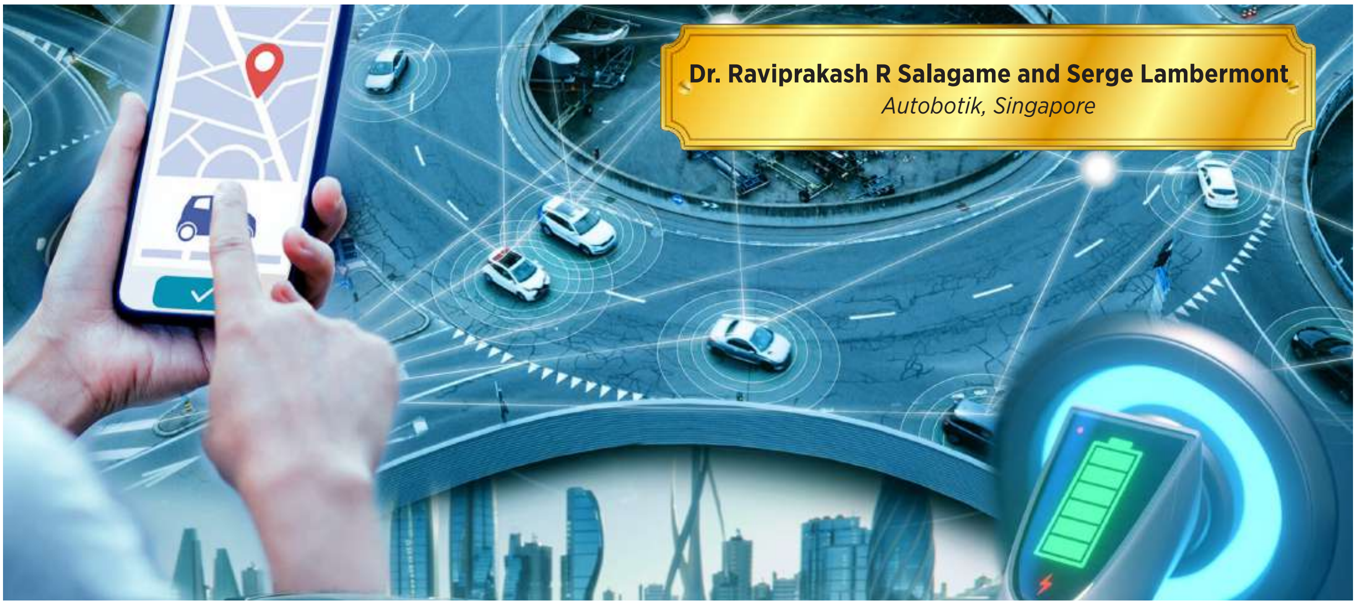
WINNING THE MOBILITY TRANSFORMATION BY TECHNOLOGY DIFFERENTIATION

Autobotik, Autonomous, Systems Integration, Digital, MLOps, Transformation



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Abstract

The convergence of major megatrends - electrification, autonomous driving, connectivity, shared economy and on-demand mobility is changing the way we think about transportation, logistics and smart city applications. Although each trend is profoundly disruptive on its own, the combination of these trends is creating new challenges and opportunities. A fundamental shift in the adoption of these technologies is driving the transformation of business, innovation and products in the automotive industry at an accelerated pace compared to previous decades. Key enablers for these changes may be traced to significantly higher computing capability, vastly improved network speeds and hyperbolic advances in software engineering. Global megatrends such as urban migration, public infrastructure and consumer choices on personalization are driving the demand for adoption and acceptance of these technologies. On-demand, sharing, personal mobility devices, and an increase in charging points are already changing the world faster than ever. Though the awareness of these changes is pervasive in the industry, many organizations struggle to find a navigable strategy that differentiates their value proposition to remain relevant. In addition, lateral technology adoption such as from cell phones to Personal Mobility Devices (PMDs) is creating new challenges for safety. While it is obvious that sustained infusion of technical skills and capability is at the core of such transformation, effort in this direction alone is insufficient. It also requires a deep-dive study to identify key differentiating technology investments in safety, autonomous drive, electrification and connected space as well as business process innovation to maximize returns from these technologies. Focus on such differentiators in product and enabling technologies and alignment with relevant business drivers will increase the chances of a successful transition towards the mobility industry vision. As this change is ultimately propelled by people and resources, we believe that leaders need to drive the right cultural behaviors in the organization to achieve the goal. An amalgamation of these tenets of transformation can be structured into a framework which can be adopted to drive systematic change.

