1 Introduction

This chapter provides a brief overview of the main topics of the book. Technology is arguably the most important driving force in today's world. Recent progress in the digitalization of everyday objects is removing constraints and enabling new possibilities that affect humans' lives, enterprises, businesses, mobility, and much more. The technological progress has always had a big impact but has accelerated in recent years. The past decade has witnessed remarkable advances in digital technologies that have far surpassed the decade of personal computers through cutting-edge innovations, such as the Internet of Things (IoT) and Open Artificial Intelligence Technologies (OAIT) like Machine Learning (ML) and Deep Learning (DL), as well as Big Data Analytics (BDA), Cloud Computing (CC), and others. These technology advances are fast and breathtaking with regard to the ways they are affecting and changing humans' lives and work as well as companies' business models. The companies that use digital technologies achieve significantly higher levels of profit, productivity, and performance through smarter decision making, elimination of inefficiencies, and a better understanding of their customers (Westerman et al. 2014).

The automotive industry, which encompasses a wide range of companies and organizations, is one of the most important worldwide industries today as it becomes more aware and responsive to its surroundings. Automakers are responsible for the design, development, manufacturing, marketing, and selling of automobiles and trucks, also called motor vehicles or, in short, vehicles. These vehicles provide promising intelligent functionality and get always smarter which can be seen at the Consumer Electronics Show (CES) in Las Vegas or the International Motor Show (IAA) in Frankfurt, the world's leading trade show of the automotive industry sector. The fundamental driving forces for this development are:

- *Digitization*: Process of converting information into a digital format. In this format, information is organized into discrete units of data that can be separately addressed. Hence, digitization is the strongest and most comprehensive driver of

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automotive cutting-edge innovation like connected and self-driving commercial vehicles which goes far beyond the driver assistance systems we have to date.

- *Electro Mobility*: Branch of industry that focuses on mobility needs under sustainability aspects by developing and manufacturing vehicles that carry energy storages and electric drives that can vary in degree of electrification. Today, most automakers have vehicle models with hybrid and pure electric drive in their portfolios and on the roads. In the short and midterm, this will enable a more zero emission mobility, which will bring a new quality of life to urban spaces by applying efficient strategies to decarbonize the transport sector. For the near future, this also necessitates digitally networked roadside units (RSU) which are computing devices located on the roadside providing connectivity support to passing vehicles.
- *Smart Transportation:* Digitization enables a quantum leap forward in the direction of smart cities with regard to facilitating more safety, greater efficiency, and a better quality of life due to a smarter form of mobility. There are already more mobility options available to users than ever before. These options include traditional modes of public transportation like rail, bus, paratransit, ferry, and others, as well as private and non-profit oriented mobility services. Thus, the transportation sector is exploring partnerships among the different types of providers (Dinning and Weissenberger 2017). Also, transportation safety is a critical societal issue and has become a worldwide top priority (Mendez et al. 2017). Fortunately, safety is rapidly increasing, for example, the smart vehicle contains surround-view cameras and sensors as well as other innovations so that the blind spot and associated dangers will become a topic of the past. Freight will be delivered on demand, individually, and on time. For smart cities, this kind of smart transportation is still a vision, but it is already conceivable for destinations in rural areas where the vehicle is supported by delivery drones that swarm out and fly to the final destination of delivery. Another important issue in smart transportation is the emergence and evolution of shared mobility services which is changing the field of mobility in transportation.

Technological advances in sensor and navigation technologies, the networked living space through the Internet of Things, and the advances of services in the form of an Internet of Data and Services (IoDaS) will spur the visionary and affordable mobility of the future, the so-called smart mobility.

Compared with this somewhat more futuristic vision, automakers have already incorporated different intelligent assistance and management systems in today’s vehicles, one of which is a smart motor management to make the vehicle fuel efficient and environment-friendly while ensuring comfortable driving characteristics. Other systems protect the drivers and passengers by the means of innovative and intelligent active safety measures, entertain the passengers or offer access to different kinds of information sources and services in and outside of the vehicle.

1.1 The Automotive Industry

The automotive industry is one of the world's most important economic sectors by revenue (see Chap. 2). Global sales of passenger vehicles were forecast to hit >80 million vehicles in 2015. Along with China, the USA is counted among the largest automobile markets worldwide, both in terms of production and sales. Approximately 8 million passenger vehicles were sold to US customers in 2014, and around 4.25 million passenger vehicles were produced in the same year in the USA. In terms of revenue, Toyota, Volkswagen (VW), and General Motors (GM) are ranked in the top list of major automakers, while the automotive supplier industry is dominated by Bosch, Continental, Denso, and Magna (URL1 2017).

