Automotive Electronics - Opportunities and challenges for Nigeria’s Auto Sector

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Abstract
The origins of the ongoing automotive – electronics components convergence can perhaps be traced back to the late 1980s, when Mercedes and its supplier Robert Bosch GmbH developed the electronic stability control, a system designed to help prevent accidents by monitoring a car's trajectory and correcting this when it strays from the direction in which the driver is steering. The enormous benefits of the automotive – electronics convergence is typified by the electronic stability control system which has been shown in several studies to substantially reduce accidents. With around 60 million new vehicles produced globally every year and the increasing electronic content in automobiles, the automotive sector is set to be the most attractive application market for the electronics industry in the short to medium term. The market for electronics applications in vehicles is estimated to reach £80 billion by the end of 2008 as new technologies and standards continue to push the adoption of electronics in vehicles to provide further driver assistance, safety, passenger comfort, information and entertainment. The electronics manufacturing sector is often described as the most important industry as it is the main driver for science, technology and manufacturing and hence the driver for the overall wealth creation economy of a nation.

The paper presents an overview of automotive electronics, including current and future design and manufacturing trends, and the technological challenges facing the automotive electronics manufacturing sector. As the automotive sector becomes more and more globalised, the two key drivers for the development and adoption of new automotive electronic features will continue to be technology and costs. The last five years has seen a massive increase in the electronic content of vehicles, increasing from some 10% to the current 25%, and according to analysts – this is set to exceed 40% by the year 2010. For the major stakeholders in the global electronics industry the key questions are: what are the business opportunities in this emerging application market and what are the possible challenges in deploying applications in vehicles? The paper reviews the status of Nigeria’s automotive manufacturing sector, and the impact of used car importation. It also examines the opportunities and challenges for Nigeria’s automotive sector in this emerging application area of automotive electronics.

After more than 30 years since its inception, the Nigerian Automotive sector is still in the nascent stage of development – analysts have reported widely on the lessons that can be learnt from the success stories from around the developing world, including the Asian tiger countries, Latin America and South Africa. The outstanding question is really one of how Nigeria can begin to build sustainable capacity in the automotive manufacturing sector. The National Automotive Council of Nigeria, the organ charged with the execution of the Automotive Policy of the Federal Government are working on a number of schemes to ensure the survival, growth and development of Nigeria’s automotive industry using local human and material resources. In terms of the automotive electronics components sub-sector, the paper also explores some of the urgent questions for the NAC and its partners; amongst others these include the following:

- As electronics migrate from the aerospace and consumer sectors into the automotive sector, what automotive electronic features are now available as standard in premium/prestige cars?
- As globalization and the associated international competition force automotive manufacturers into the outsourcing arena, what are the current and future design and manufacturing trends?
- What are the challenges and opportunities for Nigeria’s automotive manufacturing industry in this important and fast expanding electronics sector?
1.0 Introduction
Anyone sitting in a new car can easily notice that compared to new cars launched some five years ago, car manufacturers are continuing to add more and more electronic features. The GPS/Satellite Radio, DVD/Video/CD Player and Radio, automatic climate control, fuel-mileage monitoring features, electronic windows are only a small part of the electronic content in a vehicle. There are now much more electronic components under the bonnet and in the body of the vehicle – with the vehicle engine and gearbox no longer directly controlled by the driver through mechanical means, but rather via computer which receives instructions from the driver as inputs and then delivers the desired effects by means of electronic throttle control and other drive-by-wire elements.

Indeed, electronics is now essential for controlling the movement of the car, to monitor and control the chemical and electrical processes taking place in the engine and elsewhere, to entertain the passengers, to establish connectivity with the rest of the world and more importantly, to ensure safety. The need for higher level of safety has led to the development of sophisticated safety features, such as electronic stability control, collision avoidance systems and tire pressure monitoring systems.

As customers continue to demand for more features such as those for driver assistance, improved fuel efficiency, passenger comfort, convenience and safety, automotive manufacturers are incorporating more electronic features in their vehicles while continually striving to develop environmentally friendly and improved fuel economy vehicles. Some of the current trends in new/enhanced electronic features are directed to incorporating more complex electronics to help improve brand reputation and competitive differentiation rather than just improving driver/passenger comfort and safety. The ability to connect an iPod® to an in-dash entertainment system, Bluetooth connectivity between handsets and integrated hands-free units are now considered standard features. The key challenge however, is that although both the customer and the vehicle manufacturer now perceive these cabin equipment and systems as the defining characteristic, or rather as the unique selling proposition of any new vehicle, they both recognise that the need to install yet more complex electronics must not add to the cost or weight of the vehicle.

