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# Foreword by Zheng Xiancong

## Self-driving and Jolly Lifestyle—The Future You Deserve!

AI-powered driverless is the foreseeable future, the prelude to changing the way we live.

Every advance in technology will bring about changes in productivity and in a most critical aspect of the human life; the emergence of artificial intelligence represented by "driverless" will fundamentally change our lifestyles.

We spend more of our valuable time on the road while busy in driving will also be a continuation of personal disposable time. All will be returned to us via technology, and this high-quality time can make us enjoy life and happiness more.

This is the greatest significance of science and technology!

This book will talk about autonomous driving in terms of technology development, evolution, infrastructure, social collision, industry search, opportunities in China, future prospects and other aspects including driverless past and present, people's desire and anxiety, and how we describe the twenty-first century a new way of life. NextEV is very pleased to be able to provide intellectual support for this book and to lay the groundwork for an intelligent future for the automotive industry. For the whole industry to grasp the trend of thinking, doing a bit of work in a straight book, for the whole society to embrace the advent of self-driving cars, does a little consumer science education work. We will harvest your thinking and appeal to our reason; we will harvest your emotion and appeal to our sensibility.

Auto industry has more than 20 years experience in Ford, Fiat-Chrysler, and other brands. As a practitioner and observer, I have witnessed the development of the automobile industry in the twentieth century and the process of creating a new technological revolution henceforth. Today, I am also a motorist. Looking back at the development of human industry represented by automobile industry, I increasingly believe that the eternal theme of life is "to enjoy life." It is also to spend our own precious time to create good and enjoy the good. After many years of struggle for the auto industry, we finally saw the moment when cars began to fulfill their promises to people. Because of the emergence of "driverless," we will finally return to life itself, to create and enjoy the beauty of every single moment!

"Mist lock nine cities, thousands of years of jade Pan Qingyi. Weiran Tiangong re-appear world, more Xiangyi mountain green water."

This is our life full of joy, but also our inexorable future.

Through reading this book, I hope that our readers can also, much like me, look forward to the future at hand!

Shanghai, China

Zheng Xiancong
Co-founder of NextEV

# Foreword by Dr. Daniel Kirchert

## Embracing the New Era of Autonomous Vehicles

It is a great privilege for me to be invited to preface the English version of *Autonomous Driving Changes the Future* authored by James Chai (Chai Zhanxiang). In this book, James Chai elaborates what autonomous driving is from multiple perspectives like history, technology, and market, and how it will influence the development of the auto industry. Although the author modestly defines it as a "popular science reading," this book, in my opinion, can be used as a very useful reference book in the autonomous driving field, given its authoritative and comprehensive content.

Reading through this book, I feel that autonomous driving will not only change people's travel habits and needs, but fundamentally transform the competition pattern of the automotive world, thus leading to unprecedented changes to the global automotive industry.

Since my compatriot Karl Friedrich Benz was granted an invention patent on automobile in 1886, the automotive industry has evolved, as a pearl on the crown of the modern industry, into one of the most globalized industries, driven by generations of industry leaders, such as Henry Ford, Alfred Pritchard Sloan, Jr., Kiichiro Toyoda, and Soichiro Honda.

Over the century, however, despite enormous technological advances, for example, engineers developed automatic transmission and steering assist in an endeavor to improve driving and riding experience, the basic attribute of automobile as a machine driven by people remains unchanged. As a result, it is still impossible for people to choose to work, take a rest, or enjoy entertainment when they are driving their car as they do in a plane or high-speed train.

Good news is that the development and maturing of autonomous driving technologies will bring fundamental changes: With high-level autonomous driving, a car can take full control and drives itself, freeing driver's hands, feet, and eyes. When a car is no longer just a vehicle, the value it brings to driver and passengers will totally different from what it used to offer over the past 100 years. Perhaps in a few decades, a car will be considered as the extension of people's mind rather than their feet. By then, the definition of a good car will be completely different.

