ABSTRACT
With increasing urbanization, there is a heightened demand for smarter mobility solutions. This implies not only greener mobility, but also state-of-the-art commuting solutions. While “electric” is the buzzword for mobility in the current decade, soon it will be as common as any other mode of transport. Moreover, conventional cars have increased their electronic content both for human-machine interface (HMI) and also within each of the traditional systems such as engine management, steering, suspension, braking and safety systems. As technological paradigm shifts keep changing the way cars are defined, they will redefine the mobility concept in itself at a panoramic level. Recent emergence of carsharing, (as opposed to earlier concepts of carpooling), increased consumer demand to stay connected to the internet and multimedia during transport, a more sophisticated way of controlling vehicular applications, and ensuring a safe commuting experience are all key trends growing in mobility today. On the regulatory side, governmental focus on reducing emissions and fatalities in a smarter, greener society entwines itself into contemporary technological innovations - for both the car manufacturer and the mobility integrator.

INTRODUCTION
Frost & Sullivan has predicted several vital megatrends that will shape the future. With specific reference to automotive electronics, the relevant megatrends are “innovating to zero”, “e-mobility” and “smart is the new green.” Over the next decade, the focus of the automotive industry on electronic applications is expected to grow multifold. A large number of applications can be seen within the vehicle itself, whereas the application quotient varies between conventional and electric vehicles (EV). The impact of electronics on the larger scheme of things extends to enabling smarter transportation and commuting. This paper outlines these megatrends and their implications in the various spheres of the automotive industry.

LEVERAGING IN-CAR ELECTRONICS TO REAP BETTER BENEFITS
The modern day automobile is sophisticated in its every domain - from elements as evident as human-machine interface options such as the steering wheel to the more discreet such as engine throttle controls which operate under the hood. Without the help of electronics, these systems would not be all that refined and advanced. Electronic control units have grown significantly over the last decade. In a mass-market car such as the Volkswagen Golf, there are typically 49 Electronic Control Units (ECUs) in the Generation VI (2010) as against 17 in Generation IV (1998), a three-fold growth. A common application such as Adaptive Cruise Control requires about 20 ECUs to interact with each other. Going forward, future vehicles are expected to be even more advanced, entailing a staggering growth in the number of ECUs. Premium car manufacturers such as BMW use close to 70 ECUs already. As premium OEMs are expected to introduce more advanced technologies, most of which typically use an ECU, the future holds potential for 100 ECUs in a vehicle.

Contrary to this trend, the OEMs are keen on reducing the number of ECUs to keep costs low, reduce in-car energy consumption and streamline and leverage the best output from a minimal number of ECUs. Yet, the drive is also towards increasing the functionality of each ECU. This warrants state-of-the-art technology whereby the ECU hardware is capable of handling these functions with ease.
Hence, the trend is towards creating smarter ECUs that can potentially replace a sizable number of those in use today. For example, there are close to about 40 computing centers in a car, which process the information and signal the ECUs to prompt for appropriate action. The cost involved can be reduced by a fourth if an integrated set of eight to ten computing centers do the job. While this looks ambitious, the German OEMs are actively working in this direction.

Another trend is that of microhybridizing the conventional cars by introducing a supplementary power-net at 48V to supply energy to power-hungry systems. The major proponents of this initiative are the German OEMs - Audi, BMW, Mercedes-Benz, Porsche and Volkswagen - who are the early adopters of sophisticated technologies, many of which require high levels of electrical energy. The intention is to install a 48V Lithium-ion battery which will power applications such as Electric Power Steering, Vehicle Dynamics Management module, start-stop systems and few comfort and convenience functions such as Heating Ventilation Air-Conditioning (HVAC), power-windows, etc.

The semiconductor industry is fast catching up with this trend. NXP Semiconductor has already developed three FlexRay transceivers which are to operate at the 48V range. Others such as Infineon admit that while there are 48V compatible products, the width of the product line is not exhaustive to cater to the individual needs of various OEMs, as they already do with 12V systems. Yet, in due course, the industry is expected to develop dedicated product-lines for 48V as not only premium carmakers such as BMW, Mercedes-Benz and Audi are interested, but a volume carmaker such as Volkswagen as well. By 2020, many vehicles from German stables are expected to have a dual voltage system, working mainly on the FlexRay network. There are 48V-compatible CAN transceivers as well, so if OEMs who are not part of the FlexRay consortium wish to adopt this innovative trend, the semiconductor industry is ready for that move.

This is a step towards reducing energy consumption inside the vehicle as higher voltage components can be manufactured with lower physical dimensions. While these could be viewed as “green technology”, the idea is to exclude power-hungry systems from the 12V power net. Though this helps at vehicle launch in order to get a favorable rating for fuel economy, OEM initiatives in the telematics space that reduce the carbon emissions via smart routing and navigation are well known. With the United States evaluating the launch of vehicle-to-infrastructure communication, smart-commuting based on real-time traffic information is very possible.

**VEHICLE-TO-INFRASTRUCTURE (V2I) AND VEHICLE-TO-VEHICLE (V2V) COMMUNICATION**

The ability of vehicles to communicate with one another and with roadside infrastructure will yield several new features and applications which will cover safety and levels of information services to the user. Key enablers will be availability of in-car electronics and new age entrants into the car such as Smartphone apps similar to the one showcased by General Motors in the ITS world congress in Orlando. The system uses a transponder in the car and an Android app to showcase V2I and V2V features. As more and more congestion clogs the motorways, such services will grow-backed by wireless technology and in-car electronics to ensure more safety and useful services are provided to the driver. Thus, the growth of electronics in the mobility space is not just limited to the vehicle itself but the entire commuting sphere, such as infrastructure, where the vehicles are in movement.