1.1 Telematics and Intelligent Transportation
Telematics is a word which has its origins in the blending of the root words telecommunications and informatics. Broadly speaking, telematics represents the convergence of four familiar technologies: the automobile, computing, wireless communications and the Global Positioning System, but it is the massive developments in semiconductor and electronics packaging and interconnection technology that has made the difference. The main benefits of the telematics revolution can be realized within the commercial environment, as these technologies can be valuable tools for improving the efficiency of organizations when used for applications such as the following:

- **Vehicle Tracking**: This is the monitoring of the location, movements, status and behaviour of a vehicle or fleet of vehicles, achieved through a combination of a GPS receiver and an electronic device (usually comprising a GSM, GPRS modem or even an SMS sender) installed in each vehicle, communicating with the user and PC or web-based software. For transport organizations, security and emergency services, the data can then be turned into information by management reporting tools in conjunction with a visual display on computerized mapping software and used for real time decision making.

- **Satellite navigation**: This is essentially for forward planning of journeys and in the context of vehicle telematics it involves the use of a GPS and electronic mapping tool to enable the driver of a vehicle to locate his destination, and then prepare a route plan and to navigate the journey.

- **Automotive Insurance**: This is an area of growing interest for the insurance industry in which there has been pilot studies in which the basic idea is to monitor the behaviour of drivers directly over a period of time in terms of factors such as distance traveled and speed; and then transmitting this information to their insurance companies. Their insurance companies can then use the actual driver
statistics for assessing the risk of a driver in terms of the probability of having an accident. This information is then used to estimate fairer levels for the insurance premiums for each driver. A driver who drives long distance at high speed, for example, will be charged a higher rate than a driver who drives short distances at slower speeds. The Insurance firm, Norwich Union is currently offering a type of telematic auto insurance in the UK called Pay As You Drive (PAYD), which employs a combination GPS and Car cell phone to monitor driving performance and communicate risk factors to the insurance company. Drivers are offered a discount if they exhibit safe driving [1].

1.2 World Electronics Component Market
The electronics manufacturing industry can be sub-divided into seven major application areas, as follows:

- Aerospace and defence
- Automotive
- Consumer Electronics
- Energy and power
- Healthcare and medical
- Oil, gas, refining and petrochemicals
- Telecoms, radio communications and broadcasting

But as electronics becomes more pervasive, new applications are emerging in other sectors of the economy, such as those shown in Figure 1 below.

![Market/Life Sectors for the Electronics Manufacturing Industry](image)

Table 1 below presents the automotive electronics component market share in terms of the global usage of both semiconductor components and associated electronic components as at the end of 2006. It shows that the automotive sector accounts for some 4% of the global usage of semiconductor component and only 8% of the global usage of electronic components market. Although these represent a significantly small segment of the market when compared to the computer, communications and consumer sectors, automotive electronic components are much higher specification and value and as the electronic content of passenger vehicles continue to increase, the automotive sector is forecast to be one of the fastest growing sectors for the future.
1.3 Evolution of Automotive Electronics

Table 2 below shows the way in which automotive electronic features have evolved over the last two decades. In the early 1980’s, premium/prestige passenger vehicles such as those manufactured by Mercedes led the way with the introduction of the two, and four wheel anti-lock braking, cruise control and drive and front seat passenger air-bags.

With the introduction of anti-lock brakes in the early 1980s and electronic stability control (ESC) and traction control a few years later, automobiles were finally providing a means to keep drivers from getting into accidents—not just protecting them after the fact.
Prior to these developments automotive suppliers and manufacturers focused primarily on safety devices that would provide protection to the occupants once an accident was underway. Ford became the first mass-production manufacturer in 1956 to market safety by offering front lap belts as an option along with a padded dash, less protrusive instrument panel controls, and a "deep dish" steering wheel. They also added Life Guard door latches to keep doors from opening in the event of a crash.

The 1990’s saw the introduction of features such as traction control, proportional steering and side impact airbags and by the start of the 21st century, automobile manufacturers were already offering electronic stability control, power steering and other mod-cons in their basic passenger car modules.

2.0 Overview of Current Automotive Electronics Features

The automotive electronics market is very huge, and it is often quite difficult to classify the features precisely into specific heading. But one way of classifying them is into the following seven main groups, as given below:

- **Braking & Related Systems**: Anti-Lock Braking (ABS), Electrohydraulic braking, Stability Management, Brake-by-Wire
- **Driver Assistance**: Adaptive Cruise Control, Lane Departure Warning, Collision Avoidance, Night Vision Enhancement
- **Steering**: Electronically-Controlled Hydraulic, Electric Power Steering, Four Wheel Steering, Active Steering, Steer-by-Wire
- **Passive Restraint**: Pretensioners/set belts, Frontal Airbags, Side-Impact Airbags, Rollover Protection Systems, Smart Airbags, Pre-Crash Systems
- **System Level**: Multiplexing, Electrical Distribution, fault and failure diagnostics

Another classification used by the automotive industry is based on the control systems implemented and hence we have the following groupings: Engine Controls, Ignition System Controls, Fuel Injection System Controls, Transmission System Controls, Dashboard Instruments and Displays, Navigation Systems, Safety Electronics, Air Bags, Anti-Lock Brakes, Mirror Controls, Security Electronics, Keyless Entry Systems, Anti-Theft Systems, Radios/Cassette/CD/Video Players, Temperature Control Systems, etc.