1. Automotive Megatrends

According to a recent UN study [1], about 68% of the world population will migrate to cities by 2050. Thus, the goal of reducing traffic congestion, efficient parking solutions, charging points and reducing pollution, all of which lead to sustainable transportation is the primary motivator driving technology evolution in the automotive industry.

The development of smart city infrastructure and smart mobility solutions which are related to sustainable transportation are likely to play a major role in the future of transportation. Propelled by these goals, the automotive industry is witnessing a phenomenal affinity in technology adoption and huge shifts in business models which are driving these changes. Recently, Gartner released a report [2] highlighting the top 5 technology trends for 2022 in the automotive industry. A common thread among these trends is the fact that software will drive profitability growth for automakers. Another report [3] claims that digital twins, Internet of Things (IoT) and additive manufacturing will drive tectonic transformation in the manufacturing sector. It is predicted that about 10 % of today's manufacturing processes will be replaced by additive manufacturing by 2030. The rapid growth in Electric Vehicles (EV) is quite well known in the industry. The EV market size is expected to grow at 25 % CAGR till 2030, although at differential rates in different geographies of the world. From these data points, we can identify the following 4 top trends driving the automotive industry today

a) Electrification is leading to green and clean transportation

b) Safety technologies are leading to autonomous transportation.

c) Digital technologies are leading to connected infrastructure for vehicles, smart cities and manufacturing (Eg: on-demand services/vehicles, ride-sharing, car-sharing, deliveries and city logistics)

d) Changing preferences like the shared economy and consumer choices are driving innovative mobility solutions. A few examples are EV skateboard platforms, Personal Mobility Device (PMD) [4], street sweepers, urban package delivery, logistics, self-driving vending machines and smart robotic vehicles.

Most industry experts agree that these four trends will synchronize and act as catalysts for each other over the next decade. For example, in some EU cities, people are already not purchasing a second vehicle and using ride-sharing applications instead. According to one estimate [5], new business models could expand automotive revenue pools by about 30 % adding up to 1.5 trillion USD. Such rapid changes in the industry require a strategic approach to transformation which involves attention to key differentiators in technology and business investments.

2. The Industry challenge

Though technology evolution is more visible, the industry is also witnessing a business model shift. The traditional automotive industry ecosystem has been successfully run using a hierarchical structure leading to OEM at the top. In the last decade, the industry has seen new players and a broad realignment of product offerings resulting in the blurring of boundaries among the suppliers, the OEM and the consumers. While in the past OEMs successfully implemented a tiered supply chain to manage the increasingly complex supply chain globalization, automotive quality standards and innovative features, the future may necessitate them to collaborate much more from the early stages of product development. In contrast, electronics in vehicles is increasing rapidly and many of the components are developed in adjacent markets. Thus, the integration is becoming increasingly complex and a more vertically supported model may be required (Eg: Tesla). Although it is unclear at this point the direction that the industry would follow, these shifts seem to indicate that the future is likely to be more of a collaborative model with consumers at the center of the ecosystem and businesses working closely as partners to deliver superior customer experience as seen in Fig 1.

With over 40% of future growth in revenue coming from the aftermarket and mobility services, a gradual morphing of business models to collaborative ecosystems is more visible.

It is also interesting to note that a large number of startups in the automotive industry are contributing to a growing innovation portfolio. A report published by Frost and Sullivan [6] about a year ago claims that over 2000 startups are accelerating innovation within the auto industry ecosystem with innovative business models strongly supported by close to 188 billion USD. The momentum in

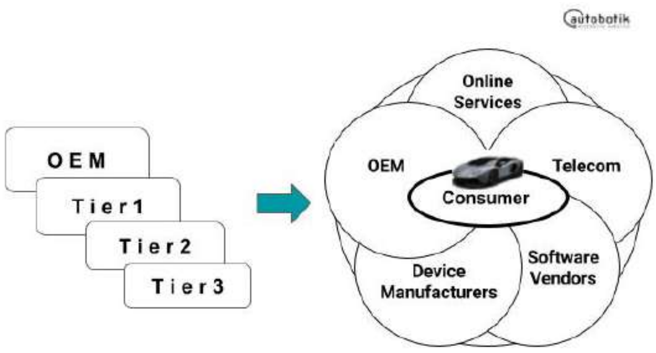

Fig 1. Automotive industry ecosystem evolution in the future

the startup scene in the automotive space is sort of unseen in the industry in the past.