Based on my understanding, I believe the development and maturing of autonomous driving technologies will lead to unprecedented changes to the global automotive industry, thoroughly disrupting the global automotive competition landscape formed over the past century.

In light of this tendency, I chose to leave traditional automakers in 2016 and founded the premium smart EV brand "BYTON" together with many like-minded partners. While I am writing this preface, BYTON is proactively boosting the mass production of its first model M-Byte. We expect it to break traditional auto designs and architectures, and become an emotional smart device as an extension of the minds of the driver and passengers to empower mobility. M-Byte is expected to hit European and the US markets in 2021–2022, when readers will have the chance to experience our insights into autonomous driving and smart driving.

BYTON is not the only company vigorously preparing for the autonomous driving era, and China is not the only country paying close attention to the autonomous driving technology and its potentials. Readers will learn from the book how major car-making countries and companies are painstakingly developing autonomous driving technologies. The strategies they take vary greatly, but there is one thing in common: They all consider autonomous driving technologies the heart of the next-stage competition.

Finally, I'd like to express my thanks to James Chai again for presenting such an authoritative and readable book that introduces the autonomous driving technology and autonomous driving era with detailed, accurate data in a concise and easy-to-understand language.

Let us look forward to the advent of this wholly new era!

Nanjing, China
September 2019

Dr. Daniel Kirchert
CEO of BYTON

# Preface

## Autonomous Driving Technology Empowers Future Travel: Safe, Efficient, and Intelligent Mobility are Coming Soon

Boldly imagine an innovative way of traveling. For every journey, a passenger only need to step into the vehicle and relax—their route already plotted by using big data and downloaded to the car through the cloud, and the vehicle would automatic driving alone this route. Instead of wasting time behind the wheel, passengers can use their time on the road to plan their day's work, or just as easily shop, or chat with family and friends. The trip is easy—even pleasant—and the passenger disembarks, well-rested to face the rest of their day. After completing its journey, the vehicle finds itself a parking space to rest until another journey is called. Children no longer need to walk to school on their own; instead, an autonomous school bus can escort them. These smart vehicles can remotely access big data on virtually every road condition, gaining experience in increasingly complex road conditions to ensure safe driving. This is science fiction which comes to life—an imminent reality that is the basis for self-driving technology.

Our generation exists at a fortuitous time in history; we have reaped the benefits of large-scale industrial production and lucky to witness the arrival of such innovative technology. When I was working in the automotive industry twenty years ago, most vehicle technology breakthroughs focused on improving the mechanical performance of the vehicle itself. Enter increasingly complex suspension mechanism in strengthened vehicle bodies, matching more shifts transmission. As global attention turned to the energy crisis, climate change, and environmental emission regulations, research and development shifted toward turbochargers and sophisticated precision electronic fuel injection systems, squeezing more power from engines and reducing air resistance for improve fuel consumption. Recent breakthroughs in battery technology have increased the energy density of a single-battery cell enabling fully electric vehicles to roam the streets. We are so fortunate to participate in and witness the exciting development and popularization of new energy vehicles. These new energy vehicles promise not only to be highly electrified, but also interconnected, and driven by data-based research. The deep integration of the products and service from Internet and electronic tech companies into these vehicles will also enable the development of autonomous driving. The safety, efficiency, and intelligence of autonomous driving will completely change our way of life.

Thoughts of this revolutionary autonomous technology are sure to excite even the most stoic of automotive industry professionals. Some may even find inspiration, as Mr. Chai Zhanxiang, Dr. Jan Becker, and I have. Thus was the genesis of this book: *Autonomous Driving Changes the Future*. We three are professionals of the automotive industry, my partners, experts, and scholars of their respective fields. This book aims to provide readers of all ages with a clear and digestible state-of-the-field introduction to autonomous driving. This innovative technology will be discussed in terms of technological R&D reform, development and evolution roadmap, infrastructure improvement, multi-dimensional challenges to new technology, corporate developments, and anticipated prospects. Chapters of the book further introduce the strategic planning of international automotive OEMs in the field of autonomous driving, and the participation of intelligent manufacturing in China. In addition to these technological introductions, this book will also discuss hot topics in the popularization of autonomous driving technology, such as social ethics, privacy, hacking, sharing economy, business models, and automobile insurance.