2.1 Active and Passive Safety Features

Automotive electronic features have also been classified in terms of the active and passive safety features as illustrated in Figure 2a and 2b below. Passive safety features such as seat belts and airbags, help drivers and passengers stay alive and uninjured in a crash, whilst Active safety features such as ABS and Traction Control help drivers avoid accidents.
2.2 Some Examples of Automotive Electronics Features

Over the last few years, automotive electronics have increasingly defined the driving experience of modern vehicles. Starting with engine management and car audio, electronics have now penetrated all major systems in the vehicle ranging from power train, body, chassis, driver assistance systems, and active and passive safety systems. Three examples of the automotive electronics features currently implemented in passenger vehicles are presented below:
(i). **Electronic Stability Control**  
Figure 3 shows the Electronic Stability Program (ESP) as implemented by Bosch for Mercedes modules [2]. The ESP system has five main components, namely: the ESP-Hydraulic Unit with integrated ECU, wheel speed sensors, steering angle sensor, the YAW rate sensor with integrated accelerator sensor and the Engine Management ECU for communication. The ESP uses various sensors to intervene when the car senses a possible loss of control. In these circumstances, the car's control unit can reduce power from the engine and even apply the brakes on individual wheels to prevent the car from under-steering or over-steering.

![Electronics Stability Program](image)

**Components of Electronic Stability Program ESP®**

- ESP-Hydraulic Unit With Integrated ECU
- Wheel Speed Sensors
- Steering Angle Sensor
- Yaw Rate Sensor With Integrated Acceleration Sensor
- Engine-Management ECU for Communication

© Bosch

**Figure 3: Electronic Stability Program – Mercedes/Bosch Implementation [2]**

(ii). **Tire Safety Monitoring using MEMS**  
All tires gradually lose pressure. The most basic tire monitors use a MEMS sensor mounted in the wheel or imbedded in a tire valve to measure air pressure within the tire. A signal is sent to a dashboard display, which warns the driver when the tire pressure drops below the recommended level. It also alerts a driver about leaks and punctures.

![Tire Pressure Monitoring Using MEMS](image)

**Figure 4: Tire Pressure Monitoring using MEMS Technology**
Most sensors also measure temperature, which can indicate internal wear and an imminent blowout. Other MEMS and Microsystems can be added to relay that information to a dashboard display or an intelligent air pump. Tire makers such as Michelin and Goodyear are aligning with major automotive manufacturers to offer this technology as a standard following the US legislation in 2006 making this feature mandatory for all tire manufacturers [3].

(iii). Driver assistance
Driver-assistance mechanisms are of several distinct types including the sensorial-informative and the actuation-corrective systems. The Cooperative Travelers Assistance shown in Figure 5 below is an application which focuses on assistance of the drivers. It increases the transparency of the evolving traffic situation downstream on the road network, personalizes the information to travelers, enables them to make optimal use of the road network and assists the traveler in making the right choice navigating through the road network, based upon full cooperation between Roadside systems, in-vehicle sensors, Traffic managers and Service providers. According to reports, this system will provide information to the driver within 15 seconds about a major congestion incident, and 15 seconds later they receive a recommendation about an alternative route [4].

Figure 5: An Example of a Driver Assistance System – providing Real-Time Traffic Information [4]

Sensorial-Informative: These systems warn or inform the driver about events that may have passed unnoticed, such as Lane Departure Warning System and the Rear View Alarm System for detecting obstacles. These systems get activated when the vehicle wanders off its lane or when the driver engages the reverse gear.

Actuation Corrective: In general, these systems can modify the driver's instructions so as to execute them in a more effective way – the most widely deployed system of this type is Anti-lock Braking System (ABS) and compared to the power steering system which is not a control mechanism, but just a convenience and hence is not involved in any decision making. The ABS is often coupled with the Electronic Break-force Distribution system (EBD), which prevents the brakes from locking and losing traction while braking in effect helping to shorten the stopping distance and more importantly, allowing the driver to steer the vehicle while braking.
(iv). Benefits of Automotive Electronics
So what are the key benefits of automotive electronics to the driver, passengers, and public and government agencies? In terms of safety, a simulation model showed that drivers with navigational devices made fewer wrong turns, used better roadway facilities, and decreased their crash risk by up to 4% and a study carried out in Turin, Italy as part of the EU CLEOPATRA project showed that cars equipped with in-vehicle navigation systems experienced a travel time savings of more than 10% and this has been confirmed by other reports which claim that the operating costs for a service company declined 10% after they installed GPS/AVL mobile data terminals to eliminate miscommunication between drivers and dispatch [5]. Even more important for automotive manufacturers is another finding that showed that in terms of customer satisfaction, the participants in a major survey of new automotive models, overwhelmingly ranked intelligent cruise control (ICC) over manual or conventional cruise control for convenience, comfort, and enjoyment [5].