Given these challenges, the transformation needs to consider competitive differentiators and sustainability as two drivers of success.

3. Technology Differentiators

When businesses strategize transformation, technology investment decisions and organizational alignments typically pivot these changes. However, any directional re-alignment hinges on technology, business and the internal culture. Any strategic plan to accomplish this goal is a balanced combination of these three factors. Although technology is at the center of this strategy, business and cultural aspects must be passionately driven for success in this journey. In this section, we will examine deeper aspects of technology to identify major influencing factors. However, we will comment on other factors for completeness.

A macro-level view of the key focus areas for any organization is more easily derived based on the long term goals and vision. However, in our experience of working with several companies and a study of the technology dynamics, the essential differentiating factor between a good and a great transformation story is the right identification of major influencing levers of technology and prioritized strategic focus in these areas. Considering the four top trends that we discussed earlier, we believe that the following five areas of technology would be key contributors to these trends in moving an organization to a higher competitive space.

3.1 Systems Engineering and Systems Integration

A large number of products and services today require vertical and horizontal integration across disciplines such as hardware, software, communication and user experience. Systems engineering thus becomes a key differentiator to create/launch robust products into the market. A majority of flawed launches and product issues are typically traced back to system integration issues. They may be minimized with a proper systems approach. Systems Engineering is the science of structured development process which revolves around managing requirements through the life cycle of concept, design, build and launch. System Integration is the process of bringing together the component subsystems into one system to ensure that they function together as a coherent system. The traditional V-diagram shown in Fig 2 illustrates this relationship. A strong capability in systems engineering deeply relies not only on the broader experience of multiple value chains by engineers but also on the disciplined thought process. Thus, organizations find it challenging to build deep and reliable systems engineering capability. Well-known automotive processes such as ASPICE [7] and ISO 26262 [8] structure will be quite helpful in this regard. Relying on these processes with application life cycle integration and the right tools can mitigate this challenge to a significant extent.

Traditionally, the automotive industry has relied upon hierarchical development across sub-systems culminating in a final integration at the vehicle level. As the industry transitions, we see two major challenges that this structure poses for systems integration

i) With the ability to do OTA (Over-The-Air) updates, product features and upgrades will continue to happen post-launch similar to smartphones. Though this increases flexibility to a large extent, the automotive industry is tightly governed by safety, warranty and liability parameters, which poses a challenge for system integrators to create reliable software-defined architectures.

ii) EV or autonomous products involve a combination of complex sub-systems in hardware, software, communication and User Interfaces, often supplied by vendors with highly variable capability and automotive industry experience. In addition, as OTA enables them to update the features post-launch, development, particularly