Mr. Chai Zhanxiang is a graduate of the Department of Automotive Engineering of Tsinghua University and the Business School of Colorado State University. He has worked in the automotive industry technology, market research, and management for more than 20 years, and has rich and comprehensive industry experience. He has penned most of this book. Dr. Jan Becker is an internationally renowned expert on autonomous driving and a lecturer at Stanford University. Dr. Jan Becker authored most of the second and third chapters of this book. As for my contributions, I undertook the research and writing of chapters in the book, completing the book's editing, compilation, and English publication with the team. My gratitude goes to Mr. Huang, Chendong, CTO of XPT Technology Co., Ltd. belongings to NIO Inc., who personally approved Chap. 4. I am also appreciative of Dr. Sinisa Durekovic, Faraday Future, who provided content for the High-definition Digital map in Chap. 2. My sincerest thanks to the experts and executives who enabled the creation of this book through their unwavering support.

Where possible, this book uses easy-to-understand text to describe advanced, complex, and sometimes obscure industry technologies, improving accessibility for readers of all backgrounds. This format aims to provide readers keen on new technologies with a state of the field from the perspective of longtime automotive industry insiders. It is my hope that readers of this book will be able to identify and feel the unprecedented change quietly but unmistakably happening within society. The automotive industry is moving rapidly. In the era of electrification and intelligence, autonomous driving will soon become a reality. We firmly believe that in the future, automated driving technology will change human ways of life through widespread use of 5G communications, Industry 4.0 manufacturing, and biotechnology.

After participating in writing this book, I feel deeply that autonomous driving technology is not a mere theory, though the entire industrial chain cannot be established overnight. Cooperation between OEMs companies and suppliers within the supply chain is required to popularize and realize the wide use of autonomous driving, whether level 2 or level 5. This must be further supplemented by information-based road network infrastructure, High-definition Digital map, and other resources. This future-oriented driving technology is on the cusp of industrialization. Autonomous vehicles need driving system with full controlled by wire capabilities to enable faster responses and higher efficiency. Multiple control redundancy is also necessary to ensure the safety of the system. At present, products on the global market are not yet able to meet all these requirements. To that end, I founded AIKAR Technology in early 2018 in Los Angeles, bringing together professionals from the North American Bay Area and the world widely to work on an innovative, integrated, drive-by-wire system using a mature supply chain. This system features a highly integrated drive unit, brake unit, and control system that responds in real time to adjust the distribution of driving and braking forces by software. This in turn enables efficient energy recovery, reducing energy consumption, and significantly improving the mileage of electric vehicles. In addition, the integrated system uses existing vehicle-grade sub-components and modular design concept to reduce product development risks and shorten development timing. Our global team is accelerating the integration of supplier resources and launching products. We are committed to enable our product for service autonomous driving technology. In doing so, we hope to usher in an era of safe, efficient, and intelligent mobility.

Los Angeles, USA

Tianxin Nie
Former Faraday Future
Senior Vice President and Co-Founder
AIKAR Technology Founder and CEO

# Contents

# Chapter 1
# The Centennial Automotive Industry and the Looming Transformation

Inventor, entrepreneur and visionary Ray Kurzweil is a significant character in our digital age. As a scientist at Google, he believes that the more developed the society, the stronger its ability to develop and iterate faster. As human society of the nineteenth century collectively master more knowledge than people in the fifteenth century, so the speed of human development in the nineteenth century is naturally faster than in the fifteenth century. He calls this phenomenon of accelerated human development the Law of Accelerating Returns.