3.0 Electronics Manufacturing Technology Trends

Table Figure 6, below shows some of the recent trends in electronics design and manufacturing technology. Achieving lower costs continues to be one of the biggest challenges for the industry as consumers demand increased functionality with further convergence of IT/computing, telecommunications and video technologies. There are other pressures for further miniaturisation and down-sizing of pocket and hand-held devices which has led to the use of higher density, but smaller and lighter electronic devices.

<table>
<thead>
<tr>
<th>Electronics Manufacturing Technology Trends</th>
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<tr>
<td>• Lower cost</td>
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<tr>
<td>• Component downsizing, increased density, miniaturisation</td>
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<tr>
<td>• Mechatronic packaging design</td>
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<tr>
<td>• Design for manufacture / assembly</td>
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<td>• Advanced chip placement techniques (e.g. BGA/CSP, Flipchip)</td>
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<tr>
<td>• Increased silicon integration (system-on-chip)</td>
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<td>• Higher temperature / higher vibration</td>
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<tr>
<td>• Improved reliability</td>
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<td>• Lead-free electronics</td>
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Table 6: An Outline of Electronics Manufacturing Technology Trends

Environmental and other safety regulations across the globe, and especially in the EU have also led to further requirements for green/environmentally friendly electronics (e.g. EU WEEE legislation and the development of lead-free electronics), and higher reliability products for high temperature/higher reliability operation demanded by under-bonnet electronics. These requirements have led to the use of more integrated design for manufacture, design for assembly, design for reliability and the development of advanced packaging and interconnection technologies such as those used for BGA/CSP, flip-chip and MEMS assembly.
3.1 Electronics Manufacturing Research at the University of Greenwich UK

The focus of the research work carried out by the Electronics Manufacturing Engineering Research Group (EMERG), at Greenwich is to identify, explore and develop suitable assembly and packaging technologies to meet the challenges of miniaturisation facing the electronics industry. A major thrust of this work is in Area Array Interconnect Technology (assembly of flip-chip, chip-scale and ball-grid array devices) and Microsystems integration (development of assembly technology for integrating electronic, optoelectronic and other devices). As new materials emerge, and the industry incorporate many different assembly materials into the assembly process, it is also critical to be able to describe the interactions between materials and process parameters, and the accurate characterisation and modelling is an important pre-requisite to achieving high yield and reliability.

The Group has an excellent track record in Electronics Packaging and Interconnection and is internationally renowned for its work on characterisation/modelling of dense suspensions and their processing for electronics interconnection applications and is currently participating in a number of UK/EPSRC and Industry sponsored research programmes including those at the EPPIC (Electronic and Photonics Packaging and Interconnect) Faraday Centre at TWI, Cambridge, UK; and the IeMRC (Innovative Electronics Manufacturing Research Centre) at Loughborough University, UK. The group has worked on a number of UK EPSRC (Engineering and Physical Sciences Research Council) funded projects in the area of process and materials development for new interconnection technologies, including the reliability of lead-free solder joints for flip-chip applications [6, 7].

![Figure 7: The Evolution of EMERG Research Interests since 1992](image)

EMERG has an established track record for research grant income generation – with some £2million (cash) generated to date from the UK EPSRC, DTI and Industry. The Group has successfully completed 19 research and 3 knowledge transfer projects (see Figure 7 for listing of EMERG research interests) – with the majority of the EPSRC funded projects rated excellent by EPSRC (as internationally leading for research quality, potential scientific impact and the output of research staff). It also has an established record for publishing in refereed academic journals and for postgraduate supervision in these fields (with over 120 papers published in refereed academics journals and presented at national and international
conferences). In recognition of the work done by the Group, one of its staff members was awarded the Society of Manufacturing Engineering 2006 Total Excellence in Electronics Manufacturing Award and the Royal Society 2007 Royal Society Kan Tong Po Visiting Professorship.

EMERG has very relevant experience of working directly with industry on industry-academic research partnership projects, and has worked with more than 50 manufacturing companies in the UK and abroad (including BAe, HP, NEC, Nortel), on EPSRC funded projects and on knowledge transfer partnerships. It has also established excellent links with industry and academic research groups in the UK, Europe, the USA, China, Hong Kong and South Korea. It has also worked closely with several Industry-Academic Groups in the UK to organize/host industry-academia seminars/workshops focused on developing and fostering fruitful collaborations. For more information on EMERG research activities and opportunities for collaboration, please visit the EMERG website at http://engweb.gre.ac.uk/emerg/home.htm.

3.2 Future Directions in Automotive Electronics Manufacturing

The automobile manufacturing industry across the world has recently been plagued by the excessive capacity. However, the rate of growth in Europe and the USA car market when compared to the rate of growth in countries such as China, India and Brazil has been significantly different. The next few years will see huge changes in the world automotive manufacturing market, with the Asian automobile manufacturing market (including Japan) becoming the largest producers. The market in the other emerging countries, such as those in Latin America will also increase. This is due to the huge pressures on automobile manufacturers in the EU, Japan and USA to maintain and improve on their profit margins by maintaining the export markets and associated revenue streams. To remain competitive, automobile manufacturers around the world are increasingly seeking to purchase components from suppliers in low cost producing countries rather than manufacturing locally. This trend of sourcing and purchasing components from non-traditional suppliers located in the lower cost economies is called automotive component outsourcing and will continue to increase in the short to medium term.