The big German automakers have been the driving force behind the German economy in the past 10 years. BMW, Daimler, and VW alone represented a considerable share of global sales in the passenger vehicle market at around 20%. Within the German Stock Exchange Index (DAX), the three corporate giants are listed in the top five.

According to the study by Roland Berger and Lazard (URL2 2017), global vehicle production was expected to grow only moderately at around 2% in 2016 and beyond. The cooperation between automakers and automotive suppliers allows the automotive industry to introduce innovative changes in technologies and new mobility concepts for vehicle usage certainly within the next 10 years. On the powertrain side, for example, the development of e-mobility is the main driving force. Technological hurdles may prevail, and a convincing business case for the end user may not be accomplished yet, but tightened emission regulations will likely have a catalytic effect over the coming years. To stay successful in this volatile and rapidly changing environment, automakers and automotive suppliers will have to increase their agility, flexibility, and speed up innovation cycles in developing and running their business. Due to the high demand for ever new innovations in mechanics, electronics, and information technology, automakers and automotive suppliers have developed an excellent knowledge base with respect to development, production, and process integration, which is also being deployed and monetized in other branches of industry.

The term innovation can be defined from a general perspective as follows: Innovation is the process translating an idea or invention into a product or service that creates value or for which customers will pay. Innovation can be divided into two categories:

- *Evolutionary innovations* (continuous or dynamic): Based on many incremental advances in technology or processes
- *Revolutionary innovations* (discontinuous innovations): Often disruptive and new, such as disruptive mobility determining efficient strategies to decarbonize the transport sector

Therefore, innovation is synonymous with risk-taking, and organizations that create highly innovative products or technologies at the frontiers of knowledge take the greatest risk because they create new markets or services.

Technological innovations at the frontiers of knowledge are often considered to be cutting-edge innovations. Cutting-edge technology refers to current and fully developed technology features, unlike bleeding-edge technology, which is so new that it poses unreliability risks to users. In this sense connectivity and connected vehicles can be regarded as cutting-edge innovations of the automotive industry. In contrast, self-driving vehicles represent a bleeding-edge innovative technology because it may pose unprecedented risks with regard to the required digitized and intelligent infrastructure and the interaction of human and self-driving vehicle. Furthermore, the technology puts pressure on governments to make regulatory changes permitting on-road testing of autonomous vehicles.

As a term, cutting-edge technology is somewhat ambiguous and often used in the context of marketing. In connection with the automotive industry, the following cutting-edge technologies are recognized as important:

- *Artificial Intelligence:* Mimics cognitive functions that typically would be associated with human intelligence such as learning and problem solving. Traditionally, AI includes disciplines like reasoning, knowledge representation, planning, learning, natural language processing, and perception. Machine Learning algorithms attempt to model high level abstraction in data and allow to increase the knowledge base from data by identifying underlying structures. AI already shows outstanding results in pattern recognition problems, such as recognizing objects in images, speech recognition, and robotics. Self-driving vehicles rely on AI for sensor fusion, perception, behavior and navigation. Deep Learning is important for intrusion detection and defense discovering intricate structures in large data sets by using backpropagation algorithm to indicate how systems should change their internal parameters that are used to compute the data representation in each layer from the representation in the previous layer.
- *Big Data Analytics:* Big data are data sets that cannot be held and evaluated in conventional databases due to their huge amount of sets (volume), their diversity in structure (variety), and their volatility and availability (velocity), the three V's. Big Data Analytics describes concepts, methods and technologies to handle, structure and visualize large amounts of data, both structured as well as unstructured. In this sense, big data represents a "data tsunami" of an exponentially growing amount of different kinds of information which is threatening to overwhelm vehicle drivers and passengers alike.
- *Internet of (Smart) Things:* The Internet of Everything (IoE) is rapidly emerging which can connect everything with anything from everywhere to anywhere at any place and any time. An autonomous driving vehicle contains a huge number of sensors and actors that need to talk to each other, to central data controllers, and to all other vehicles around it on the road as well as road side units (RSUs). Digitized road infrastructure information such as traffic signs, traffic lights, roadworks, and other components will become IoE enabled and will provide vital information to autonomous cars. Already, these systems have practical applications, for example, a parking area e-plate recognition system can connect back to any driving licensing authority if the driver fails to pay the parking fees.