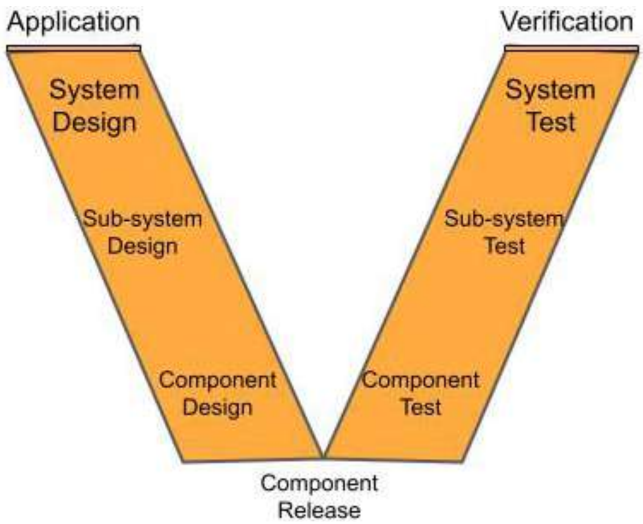

Fig 2. Traditional V-diagram for system engineering

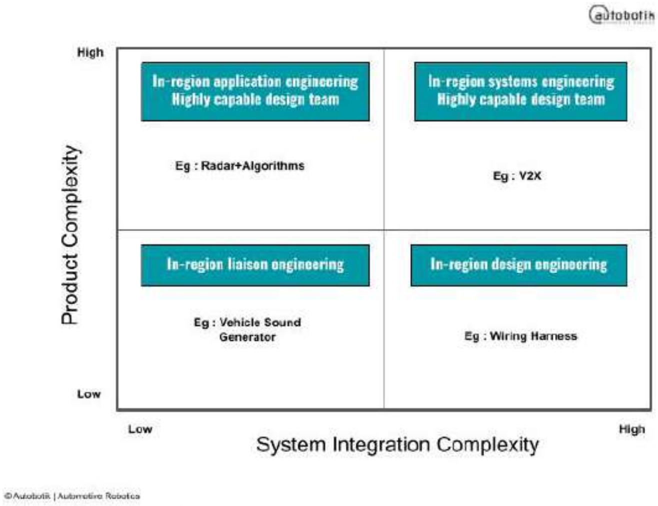

Fig 3. Global Footprint strategy based on complexity matrix

software development follows CI/CD (Continuous Integration/Continuous Delivery) model.

These challenges need to be considered while defining an integration capability roadmap. There are several dimensions to creating such a roadmap including optimal resource management. Fig. 3 shows an example which looks at the intersection of product complexity and integration complexity to develop a strategy for a global footprint plan. Differences in Complexity define the development location and effort.

In our experience, businesses with robust product launch experiences typically master systems engineering capability with critical mass.

3.2 Digital Engineering Integration

Advances in the Internet of Things (IoT) and cloud computing is transforming the way products are developed and launched. Besides, the use of enterprise-wide data and deeper analytics can enhance not only internal productivity but also provide pathways for new products and services. Today, the passenger car itself may be thought of as a giant IoT enabled moving device. According to a McKinsey Report [9], "the overall revenue pool from car data monetization at a global scale might add up to USD 450 - 750 billion by 2030" . Digital transformation across the entire organization will no longer remain an option in the next decade. While most readers are aware of the impact of digital engineering and its penetration across enterprise-wide processes, we will highlight the following three key differentiating areas for successful digital implementation

i) Life-cycle management with digital across the value chain

Leaders often struggle with data aggregation across the value chain that provides meaningful insights and enablers for business decisions. It is critical that the data is quality-controlled, integrated and managed through the lifecycle of product development, launch and service across the entire value chain in engineering, manufacturing, supply chain, finance and quality. The difference between analytics with siloed data vis-a-vis coordinated data across the enterprise can be a huge advantage for businesses.

ii) Legacy data integration

Large companies with decades of history need to focus on building a high-quality data pipeline with the ability to integrate legacy data seamlessly and make it available across all the value chains. Without seamless integration of legacy data with a planned data strategy for the future, the data story typically remains incomplete. A dedicated focus is necessary to accomplish this task and derive maximum mileage out of data analytics.

iii) Predictive Analytics

The pinnacle of data analytics is to be able to build predictive models across various value streams like design, manufacturing, procurement, sales and finance. Most modern data analytics approaches have strong fundamentals in statistics and probability and can be used to build sophisticated models for exploratory as well as predictive methods. However, the accuracy of such models depends on the quality and threshold of critical data from every value chain. Building capability to create such validated and useful predictive models would provide a competitive edge both for products and on-demand service opportunities.

3.3 MLOps in Software Engineering 2.0

Modern cars are turning into computers on wheels gradually migrating to a software-defined architecture. This requires a radical rethinking of development processes. The automotive development processes of today are based on mechanical processes, machined parts, soft tools and hard tools, and a tiered supply chain with defined change control processes. However, software development is becoming increasingly complex and many modules and technologies are re-used from adjacent industries. Agile fast development cycles (vs waterfall) require additional process verification. In such a scenario, a razor-sharp focus on growing software engineering as a core differentiator is very critical. The implementation paradigm for Software 2.0 is likely to permanently shift as AI and Machine Learning based development takes deeper roots. For example, ADAS safety and automated driving algorithms must include field learning as the environment does change over the lifetime of the vehicle. Besides, current research indicates that less than 20% of the ML projects go into production [10]. One of the primary reasons cited for this poor yield is the fact that trained ML models don't generalize well when field-tested. Hence, smart organizations with competitive goals use MLOps more productively. As an example, Tesla [11] claims that its neural networks learn from diverse scenarios in the world iteratively sourced from a fleet of 1 Million vehicles in real-time and the autopilot outputs 1000 distinct predictions at each timestep. It must be observed here that the software is continuously developed and updated even after the product is already in the field. A smart way to manage this paradigm shift is to adopt and build MLOps practices across the entire value chain.

MLOps was conceived at the intersection of Data Science, DevOps and Machine Learning [12]. It is a set of practices for collaboration and communication between data scientists and ML professionals aiming to continuously develop, deploy, learn and improve predictive models as described in Fig. 4. As ML becomes the primary mode of development, a deep capability and a productive MLOps will become a key ingredient of any differentiation strategy.