With increasing competition and globalisation, key automotive manufacturers are consolidating on brand ownership with production in their core competencies whilst focusing on the building of closer supply-chain relationships. The trend is therefore towards more outsourcing and divesting of non-core activities, principally to lower-cost producing economies. In terms of the challenge of building and maintaining the very critical customer support base and satisfaction, the key needs of the automotive manufacturing industry in the short to medium term, perhaps the two key needs of the industry are to enhance the standardization and re-use of platforms; and to minimise/avoid recalls.

3.3 Challenges and Trends in Automotive Electronics

In terms of the future requirements and trends for automotive electronics, one of the key areas is in the development of novel control and power electronics systems. For low-level control electronics, the requirements associated with the environmental and operating conditions of automotive electronic components are typically characterized by at least three factors, namely:

- The operating temperature range (minimum and maximum temperatures)
- The number of temperature cycles over lifetime in the application
- The peak mechanical accelerations.

Another area of huge interest to the industry which has attracted a lot of research interests is the rising under bonnet temperatures as a consequence of higher engine output, the rising electrical power demands of control unit loads, and the higher integration of automotive electronics (more power in smaller packages).
With respect to the trends in the development of the power electronics required for electric, hybrid, and fuel cell vehicles, the key challenges are to develop a highly efficient, rugged, small size, and low cost inverter and the associated electronics for controlling the three phase electric machine. In fuel cell vehicles, a power-conditioning unit such as a DC-DC converter to match the fuel cell voltage with the battery pack is also a key requirement. For developments in steer-by-wire and brake-by-wire applications, a fast response motor, inverter, and the control system are the core requirements and as well as the capacity to operate in adverse environmental conditions.

4.0 Nigeria’s Automotive Manufacturing Sector

The automotive manufacturing industry in Nigeria is now over 30 years old and according to the Nigerian National Automotive Council (NAC); the industry has the capacity to produce 108,000 cars, 56,000 commercial vehicles, 6,000 tractors, 1.2 million motorcycles and one million bicycles annually [8]. There are over 50 auto component manufacturers some of who are original equipment manufacturers (OEM) and others supply the after sales market. In the late 1970s, Nigeria enjoyed a good boost in the automotive industry. The innovative engineering work in the country then resulted in car assembly plants in the country making more money in export revenue. Peugeot is one of the most popular marques in the country and the success of the industry ensured that the country enjoyed good returns from the export of Peugeot cars to neighbouring countries like Guinea, Ghana, Sierra Leone and Liberia.

Unfortunately, due to a number of factors, including the globalization of the automotive market and the impact of the second hand car imports, the capacity utilisation in the sub-sector, which was 90% in 1981, is currently 10% in automotive assembly and 40% in components manufacture [8]. According to the National Automotive Council, in the last decade, total vehicular supply (local product plus imports) was over a million units, about 80% of which were used. There is therefore a scope for new investment in the manufacture of low cost vehicle.

According to a recent media report [8], the total vehicular demand in Nigeria is considerable owing to the fact that transportation by automotive vehicle remains dominant. Data from the report shows that in 2005 ending, the total vehicular import stood at 51,525 units. In 2002 available record shows total import as 114,463 as against registered 1,073,146 registered numbers. In 2003 it was 223,664 units as against 702,487 registered numbers. In terms of local production, Nigeria's car market has been boosted by a Federal Government loan scheme for civil servants, as they are tied to the purchase of locally produced Peugeot models. According to the BMI report for 2006 [17], the Federal Government's car loan programme for its employees to buy PAN manufactured cars will continue to help sustain demand for PAN output, but BMI forecasts show that output will rise from an estimated 14,500 units in 2006 to 15,500 units by 2011.

4.1 National Automotive Council

The Nigerian Federal Government is very aware of the importance of the automotive industry as a veritable engine of development and is therefore determined to establish a viable self-sustaining automotive industry. To this end, the Government has therefore evolved a National Automotive Policy for Nigeria aimed at ensuring the survival, growth and development of the Nigerian auto industry using local human and material resources [9]. To achieve the aims of the Automotive Policy the Government has also set up the National Automotive Council, whose future plans include the provision of soft loans to the sub-sector; development of an Auto Test Center to test locally produced and imported components; funding research and development in auto related projects; training and retraining of manpower for the auto industry.
Although Nigeria is still a car producer, most domestic demand is met by imports. The Federal Government’s privatisation programme is picking up pace, with the government keen to divest its stakes in the country’s failing automotive sector [9]. The Federal Government has successfully divested its stakes in Volkswagen of Nigeria (VWON) and Steyr Nigeria and recently sold its 35% stakes in Peugeot Automotive Nigeria (PAN), which is 40% owned by Peugeot.