By this logic, Kurzweil also concludes that the progress of the entire past century could be achieved in only 20 years time going by the speed of development of the year 2000. (This would mean that the development speed of 2000 is five times the last century.) Based on this yearly acceleration, it would take 14 years from 2000 to achieve the progress of the whole twentieth century. Then in 2014, it would take only seven more years (2021) to achieve another century of progress. Within only a few decades, we would achieve several times the progress of the twentieth century, until each century takes only one month. In accordance with the Law of Accelerating Returns, Kurzweil believes that human progress in the twenty-first century will reach 1000 times the speed of that in the twentieth century. If Kurzweil is correct, then the world of 2030 may become shocking to those in 2000, and the world of 2050 will be beyond recognition.

These changes that have shocked us will undoubtedly come from different factors. The most shocking of these changes will likely be from autonomous driving vehicles (including driverless cars) that will fully drive into our lives, even faster than we expected.

For the Chinese people, the car should hold special significance. The wheel was first invented by the ancestors of the Chinese nation. The first cart in human history was also made by the dexterous hands of our ancestors. In ancient Chinese mythology, the Yellow Emperor made a cart, resulting in his moniker *Xuanyuan*. *Xuan* refers to an ancient carriage with a shed, and *Yuan* is the basic building block of a vehicle. Even from the title, we can conclude that the Yellow Emperor is the inventor of the



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carriage. (Of course, the carriage mentioned here refers to a kind of hand-held trolley, and only later developed into the horse-driven carriage.)

The automotive industry is facing unprecedented and profound changes. Those changes are mainly reflected in the following four aspects. The first is interconnection. Many IT companies enter the automotive industry because they see automobiles as smart mobile terminals. The second is autonomous driving. Even people who don't drive can also enjoy the convenience of car travel in the future. The third is "Transportation as a Service" (TaaS). The future car not only serves as a product, but also gradually becomes an indispensable transportation service in the intelligent age and for future society. The fourth is the sharing economy. The twilight of car sharing will shine on the reality of car use, which will inevitably lead to changes in the ways cares are sold and used.

In a word, the future of the automotive industry is greatly reliant on the evolution of connectivity, intelligence and car sharing, which serve as the ultimate core of autonomous driving. Self-driving cars will change every aspect of our lives, like never before. Although current autonomous driving technology has not yet matured, opinions differ on the prospect of self-driving cars entering thousands of households. However, car makers and emerging technology companies have shown overwhelming enthusiasm for autonomous driving, making the new trend of this technology development crystal clear. The century-old automotive industry plans to use autonomous driving to achieve new feats of rapid transformation. We should prepare ourselves from this revolution accordingly.

# 1 From Feature Cars to Smart Cars

## *1.1 From the Birth of a Car to the Boom of Automotive Electronics*

Karl Benz invented the car and brought mankind into the car era. Henry Ford made mass production a reality through his assembly line, which enabled the car to enter thousands of households at an affordable price. Ford's production line is a revolutionary and epoch-making innovation of large industrial production methods. The assembly line production is based on standardization, which facilitates mass production and becomes a form of production organization with high labor productivity. It has greatly changed the form of industrial production, promoted the development of the automotive industry, and brought the industry into a promising and practical field, changing society.

The Toyota Production System (TPS) can be said to be another great milestone in the history of world manufacturing. The leading position of the Japanese manufacturing industry in terms of "mode of production", "organizational capabilities" and "management methods" represented by Toyota Production System has changed the form of global manufacturing in the twenty-first century, promoting the lean production of the global automotive industry. An even leaner era comes.

For more than a hundred years, the car has not changed its basic structure as a box with four wheels, one steering wheel and several rows of seats. Even the basic structures of chassis and engine remain similar to how it was first conceived. However, the application of automotive electronics has been constantly improving.

The development of automotive electronics technology can be divided into three stages.

The first stage is one of separate control. The 1950s and 1960s marked initial stage of the development of automotive electronics technology. The mechanical designs of electronic devices such as the electronic engine ignition module were divided into independent components to improve performance and cut costs. From the late 1960s to the 1970s, electronic systems combined various discrete electronic devices formed, improving energy consumption and safety.