The first two circles represent the adoption of lateral technologies in the automotive industry. As an example, features of deep learning for gesture recognition from vision may be used to train networks for traffic signs and hand recognition at intersections. The key to an eventual successful ML product in the field would be the organization's ability to create a robust closed-loop system where the ML algorithms may be improved with field learning in a dynamic development process as represented in the third circle. The amount of data from the field among tech companies is huge, but the trick is to make the applications work for the automotive industry. Often, the difference between a working autonomous software and a robust autonomous software lies in the way networks are trained with corner cases. In this context, it is worth mentioning that a recent SAE paper [13] dives deeper into this aspect focusing on corner cases for automated driving and how field data can assist in improving ML algorithms for autonomous technology.

Selection of the right set of tools, setting up the right execution structure and creation of agile processes are the building blocks of a good MLOps strategy.

3.4 User Experience between Cyber and Physical Systems

The systems of tomorrow live in both physical and digital planes. A connected car for example needs to integrate into cloud infrastructure and be able to interact with the driver just as seamlessly. The key differentiator in the user interface would be how physical and digital worlds are integrated with each other to provide the end-user with a smooth experience. User Interface/Human Machine Interface (UX/HMI) is becoming more and more important. New technologies from UX/HMI can provide additional assistance such as warnings, head-up displays and augmented reality based head-up displays. As an example, the integration of these systems for smart city transportation involves the integration of cloud, the infrastructure and the vehicle as described in Fig. 5.

These cyber-physical systems exhibit a high degree of flexibility for software systems but need to work within

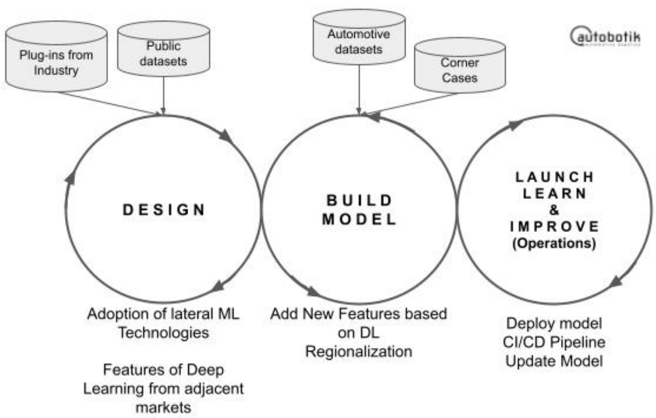

Fig 4. A Generalized MLOps representation

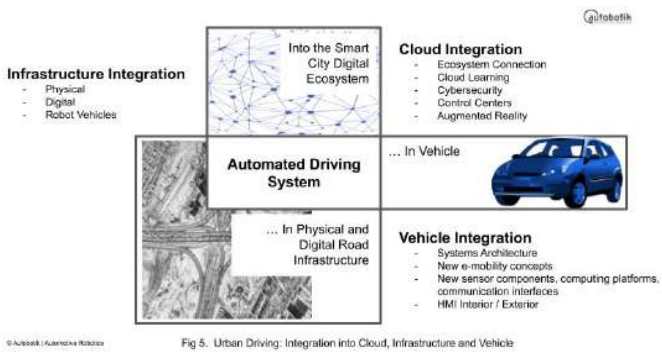

Fig 5. Urban Driving: Integration into Cloud, Infrastructure and Vehicle

the constraints of physical systems. As described in the research paper [14], there are several challenges in designing user interfaces for such systems. A major challenge is to resolve the conflict between the use of "smart" components which lead to more flexible and adaptable systems and increasing technological complexity. Meeting this challenge would require organizations to view this as a systems challenge since a vast majority of automotive products and solutions would somehow become part of a cyber-physical system. In addition to this, these UX/HMI must also work with regulatory bodies to comply with regional regulations for safety and SOTIF (Safety of The Intended Functionality) while most countries are yet to develop a charter to accommodate automated driving.

3.5 Cloud-Based Computing Architecture

To create a competitive edge with technologies, all these technologies are driven by a reliable computing infrastructure which includes a futuristic architecture and a balance between edge and cloud computing. Demand for resources for agile development coupled with open source innovation will challenge IT groups to provide differentiating infrastructure within the businesses while balancing development costs. For technology implementation and successful deployment, a deep cloud-based IT strategy is a great differentiator.