According to a USA Department of Commerce Report [10], the road mode of transportation accounts for over 90% of Nigeria’s traffic, a situation that has remained the same over the past 20 years. One of the major reasons for this is the dilapidated state of the country’s railway system which has remained grossly under-developed compared to railways in industrialized economies. This is why Nigerians have come to the view that “owning a car is no longer a luxury, but an essential necessity”

4.2 Challenge of Imports

Nigeria is the largest market for used car parts in sub Saharan Africa and constitutes the biggest export market for automobile products in the region. With an estimated per capita GDP of just over $400 in 2004; new cars are beyond the reach of a vast majority of the population. Over the years, this has increased the demand for imported used cars. In the market popularly known as Tokunbo, used cars and parts have recorded significantly high sales since the 80s. In 2000 for example, Tokunbo cars accounted for nearly 90% of total new and used car imports in volume terms.

In 1999, the Nigerian government imposed a ban on the importation of cars above eight years of age to curb the influx of old automobiles into the country. This has failed to yield significant results and only encouraged massive smuggling through neighbouring countries like Togo, Benin, and Niger. According to the Nigerian Automotive Manufacturers Association, while over 13,000 units of new automobiles were imported into the country in 2004, an estimated 25,000 units of used cars entered the market. Of this figure, only about 12,000 units passed through customs clearance while the rest were smuggled.

It is a well known fact that most Nigerians have developed a very high taste for prestige cars, but the fact is that none of those more expensive cars are produced locally and there is always some form of pressure on the foreign currencies needed for their purchase. On the other hand, however, importation of cars and their accompanying parts has also led to improved revenue collection for some government agencies in Nigeria. For example, it was reported that the Nigerian Customs Service (NCS) surpassed its revenue target for the year 2002, following the deluge of imports into the country; recording a total of N41.406 billion for the first half of 2002. Some experts say the increased importation of cars and other automotive products contributed to the improved bank balance of NCS [19]. The question is this: to what extent does the short term revenue from import tax offset the need for developing the local capacity for automotive manufacture in Nigeria?

It is very encouraging to note that the Federal Government and the NAC strongly advocates policies that can promote the development of local technology. If the basic technical capacities are present it would reduce or rather help to discourage the importation of completely built up units, providing better incentives to local assemblers to increase local content in production. It is also encouraging to note that the Nigerian Senate recently introduced legislation to ban the importation of vehicles that are above five years old from the date of manufacture into the country. Although the legislation was aimed in part at reducing the congestion in Nigeria’s seaports, which has been the bane of the country’s economy for sometime – it is expected to help provide further boost for the local automotive manufacturing industry.
5.0 Opportunities for Nigeria’s Automotive Sector

As part of the setting up of the first passenger vehicle manufacturing plants in Nigeria in 1975, the essential features of the technology agreement between the Federal Government and PAN/VWON were that [11]:

- PAN and VWON were "to assemble/manufacture" passenger cars using CKD components supplied by their parent companies but were "subject to progressive replacement with such parts, components, and elements made under licence in Nigeria or purchased from Nigerian suppliers." PAN and VWON were to procure necessary equipment from their parent companies
- In the first 3 years, the plants were to achieve 30% local content by value of the CKD -- 15% through in-plant manufacture and 15% through purchases from local manufacturers. The plants were to achieve 50% local content after 5 years and 100% after 13 years
- The initial capacity of each plant was to be a minimum of 10,000 vehicles/year
- Indigenous managerial and technical staff were to be recruited and trained locally in all essential activities such as "design and procurement of equipment, planning, installing and maintaining assembly machinery, tools, and jigs."

A review of the actual implementation and operation of the agreement show that the most important single issue has been the inability of the plants, deliberate or otherwise, to achieve a level of local content anywhere near contractual provisions. Other issues for examination include: quality of products; management practices and labour relations; transfer of technology to local staff; production costs and product pricing; and channels of distribution of products [11]. The question is, what lessons has been learnt by the Nigerian automotive sector after 30 years of operation of these plants?

The Federal Government policy on the privatization of the industrial sector is clearly stated in Section 5:13 of the Industrial Policy Document [9], which says, “Government plans to divest its interests from all industrial concerns in which it has equity holdings. Already, virtually all cement plants in which Government had interest have been privatised under the first phase of the programme. In the second phase, Government interests in the pulp and paper, sugar, fertilizer, and automotive sub-sectors will be privatized”.

In launching the new Policy, Chief Kola Jamodu (MFR), the then Hon Minister of Industry stated that “The Government of Nigeria is putting in place a system that will ensure, in the long-term, permanent resolution of the problems impeding industrial development. The Industrial Policy document has therefore addressed very concisely, critical issues of competitiveness, policy, finance, technology advancement, incentives to industries, research and development, among others”. As part of the Institutional Framework of the Nigerian Industrial Policy, the NAC is charged with the execution of the Automotive Policy of Government and the evolution of local content programme for the auto industry in the county. It also administers incentives to qualified auto industries.