The second stage is characterized by centralized control. In the 1970s and 1980s, the adoption of digital circuits and large-scale integrated circuits and the increase in CPU computing speed and storage capacity expanded the control functions of automotive electronic control units (ECUs). In addition, the sensors used in the various controllers were universal, so multiple controls were concentrated on one ECU. This type of control is called a centralized control system, also known as a car microcomputer control system.

The third stage consists of the network control stage. Before 1990, most of the car's electronic control systems were run independently, resulting in bulky wire harnesses. In a high-end car designed the traditional way, the wire length can reach over 2000 m, and with more than 1500 electrical nodes. Only after the gradually adoption of network control and use of data sharing by the ECU was the overall performance of the system optimized and electrical wiring simplified. The network technologies that were widely used in automobiles at this stage were CAN bus and LIN bus.

**Extended Reading**

*CAN Bus and LIN Bus Technologies*

*Bosch originally developed the Controller Area Network (CAN) in 1985 for in-vehicle networks, which reduced wiring cost, complexity, and weight. CAN, a high-integrity serial bus system for networking intelligent devices, emerged as the standard in-vehicle network. The automotive industry quickly adopted CAN and, in 1993, it became the international standard known as ISO 11,898. Since 1994, several higher-level protocols have been standardized on CAN, such as CANopen and DeviceNet. Other markets have widely adopted these additional protocols, which are now standards for industrial communications. Its emergence provides powerful technical support for distributed control systems to achieve real-time and reliable data communication between nodes. However, the CAN bus still has some drawbacks. The CAN bus communication adopts the carrier monitor lossless arbitration technology. When the network load is small, the CAN bus real-time performance can meet various requirements, but as the network load increases, the probability of information collision on the bus also increases. If you continue to use the basic CAN protocol, the* *real-time performance of lower-priority information transmission will be affected. After the network load reaches a certain level, it will even exit the bus competition. The CAN bus protocol adopts a static fixed priority allocation method, making it difficult to share the bus usage rights fairly with information of different priority. These defects become factors that restrict its further development.*

*Initially developed in Germany in 1998, Local Interconnect Network (LIN) automotive communication protocol offers a cost-effective way to deliver low-speed communication. It is used for all comfort and convenience applications in modern cars. LIN has the capability of addressing all applications which cannot be directly connected to the controller area network (CAN) because of the high costs involved. In addition to defining the basic protocol and physical layer, the LIN specification defines development tools and application software interfaces. LIN communication is based on the SCI (UART) data format, using a single master controller/multiple slave device mode, and a single 12 V signal bus and a node-synchronous clock line with no fixed time benchmark. This low-cost serial communication model and corresponding development environment has been standardardized by the LIN Association.*

The application of modern automotive electronics technology can be reflected in the following aspects.

First, in dynamic performance and environmental protection, including CPU-controlled ignition, idle speed control, engine deflagration control, automatic gear shifting, engine electronic fuel injection, air–fuel ratio feedback and exhaust gas recirculation, etc.

Second, in safety, including acceleration anti-slip control, automatic power distribution, anti-lock braking systems, traction control and automatic brake differential, etc.

Third, in trafficability, such as differential lock control, adjustable shock absorber, etc.

Fourth, in vehicle handling and stability, including cruise control, stability control, body active control, dynamic stability control, etc.

Fifth, in the vehicle body electronics, including seat automatic adjustment system, intelligent headlightsystem, night vision system, electronic door lock and anti-theft system, etc.

Sixth, in communication and infotainment systems, including intelligent car navigation system, automatic speech recognition system, car maintenance data transmission system, car audio systems, real-time traffic information consultation system, dynamic vehicle tracking and management system and television entertainment system.

As the vehicle performance becomes more dependent on electronic technology, the future development of the automotive electronics industry must be more cognizant of environmental protection, safety and communication connectivity.

The first issue is environmental protection. The current trend in the automotive industry is to develop engines with high efficiency and low carbon emissions. The current options are as follows: First, an advanced diesel engines with electronic control systems, can improve fuel economy on the highway by 30–40%; second, pure electric vehicles or hybrid vehicles can improve the fuel economy by 30–40% and reduce carbon emissions by 60%; Third, cylinder pressure sensing and homogeneous charge compression ignition (HCCI) systems can be used to improve fuel economy and reduce emissions. These innovative powertrain technologies will add substantial electronic contents to cars around the world in the next five to fifteen years.