4. Catalysts for Transformation

Driving differentiation through technology is more likely to be successful with a realignment of business and cultural drivers which act as catalysts in the transformation. Newer and unfamiliar business models which are making their way in the industry today are more likely to become commonly accepted ways to work eventually. Thus businesses would do well to adopt a few of the best practices such as agile development workflows and digital integration across business value streams.

A visible outcome of the adoption of integrated digital tools across functions such as marketing, sales, finance and customer service would be the ability to launch products and services on-demand. The digital integration in turn renders productivity within the organization as well and minimizes variance in the workflow. These value-added services can become a huge differentiator. Popular use of Robotic Process Automation (RPA) tools which begins with workflow automation can eventually lead to enterprise workflow integration.

Over the last four decades, statistics show that technology adoption and eventually the half-life is reduced by an order of magnitude. A recent NYT article [15] which covered technology adoption rates since 1900 clearly shows that the rate of adoption is reduced by at least 50 % or more. Technology obsolescence is thus a major challenge to overcome in this path. A rewards and recognition focused learning and development culture enabled by the state of the art tools, resources and support for continuous skill development across all levels and ages will be the right solution for this challenge.

For these efforts to be successful, a culture of innovation must be developed by exploring concepts such as open innovation in addition to promoting intellectual property. Open Innovation was first put forward by Henry Chesbrough in 2003 as a means of sharing, collaboration and mutual growth. According to a recent IBM report [16], "organizations that embrace open innovation had a 59% higher rate of revenue growth than those that didn't". Most large corporations today adopt a version of the corporate accelerator (CA) program to promote open innovation in a customized fashion. A case study about this can be found in a recent MIT Sloan review article [17]. Such programs need to be run with a strategic seeding of the right start-ups and investments which eventually can promote not only innovation but also a roadway to successful transformation in the industry.

5. Implementing Transformation

We recommend an implementation roadmap and a framework to be adopted by organizations to drive this accelerated change. Such a framework must begin with a layout of the enterprise capability roadmap supported by its long term vision and goals. The effort is best led by a full-time leadership and task team with a multi-generation plan. Autobotik advises its partners and clients to implement and execute such a framework with a 3-stage transformation model called the 3E model [18]. The 3E model starts with an exploratory phase where the organization's maturity is assessed. This activity would be a precursor to the next engagement phase where stakeholder engagement would help to create a practical multi-generation plan followed by a phased execution.

6. Summary and Looking Forward

The Automotive industry is witnessing metamorphosis in the way technology is adopted, the way business is run and the way innovations are commercialized. This transformation is moving the industry to a customer-centric ecosystem with all the partners playing a collaborative role to enhance customer experience. Coupled with consumer preferences and urban migration, new mobility products and services will continue to drive this paradigm shift. As businesses morph to adapt to these changes, it is critical to recognize key influencing levers to work with and affect a successful business makeover. A structured framework with strategy at the center provides the essential guiding principles for organizations throughout this journey.

About the Author

Dr Raviprakash R Salagame is currently a consulting partner at Autobotik, a systems consulting company in the automotive industry. His expertise is in autonomous, electrification and mobility solutions, strategy, operational excellence, automotive quality systems for hardware, software and data analytics. He is also a mobility engineering strategic advisor for Intuceo, a data analytics company. Over the last two decades, he has held various global leadership roles in research, product engineering and operations at APTIV (formerly Delphi Automotive), GE Global Research and IBM Almaden Research Center. At APTIV, Ravi built a strong global product development capability and led Hybrid/EV product portfolio for India. He led the development and launch of automotive electronics products for the Indian market.

Serge Lambermont is a technical expert in automated driving, robotics, and vehicle electrification. In 2018, Serge is the founder and CEO of Autobotik, a consultancy and advisory firm for AD strategy, new mobility solutions, and vehicle electrification. Prior to Autobotik, Serge served as APTIV's Technical Director of Automated Driving (AD) based in Silicon Valley and Pittsburgh and was responsible for Delphi's global urban AD technology development. During this time, he initiated the acquisition and integration of Ottomatika, a Carnegie Mellon University start-up in AD robotics. In 2015, he led Delphi's 3,500-mile San Francisco to New York City coast-to-coast automated drive and Aptiv's 2015 CES urban driving demos. Most recently, he has been leading the urban self-driving vehicle development platforms for the Singapore Automated Mobility on Demand Pilot and urban driving activities in Europe.

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