Traditionally, automakers have distinguished themselves by engine performance, the powertrain, and the vehicle design itself as most important features, and customers have always carefully and critically evaluated these characteristics before making a decision which brand they want to buy. But today the automotive industry is also developing and embedding cutting-edge technologies in their vehicles such as modern information and communication technologies (ICT) which address on the one hand tomorrow's mobility needs and on the other hand today's demands of the younger generation, the so-called digital natives, to be online all the time and to access and control everything with their smartphones.

Car IT considers all of the information flowing into a vehicle and out of a vehicle or within the vehicle itself. Thus, Car IT is the key enabler for accessing innovative information technology (IT) within today's vehicles- from integrating Google or Facebook, services help finding where a car is parked, to remote functions, like closing the sunroof from afar when it rains. Car IT helps automakers to shape and adapt their vehicles to technology trends and market requirements. As a result, Car IT is a dynamically developing subject area for which there is currently no general definition available.

In order to rate the opportunities and risks of Car IT for automotive original equipment manufacturers (OEMs), their suppliers, as well as for vehicle users, Johanning and Mildner (2015) have developed a strengths-weaknesses-opportunities-threats (SWOT) analysis which has been adapted for this book, as shown in Tables 1.1 and 1.2.

Furthermore, the goal of Car IT research and development (R&D) is the definition of connected cars (see Chap. 5) and self-driving vehicles (see Sect. 5.5), including current developments in automotive electric and electronic (E/E) devices and automotive software technology (see Chap. 4), implementation variants, safety, and cybersecurity (see Chap. 6), as well as legal challenges to automotive connectivity. Thus, autonomous vehicles will become more aware, dexterous, and sensitive to

Table 1.1 SWOT analysis for automakers and Tier 1 suppliers (Johanning and Mildner 2015)

Strengths	**Weaknesses**
Collecting data on the behavior of the vehicle user	Missing or hard to recruit development staff
Creating an attractive user experience	Lack of experience with new IT technologies in the vehicle
Direct contact with the vehicle user	
Increasing comfort and operation	
Relieving the driver through intelligent driver information and assistance systems	
Opportunities	**Threats**
Developing new mobility and add-on business models	Automotive cybersecurity (hacker attack on the car)
Establishing direct and long-term customer relationships	Dealing with the information overload (big data phenomena)

Table 1.2 SWOT analysis for vehicle users (Johanning and Mildner 2015)

Strengths	**Weaknesses**
Access to the vehicle and its control from anywhere via app or web portal	Inadequate experience with new IT technologies in the car (specific difficulties: handling and communication)
Higher level of comfort and easy operation of the vehicle	
Higher level of safety while driving	
Opportunities	**Threats**
Avoiding congestion and detouring around accident situations, and thus arriving faster at the final destination	Can unauthorized persons access the vehicle?
Completing work from the vehicle (car office)	Anonymity still guaranteed?
Increasing traffic safety	Security of personal data guaranteed?

their surroundings based on the data they will generate. For example, the data generated by drones, which started flying in remote access areas at first and then moved on to more populated areas, will be combined with the streams from countless sensors instrumented in just about everything and everywhere.

The term "connected car" refers to the next generation of car technologies making use of the Internet, enabling the passengers of the vehicle to take advantage of numerous new services and features (see Chap. 5). Based on these embedded, advanced information and communication technologies, connected cars promise to provide customers with more effective and safer transportation, with less harm to the environment and increased in-vehicle comfort and safety. Thus, over the next decade, Internet-connected vehicle technologies and autonomous vehicles are set to stir up yet another era of cutting-edge innovation in the automotive sector.

The idea of fully autonomous vehicles seems to be too futuristic for many drivers right now. But for automakers, the path from current models to driverless vehicles is going to be an exciting period of transformation. For passengers, self-driving vehicles offer a comfort advantage, since the driver would be freed from any kind of driving activities. Furthermore, for the group of people who have been partially or completely excluded from the participation in public life, due to their mobility restrictions, self-driving vehicles offer new opportunities for their mobility (Friedrich 2015). All this can be accomplished through innovative developments that represent enormous opportunities, although, for the automotive industry a perilous, unsteady phase is being predicted. Thus, the original equipment manufacturers (OEMs) must navigate the challenges of designing, manufacturing, and upgrading, for example, traditional powertrain models, while staking a claim in emerging technologies and improved customer experiences (URL3 2017). In the future, data generated by these connected car technologies is not only circulating within the vehicle but also, to a large extent, outside of the vehicle making use of new cloud services offered by the automakers and their suppliers. Therefore, security of data becomes a key issue for the industry and ultimately for vehicle users.