This is followed by safety. Currently, passive safety technology provides protection technologies and products for drivers and passengers in the event of a collision, such as collision sensors, airbags and safety belts. The latest development direction is to pursue active safety. Sensor technologies such as LiDAR, radar, and camera allow Advanced Driver Assistance System (ADAS) to actively avoid collisions.

Finally, communication connectivity. Today, consumers enjoy the benefits of digital electronics and internet infrastructure such as mobile video, digital TV, Wi-Fi and GPS. Consumers also want to enjoy the same technology and communication benefits in cars to make the driving process more efficient, convenient and entertaining.

## *1.2 The Era of Smart Cars is at Your Fingertips*

Following these automotive electronics technology trends, cross-border cooperation between automakers and IT companies has also begun. The huge amount of information that cars can collect is very attractive to tech companies like Google, who mine personal data. Such a philosophy existsi nside Toyota: “If you can father data from all the windshield wipers, you can understand the detailed weather information of each place.” If you can collect various kinds of information from tens of millions of vehicles on the road, that will generate unlimited business opportunities. Be it Toyota, other global leading automakers or parts companies, or even IT giants, everyone wants a slice of the pie. Through their exploration, automobiles are led to pursue intelligent technology. At this point, the hundred-year-old automotive industry is experiencing an exciting transformation from the era of feature cars to the era of smart cars.

What is intelligentization?

What is intelligentization? Intelligentization refers to the application of a certain aspect by a combination of modern communication and information technology, computer network technology, industry technology and intelligent control technology. The process of transforming feeling to memory, then to thinking is called “wisdom.” The result of wisdom produces behavior and language, and the process of expression of behavior and language is called “ability”. The two are collectively called “intelligence.” Intelligence generally has the following characteristics:

Firstly, it is able perceive the outside world and through external information. This is a prerequisite and a necessary condition for generating intelligent activities.

Secondly, it has the ability to remember and think, to store the perceived external information and the knowledge generated by the thinking, and to use the existing knowledge to analyze, calculate, compare, judge, associate and make decisions.

Thirdly, it has the ability to learn and adapt through the interactions with the environment, continuous learning and accumulation of knowledge, so as to adapt to environmental changes.

Fourthly, it has the ability to make decisions, to respond to external stimuli, to form decisions, and to convey corresponding information.

The system with the above characteristics is an intelligent system or an intelligentized system.

With the overall development of the automotive industry, intelligent technology will be applied more frequently. In recent years, we have witnessed the trend in which a contemporary “Feature Car” gradually evolves into a “Smart Car.” Automobile intelligentization has become a central issue, and smart cars have become one of the future development trends of the automotive industry. Intelligentization will bring more and more changes to the manufacturing technology and business models of the automotive industry, making the operation of a car simpler, the engine more and more powerful and efficient, and the driving safety more and more reliable.

There are many intelligent applications for automobiles, such as vehicle power control systems. The system detects the speed, angular velocity, steering wheel angle and other motion states of the vehicle through various sensors, and changes the motion state of the vehicle by actively braking one side wheel as needed. The car is optimally driven and maneuverable, increasing its wheel adhesion, the handling and stability. Other intelligent applications include automatic emergency braking system(AEB), adaptive cruise control (ACC), etc., which will be discussed in more detail later in this book.