**AS THE CONTENT INSIDE THE CAR INCREASES THE NEED FOR SOPHISTICATED HMI WILL INCREASE**

This will be largely dictated by OEM's need to differentiate their brand and also address issues such as driver distraction with the increasing amount of devices and content inside the car ranging from smartphone apps to browsers, etc. The result will be a multimodal HMI suite which will center itself on voice and use other technologies such as visual and haptics to complement voice.

**Large Center Displays with Touch**

Display screens presently average about 5-6 inches, but an increasing number of OEMs are looking at 8 inch screens and above displays in the center console supported by a mix of resistive and capacitive touch screens depending on the vehicle segment and cost. OEMs such as Ford, GM, and Chrysler have all moved towards interactive touch. This will in turn increase the level of software and electronics in the car required to present the information and create powerful user interfaces with large icons and clear graphics that do not distract the user.

**Reconfigurable Instrument Cluster**

With the advent of hybrid and electric vehicles and with the increasing content inside the car creating distractive scenarios there is an increased pressure on OEMs to deliver customizable information outputs to the user. This has led to the advent of displays within the instrument cluster (in line of sight of driver) that can be customized by the driver to present different layers of information suitable to the driving...
situation (e.g. Navigation instructions, eco drive information, etc.). Already OEMs such as Ford and Jaguar are offering this as an eco-driving monitor beside OEMs such as BMW who have pioneered this effort.

**LINK BETWEEN EV INFRASTRUCTURE AND CAR FOR REDUCING RANGE ANXIETY AND BETTER ENERGY MANAGEMENT**

As more EV's penetrate the market and charging infrastructure grows, there is an increasing need to manage energy grid networks and also provide valuable services to the user to reduce range anxiety and create compelling use cases for an EV. Similar to what Bosch offers with their e-mobility IT Infrastructure platform in Singapore, where they are linking the car, charging station and associated stakeholders at a single level and providing multiple services for the different parties involved, there is an increased focus from non-automotive players and automotive players such as IBM, Continental, and Siemens to create electronic interfaces in the car that link with the battery and vehicle CAN to the charging infrastructure. This provides useful services such as state of charge, charging station location and navigation directions, smart charging options, etc. This will lead to better energy management at the utility end and also provide incentives to users for charging at off peak times and using renewable energy options.

**DIAGNOSTICS INCREASINGLY IMPORTANT WITH GROWING ELECTRONICS**

There is a clear intent from OEMs such as BMW and GM who presently offer reactive diagnostic solutions in their ConnectedDrive and OnStar programs respectively, to offer more proactive diagnostics that have the ability to sense failures from an electronic standpoint and use OTA techniques to solve it remotely with the growing wireless communication bandwidths provided by technologies such as 4G, etc. This will enable OEMs to offer more value out of the electronics provided in the car, decrease warranty costs, better align inventory and most important create powerful CRM for brand loyalty.

**ELECTRIC MOBILITY AND THE DRIVE TOWARDS ZERO**

With constant fluctuation in fuel prices and an ever-present scare that fossil fuel reserves may get depleted in coming decades, the future of mobility is essentially electric - partly or wholly - although a large number of innovations are still seen in the conventional powertrain of internal combustion engines. A large fraction of the bill of materials for a conventional vehicle may not be relevant in the electric vehicle value chain. Valve timing, electronic throttle control and other engine-related systems are clearly not required. That said, the prime-mover of the EV requires a separate set of components - both to power the battery and to run the motor - thereby creating a separate ecosystem that caters to the EV value chain.

From veterans such as Delphi to various new entrants in the market, a new supplier base is evolving to cater to the dynamic needs of the EV value chain. The vehicle supervisory controls required for an EV is fundamentally different from the control systems for the conventional car to check the various vehicle systems and modules. Moreover, conventional cars have themselves increased their electrification content from earlier applications of purely mechanical systems, which intermittently transitioned to hydraulic and electro-hydraulic and eventually pure electrically-powered electronically controlled systems. Applications such as electric power steering and electromechanical braking are true examples of this transition. While traditional hydraulic applications used to draw power from the engine output shaft, the EV stores and generates all its energy in the battery. This belies the viability of a hydraulic system to be installed, thereby paving the way for pure by-wire systems for braking, steering and even suspension systems. This entails neither the frictional losses of a purely mechanical system, nor does it cause any adverse impacts on the environment that a hydraulic system would. With every electrical system, there is a need for control and this is typically established by electronic control units. Hence, the scope for electronics in an EV is much larger than in the conventional automobile.

In the bigger picture, Information & Communication Technology giants such as Google, IBM etc. and utility companies are expected to play a major role in the overall dynamics of the EV ecosystem ranging from various associated needs such as charging stations, a cloud computing facility to transform the vehicle as a living space, to enable V2X communication and to eventually pave way for Intelligent Transportation Systems (ITS).

**CONCLUSION**

The above mentioned trends tie into various megatrends put forth by Frost & Sullivan. The future ahead promises a natural drift towards “smart is the new green” whereby the industry focuses on creating smarter electronic components as against their earlier focus on merely going green. The other mega-trend on e-mobility is an expected outcome of various OEMs and other stakeholders investing huge sums of money into the electric vehicle space. And last, but not the least, the concept of innovating to zero is evident from the initiative of every tier-1 in trying to reduce the size of the individual system for packaging needs, integrating electronics
from across domains and enhancing the power of electronics beyond their current domains.

REFERENCES

1. Frost & Sullivan analysis

DEFINITIONS/ABBREVIATIONS

CAN - Controller Area Network
EV - Electric Vehicle
V2I / V2X - Vehicle-to-Infrastructure