Furthermore, connected car services at the cutting edge of innovation will require cost-intensive special equipment. To keep the costs of these services low, some automakers are offering their customers monthly holdback payment purchasing using mostly cloud-based, connected car services. Thus, some automakers offer selected services directly to end users to reinforce the attraction of their brand while not competing with their brand dealership. This requires a deep transformation in the business model from the traditional business-to-business (B2B) model to a business-to-business-to-customer (B2B2C) model. To evolve this B2B2C model, the respective leading automakers are relying heavily on digital technology, such as mobility, social media, analytics, and smart embedded devices. But the technology necessary to manufacture connected, intelligent, and autonomous vehicles is not within the traditional scope of automakers. This, of course, is an invitation to high-tech companies, such as Apple, Google, and others to develop their own technologies and communications systems for critical components of the networked and autonomous vehicle ecosystem, as reported by PricewaterhouseCoopers (PwC) in (URL3 2017). These companies will likely prove to have a major influence on the automotive sector in the coming years, mainly because their skills and the industry's needs align perfectly. They are adept at seamlessly and efficiently connecting components to create networks highly valued by consumers for the information, entertainment, and experiences they deliver (URL3 2017).

In addition, connectivity can also increase road safety and, hence, improve the transit experience. But the more vehicles become connected, the more they are vulnerable to cyber attacks. Being no longer a topic of science fiction, recent events have shown that cyber threats and cybercrime can affect all passenger cars and commercial vehicles equipped with embedded telematics or connectivity solutions from the aftermarket. Thus, automotive cybersecurity is quickly becoming an important factor when purchasing a modern vehicle, due to the increasing proportion of software, digital components, and systems onboard connected to surrounding digital infrastructure. Consequently, this book discusses the situation in which the automobile industry finds itself and addresses the opportunities, challenges, and threats of the digital transformation and the connected vehicle ecosystem.

1.2 Scope of This Book

The automotive industry will be facing numerous sweeping and interlinked changes in the next several decades. Unlike most other industries, the automotive industry, while incorporating modern Internet network-enabled technology, has been forced to completely and fundamentally reinvent itself (URL4 2017). Compared to other industries, the automotive industry has taken advantage of many efficiency improvements driven by Internet-based technology but has also remained in the same structure, as opposed to reorganizing its whole ecosystem. There could be a reconceptualization of how the core activity is organized, coordinated, and executed. A number of factors could push the automotive industry into new alliances and organization structures, perhaps ultimately towards futuristic concepts such as smart mobility. Smart mobility characterizes the visionary mobility of the future, available for everyone regardless of location and region, regardless of periods of use and duration, as well as regardless of individual ability and budget (Flügge 2016).

The many new features of the networked vehicle will begin with Google's and Facebook's involvement and extend to services that help users find where they parked their cars, control functions via app remotely, like closing the sunroof when it rains, and ultimately lead to completely new services based on the car data being generated, as described in (Johanning and Mildner 2015). Thus, the automotive industry will be facing a situation of profound change and opportunity in the coming decades due to disruptive innovations (Meyer and Shaheen 2017), which not only substitute existing solutions but will also create new markets and change society with regard to smart mobility, for example:

- Introduction of self-driving vehicles
- Energy- and emission-efficient innovations
- New models of smart transportation and service delivery
- Sharing economy and multimodal mobility
- 3D printing of automotive spare parts

In this context, smart mobility can become a motivator for own projects within the framework of a holistic mobility management. It is an offer that is primarily intended to enable energy-efficient, comfortable, and cost-effective mobility. It also is a paradigm shift to a more flexible and multimodal transport system for hassle-free usage of multiple modes of shared and public transport as key for inner city areas, an example being a proximity-based service that shows information if and when passengers really need it, whereby an integrated mobility platform as information broker allows seamless travel across transport modes. Smart mobility will see the emergence of new business models, for example, Mobility-as-a-Service (MaaS).

The term "connected cars" means that vehicles are now more becoming part of the connected world, continuously Internet connected, generating and transmitting data, which on the one hand enables applications, such as the broadcast of real-time traffic alert to smart watches, but which also raises security and privacy concerns. The decisive feature of a connected car is the ability to do network, both internally as well as externally, with smart devices, other cars, the Internet and applications and platforms on the cloud. With the mandatory introduction of the automatic emergency call system e-call, in the EU, from March 2018, virtually every newly built vehicle will be a connected car.

In the context of the above topics, this book gives a detailed overview of automotive connectivity and the associated cybersecurity issues.