Other developing nations such as Malaysia, South Korea and now South Africa that has successfully developed their auto sector have shown the way forward, by demonstrating that one of the most potent means of achieving economic growth is through effective building of capability in Research and Development (R&D). They have all shown that the key to developing the automotive sector is through a long-term investment in individuals and the Higher Education (HE) sector to ensure the development of local capacity in knowledge, skills, and resources for competing in the global market place.

The development of a world-class HE sector and associated Research Institutions has a central role to play in the building up of the capabilities for R&D for building and sustaining the local automotive sector. There is ample evidence from the UK HE sector that the R&D generated by these institutions have
contributed immensely to the building up and expansion of the knowledge and intellectual capital required by the automotive manufacturing sector. The setting of the Knowledge Transfer Partnership (KTP) Scheme in the UK which brings together the HE and Industry, has been the vehicle for helping businesses to improve their competitiveness and productivity through the better use of knowledge, technology and skills that reside within the HE knowledge base. Perhaps a “KTP” type scheme could provide a vehicle for deploying the Federal Government’s Education Trust Fund (2% of Higher Education Tax on company profits used to provide R&D facilities: physical infrastructure, equipment and human capability development). This will ensure that the knowledge base currently “locked up” within the Nigerian HE sector is harnessed by the automotive sector.

5.1. **Spare Parts Manufacture**
Analysis of the over fifty automotive component manufacturers in Nigeria [12] shows that there are huge potentials for automotive electronics components manufacture in Nigeria. Only 5 of these firms are currently engaged in the manufacture of electrical/electronic components – with the majority focusing on the provision of seats, wheel covers, brake pads/linings and other ancillary parts.

According to a recent report [8], the NAC carried out some work on “The Nigeria low cost vehicle project”, in collaboration with UNIDO and the Centre for Automobile Design and Development (CADD). CADD is a partnership between ABU, PRODA, Addis Engineering, and KWARATECH, amongst others. The NAC has other new initiatives which are relevant to building up the capacity to support R&D in automotive components manufacture. For example, they are collaborating with The Welding Institute (TWI) Cambridge, UK, to set up a world class centre of excellence in material joining and allied technologies with a focus on automobile technologies. They are reported to have recently signed a technical agreement with the Automotive Association of India (ARAI) to act as a lead consultant for the establishment of an automotive Test Centre in Nigeria.

With respect to automotive electronics components, when established the new Centre of Excellence will also need to link up with the Component Technical Committee of the Automotive Electronics Council (see website at [http://www.aecouncil.com/](http://www.aecouncil.com/)) which is the standardization body for establishing standards for reliable, high quality automotive electronic components. Components meeting these specifications are suitable for use in the harsh automotive environment without additional component-level qualification testing. With the support of the NAC, Local automotive component manufacturers can in the very near future, explore opportunities for exporting overseas – especially, taking up export opportunities such as that offered by the US African Growth & Opportunity Act (AGOA), primarily aimed at opening up the American market to the African Continent.

5.2 **Import of Used Spare Parts**
Although trading in used parts in Nigeria dates back to the early 80s, in the last ten years, it has become a full-fledged multi-million dollar business involving a large number of small and large enterprises spread all over the country. From an estimated market size of $40-50 million in 1998, the industry has grown ten times over to $400 million in 2004. There are prospects that this market size will exceed the billion-dollar mark in the next 10 years.

The Ladipo market is the major center for used auto parts trade in Lagos and supplies the rest parts of the country. The market is known for being the largest spare parts destination south of the Sahara. In fact, it is the biggest in terms of size and available varieties of car accessories in the whole of Nigeria. It is often said that whatever one cannot find in Ladipo is not yet in the country. The growing activity in the used parts trade has led to the emergence of a highly competitive environment, which almost poses serious threats to new auto parts manufacturing.
Secondly, there is growing concern on the increase in automotive accidents on Nigerian roads which are often linked to the poor quality/reliability of imported used parts. According to a recent media report [13], the Corps Marshal and Chief Executive officer of the Federal Road Safety Commission (FRSC), Mr. Osita Chidoka, disclosed that some 434 lives were lost and 1,123 people sustained various degrees of injuries in road accidents recorded in Lagos State, between January and June 2007. Analysts believe that there are some links between the rather high rates of fatal accidents and the increase in the use of imported used automotive components. There is a need for some studies to firmly establish if the use of imported used automotive parts is in any way responsible for the death toll in our roads.

5.3 Challenge of Automobile Components Reliability

Today, electronic systems and controls account for around 20% of the value of the average light vehicle. However, while 90% of the innovations in today’s vehicles are based on developments in electronics, according to Siemens VDO, and they account for about 70% of the quality problems, according to Daimler Chrysler [14]. Automotive recalls are common. Every month automakers announce recalls to replace products or parts that fail. These include such things as fuel lines that rupture, components that melt due to proximity to a hot manifold, or electronic failures that may cause the vehicle to stop dead in traffic for no apparent reason. Reliability problems become field failures that can erode credibility and ultimately result in a loss of reputation. It is estimated that the £40 billion automotive sector has product recalls costing over £500 million due to electronic failures – and high profile cases have had significant impact on brands. As one example of many, a major automotive manufacturer had to recall 55,000 vehicles due to short circuits within ABS units in 2002 alone. Just recently, Jaguar had to recall some 68,000 vehicles in North America, Europe and Japan due to an electronic system failure that could inadvertently select the reverse gear if the controller detected a major loss of transmission – oil pressure. In another example, it was reported that Toyota voluntarily recalled about 7500 Prius Hybrid vehicles [18]. They recalled slightly more than half of the Prius built in the last 2 years. The problem is associated with the gas – electric engine Electronic Controller module which sometimes causes the car to stall or shut down.

