comfort is driving the FATC market and it is expected to grow from INR 141 Cr to INR 688 Cr at a CAGR of 48.5% over next four years.

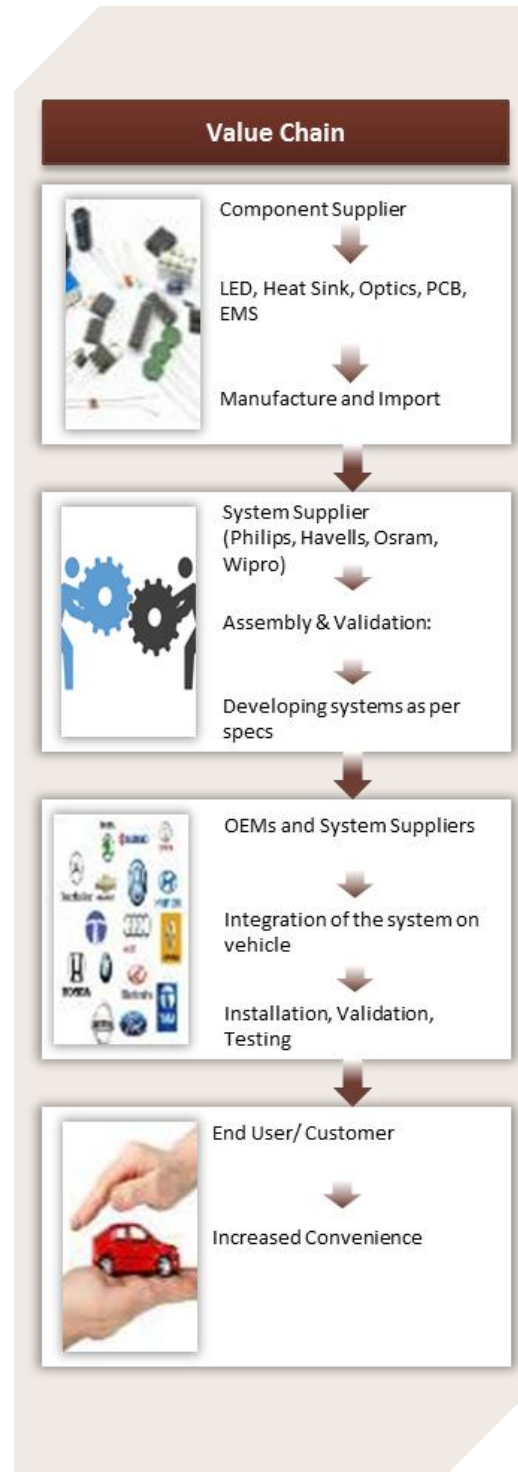
### Major Components and Share by Value (%)

- Controllers: 50%
- Sensors: 50%



### Market Trends

- Stand-alone controllers being used
- Sensors used in the FATC system are being imported and as well as domestically manufactured by the Tier-2 Suppliers
- FATC system’s penetration is increasing in the Mid-Size segment cars



**Key Players**

- Sanden Vikas
- Subros
- Delphi
- Denso
- Mahle Behr
- Visteon

**Technology Evolution**

Air Conditioning System → HVAC System → FATC System  
→ Dual Zone Climate Control System

**Opportunity Analysis and Recommendations****Short Term**

- Focus on manufacturing of:
  - Ambient temperature sensor
  - Sun sensor
  - Humidity sensors

**Medium Term**

- Focus on manufacturing of standalone controllers as a Tier-2 supplier
- Focus on compact segment cars where HVAC could be upgraded into FATC

**Long Term**

- Build expertise for Integration of the FATC controller into the BCM
- Build expertise on the development of Dual Zone Climate Control System for high end cars

## About ACMA

The Automotive component manufacturers association of India (ACMA) is the apex body representing the interest of the Indian auto component industry.

Its active involvement in trade promotion, technology up-gradation, quality enhancement and collection and dissemination of information has made it a vital catalyst for this industry's development. Its other activities include participation in international trade fairs, sending trade delegations overseas and bringing out publications on various subjects related to the automotive industry.