1.3 Overview of Topics

The automotive industry is facing profound changes and opportunities; automakers are dealing with new technologies and vehicle concepts that have the potential to transform the vehicle itself. What is already emerging is the beginning of the connected vehicle, for example, a fully digitalized vehicle with wireless fidelity (Wi-Fi), a wireless networking technology that allows computers and other devices to communicate over the air (OTA). Wi-Fi is based on one of the 802.11 standards developed by the Institute of Electrical and Electronic Engineers (IEEE) and adopted by the Wi-Fi Alliance® for advanced infotainment systems and apps. Furthermore, these vehicles use vehicle-to-vehicle (V2V) communication technology to talk to each other, exchanging essential safety data, such as speed and position, real-time location services and routing based on traffic conditions as well as networked web links, facilitating vehicle diagnostics, maintenance, intervals, and repairs (URL3 2017).

This digital transformation requires a thorough theoretical background on the respective methods and technologies like automotive connectivity, Car IT, autonomous, self-driving vehicles, and automotive cybersecurity. This book also provides a framework within which the reader can integrate the associated essential knowledge from:

- Automotive research and development
- Automotive mechatronics
- Automotive electric and electronic (E/E) systems
- Automotive software technology
- Automotive cyber-physical systems
- Advanced driver assistance systems (ADAS)
- Automotive cybersecurity

Without such a reference, the practitioner is left to ponder the plethora of terms, standards, and practices that have been developed independently and which often lack cohesion, particularly in nomenclature and emphasis. Hence, the intention of this book is to give a comprehensive overview of automotive connectivity and to provide a framework for discussing the many challenges and issues associated with automotive connectivity, both from a technical as well as a business oriented perspective. The chapters are entitled:

1. Introduction
2. The Automotive Industry
3. Automotive Research and Development
4. Automotive E/E and Automotive Software Technology
5. The Connected Car
6. Automotive Cybersecurity
7. Mobile Apps for the Connected Car

8. Carsharing
9. Car Hailing and Ridesharing
10. Connected Parking and Automated Valet Parking
11. Advanced Driver Assistance Systems and Autonomous Driving

The final chapter is Chap. 12.

12. Summary, Outlook, and Final Remarks

Against this background, the book covers, in contrast to other books which focus more on automotive E/E and software technology (Reif 2014, Borgeest 2013, Schäuffele and Zurawka 2013), the essential methodological and theoretical basics from mechatronics, computer networks, distributed systems, software engineering, systems engineering and IT security and elaborates the necessary technological adaptations in future vehicles (Siebenpfeiffer 2014, Swan 2015).

Cyber-physical systems (Möller 2016) in this regard are the backbone of these technologies. These are engineered systems which have significant couplings between cyber (processing, communication, and network) and physical (sensing, actuation, and infrastructure) elements. The couplings result in the dynamic coevolution of cyber and physical properties. In the context of connected cars and self-driving vehicles, the physical domain is defined by the dynamics of vehicle motion together with the dynamics of radio wave propagation. The cyber domain is defined by the data processing in the intra- and inter-vehicle networks and the vehicle-to-infrastructure (V2I) data exchange. This enhanced complexity has also had a huge impact on the vehicle design process, its modularization with the associated platforms, virtual product creation, and the life cycle management for connected cars and autonomous driving vehicles. Based on that background, the required needs in automotive E/E and automotive software technology, as well as the evolution of the connected car, will be derivable. The evolving strong connectivity of future vehicles necessitates a thorough analysis of the vulnerability of connected cars and measures to prevent cyber attacks on vehicles by making use of cybersecurity methods (Graham et al. 2010).

The integrated use cases from different sectors of the automotive domain give a practical perspective and a detailed insight into mobility applications, which are of interest to vehicle users and illustrate new business models for automakers and their suppliers. Chapters 10 and 11 discuss different advanced driver assistance systems (ADAS) and the underlying technologies which support the driver by increasing vehicle safety and are one of the fastest growing segments in automotive electronics. Industry-wide quality standards in vehicular safety systems, such as ADAS, are based on ISO 26262, Road Vehicles—Functional Safety, the international standard for functional safety of electrical and/or electronic systems in automobiles.

Therefore, current scenarios appear as the result of, and conditions for, the development of urban dynamics, considered from the perspective of functions, relations, and actors involved. Functional dynamics relate to patterns of generation and the demand for energy, information, and transportation of goods and people and more. Some of these patterns affect the spaces of social life by occupying them or conditioning their perception. In contrast, relational dynamics refers to the required quality of social life at any given time (Garcia-Verdugo 2017).

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