In terms of the potential costs for recall, failures lead to costs that extend the time-to-profit for a product, as failures can irrecoverably stain the reputation of a company. Financial losses can be in the form of loss of market share due to damaged consumer confidence, increase in insurance rates, costs to replace parts, claims for damages resulting from personal injury and maintenance of service infrastructure to service failures. A history of reputation and poor reliability can also prevent potential future customers from buying a product, even if the causes of past failures have been corrected. As the industry continues to implement new lead free materials and processes, manufacturers know that for them to remain competitive, they do not only need to know how things work, but they also need to know how things fail and how to minimise failure.

The result is that 30% to 40% of North America's $10-billion annual automotive warranty costs are attributed directly to software and electronics. Analysts predict that this problem will grow proportionately as the percentage of in-vehicle electrical and electronics content grows from a current 25% to 40% by 2010. To this point, electronics have been used in spot locations in vehicles for such things as fuel injection, antilock brakes and electronic clocks. But now there is a shift to applications including transmission controls and drive-by-wire and future developments such as crash avoidance systems will heighten the level of complexity. What are the implications for the Nigerian Automotive sector? What about the training and retraining of engineers, technologists and technicians?
5.4 Development of “indigenous” Local Car Manufacturing Capacity

According to the National Automotive Council [12], a low cost utility vehicle would serve the needs of the vast majority of Nigerians who live in the rural areas. There is already in the country, facilities for the assembly of cars and light commercial vehicles. Most of these facilities are currently not utilised or utilised sparingly and could be used by potential entrepreneurs. There are also well established component suppliers who will supply some of the auto components required. So what are the factors hindering the development of a sustainable automotive car manufacturing sector in Nigeria?

In terms of the efforts to develop a sustainable car manufacturing capacity in Nigeria, it is very important to make the distinction between the establishment of assembly plants - which are effectively assembly operations for imported parts (often from ‘knocked-down’ kits which take advantage of cheap labour and low levels of automation); and the genuine local manufacturing plants - which will encourage the economic development of local supply chains. There has been a number of press reports on the development of “made” in Nigeria cars – the most notable being Z-600 developed by Dr. Ezekiel Izuogu which perhaps represents the most commercially viable attempt at manufacturing a low cost utility vehicles in Nigeria. The Z-600 prototype, shown below in Figure 8, looks very much like a blend of the Isuzu, Toyota, Nissan and Mazda modules. According to analysts, most of the key components were imported whilst the chassis and body were built in-house. A more recent report indicates that the South African Government are keen to acquire the rights to mass produce the Z-600 [17].

![“Made-in-Nigeria” Car – Dr. E. Izuogu](image)

Figure 8: Z-600 Prototype developed by Dr. Ezekiel Izuogu, 1997

6.0 Summary

An overview of automotive electronics, including current and future design and manufacturing trends, and the technological challenges facing the automotive electronics manufacturing sector has been presented in this paper. The paper also examined the key drivers for the development and adoption of new automotive electronic features. For the major stakeholders in the global electronics industry the key questions are: what are the business opportunities in this emerging application market and what are the possible challenges in deploying applications in vehicles? The paper also reviewed the status of Nigeria’s automotive manufacturing sector, the impact of used car importation and the opportunities and challenges for Nigeria’s automotive sector in this emerging application area of automotive electronics.

The paper argues that after more than 30 years since its inception, the Nigerian Automotive sector is still in the nascent stage of development, and that although a number of analysts have reported widely on the lessons that can be learnt from the success stories from around the developing world economies,
including the Asian tiger economies, Latin America and from South Africa, the outstanding question is really one of how Nigeria can begin to build sustainable capacity in the automotive manufacturing sector. The National Automotive Council of Nigeria, established in 1993, is charged with the execution of the Automotive Policy of the Federal Government and has achieved some success in ensuring the survival, growth and development of Nigeria’s automotive industry using local human and material resources.

In terms of the automotive electronics components sub-sector, the paper has also explored some of the urgent questions for the NAC and its partners; amongst others these include the following:

- As electronics migrate from the aerospace and consumer sectors into the automotive sector, what automotive electronic features are now available as standard in premium/prestige cars?
- As globalization and the associated international competition force automotive manufacturers into the outsourcing arena, what are the current and future design and manufacturing trends?
- What are the challenges and opportunities for Nigeria’s automotive manufacturing industry in this important and fast expanding electronics sector?

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