ACMA's charter is to develop a globally competitive Indian Auto Component industry and strengthen its role in national economic development as also promote business through international alliances.

ACMA is represented on a number of panels, committees and councils of the Government of India through which it helps in the formulation of policies pertaining to the Indian automotive industry.

For Exchange of information and especially for co-operation in trade matters, ACMA has signed Memoranda of Understanding with its counterparts in Brazil, Canada, Egypt, France, Germany, Iran, Italy, Japan, Malaysia, Pakistan, South Africa, South Korea, Spain, Sweden, Thailand, Tunisia, Turkey, UK, USA and Uzbekistan.

ACMA represents over 670 companies, which contributes more than 85% of the total auto component output in the organised sector. In the domestic market, they supply components to vehicle manufacturers as original equipment, to tier-one suppliers, to state transport undertakings, defence establishments, railways and even to the replacement market. A variety of components are being exported to OEM's and after-markets world-wide.

ACMA is inseparably linked with the auto component sector and hence forms the channel through which business contacts are established with the Indian Automotive Industry .

ACMA is an ISO 9001:2008 Certified Association

Further information and data on the Indian Automotive industry is available on the ACMA Website: [www.acma.in](http://www.acma.in)

For more information, please contact:

**Automotive Component Manufacturers Association of India**

6<sup>th</sup> Floor, The Capital Court, Olof Palme Marg, New Delhi 110 067, India

Tel: +91 11 2616 0315 Fax: +91 11 2616 0317

E-mail: [acma@acma.in](mailto:acma@acma.in) Website: [www.acma.in](http://www.acma.in)

## About Frost & Sullivan

Frost & Sullivan is a leading global strategy consulting company, headquartered in the US. Established in 1961, in New York City, the company today has 45 offices across the globe. It has six offices in India (Bangalore, Chennai, Kolkata, Mumbai, New Delhi and Pune) and three offices in the Middle East (Dubai, Manama and Dammam).

The company has a domain knowledge approach to strategy consulting and has been working closely with multiple family run businesses/corporate groups in India, the KSA, and GCC, to develop their long term strategy and identify specific areas of business opportunity.

To know more click on: [www.frost.com](http://www.frost.com)

### Disclaimer

This Report prepared by Frost & Sullivan is on the basis of the scope of work agreed upon with Automotive Components Manufacturers' Association of India (ACMA). The Report is based on analysis of secondary information and knowledge available in the public domain. While Frost & Sullivan has made all the efforts to check the validity of the information presented, it is not liable for errors in secondary information whose accuracy cannot be guaranteed by Frost & Sullivan. Information herein should be used more as indicators and trends.

Any information contained in this Report may not be current after the date hereof and the indicators may differ depending on a variety of factors, including product supply, demand and pricing; political stability; general economic conditions; legal and regulatory developments; availability of new technologies; natural disasters and adverse weather conditions and hence, should not be construed to remain the same and may change without notice.

Information in this Report is intended to provide an overall industry perspective on the basis of the scope of work. It cannot be regarded as a comprehensive or insufficient data for making decision and any loss/discrepancy arising from the action taken cannot be attributed to Frost & Sullivan.

### Copyright Notice

The contents of these pages are copyright © Frost & Sullivan Limited. All rights reserved. Except with the prior written permission of Frost & Sullivan, you may not (whether directly or indirectly) create a database in an electronic or other form by downloading and storing all or any part of the content of this document. No part of this document may be copied or otherwise incorporated into, transmitted to, or stored in any other website, electronic retrieval system, publication or other work in any form (whether hard copy, electronic or otherwise) without the prior written permission of Frost & Sullivan.





# **ACMA**

**Automotive Component  
Manufacturers Association of India**

## **HEAD OFFICE**

6<sup>th</sup> Floor, The Capital Court, Olof Palme Marg, Munirka, New Delhi 110 067, India

Tel: +91 11 2616 0315 Fax: +91 11 2616 0317

E-mail: [acma@acma.in](mailto:acma@acma.in) Website: [www.acma.in](http://www.acma.in)