The continuous application of new materials and new technologies is also improving the level of intelligence for automotive parts and materials, such as smart glass, which is often overlooked. There are many types of smart glass, including light-proof and rain-proof glass, electric snowmelt glass, image display glass, shatter-proof glass, dimming glass, and photoelectric sunshade glass. Light-proof and rain-proof glass is made of new materials and new surface treatment methods. When the rain falls on the glass, it will flow away without leaving water droplets, meaning no need for windshield wipers. The inner surface of the glass is low in reflectivity, leaving no inverted images of the instrument panel and car interior, so that the driver’s sight is undisturbed. The image display glass is coated with a transparent reflective film on a part of the windshield, so that the film displays the instrument panel via a projector. If combined with an infrared image display system, it would allow the driver to see the objects about 2 km away in a foggy day. The photoelectric sunshade glass can absorb, accumulate and use solar energy to operate the fan inside the car when driving or parking, and to recharge the car battery. The development and application of smart glass has been valued by many car companies. Tesla has a glass technology research and development team dedicated to the development of special glass manufacturing technology, which could allow it to absorb heat and melt snow on its surface through the heat of the sun.

Automotive intelligent applications will eventually lead to intelligent driving. The scientific question involved in intelligent driving include how to simulate human driving behavior, including how to formulate the driving behavior of different people, how to use sensors to characterize the visual and auditory sense of the driver, and how to use machine intelligence to describe the driver's driving process, how to achieve automatic switching between autonomous driving and manual driving, etc. In the future, intelligence will redefinition of automobiles. Electronic technology and software will overwhelm traditional mechanical and electrical systems. A car will become a moving intelligent space and serve as a new carrier for mobile work and entertainment.

## 2 Globalization has Made the Automotive Industry Flourish

### *2.1 The Automotive Industry is the Most Typical Global Industry*

The predicament of industrial civilization is a prerequisite for the arrival of globalization. Globalization is a new phenomenon that has become increasingly prominent in the world since the 1980s, and is a basic feature of the modern era. The automotive industry has since become one of the most globalized industries.

The focus of globalization lies in economic globalization, and the core of economic globalization is industrial globalization. As one of the most important industries in the economic field, the automotive industry, witnessing a rapid development in the past 30 years, has undoubtedly benefited from globalization.

### *2.2 Brilliant Manipulations in the Auto Sector*

In the context of industrial globalization, the world automobile industry has undergone two very significant and interrelated changes: First, auto giants continue to do cross-border mergers and acquisitions, forming a huge automobile enterprise group; second, the industrial chain of the automotive industry extends worldwide. These two major changes have fundamentally reshaped the traditional resource allocation of the automobile industry, the competition between and organizational structure of enterprises, intensifying global competition in the auto industry. The auto industry is also an industry with high correlation between upstream and downstream sectors. Its development can lead to the prosperity of a series of related industrial segments such as from steel, chemicals, rubber, glass and electronics down to petrochemical, road construction, automobile repair and maintenance, tourism and auto finance. Therefore, the competitiveness of the automotive industry is an important part of a country's comprehensive national strength.

Horizontally, the integration and competition among various multinational automobile groups will inevitably lead to industrial transfer. The rapid sales growth and the quick rise of local vehicle manufacturers in emerging markets have led to the shift of vehicle manufacturing to emerging countries; the thrift of emerging markets and the demand for cost reduction in automotive R&D have led to the migration of global automotive R&D resources to emerging markets as well.

The automotive industry has experienced many structural changes, changing from hundreds of brands to several well-known multinational companies. With their technical and capital advantages, each group has launched all-round fierce competition in product design, manufacturing, information technology, e-commerce, sales and after-sales services and capital operations. On the one hand, it exports surplus capital and technological know-how to emerging countries. On the other hand, it absorbs global resources and expands global market share through mergers and acquisitions, further promoting the globalization of the industry.

In 1998, Daimler-Benz and Chrysler merged to form the Daimler-Chrysler Group. In 1999, Ford acquired the Volvo Car Division, and Renault invested in Nissan. Since then the pattern of "6 + 3" has appeared, namely, GM, Ford, Daimler-Chrysler, Toyota, Volkswagen and Renault as the Big Six, and Honda, BMW and PSA (Peugeot Citroen Group) as the Small Three. The financial crisis has accelerated the pace of global auto map adjustment, mainly reflected in the changes of the Big Three in the North America: Chrysler could not survive independently. After two years of separation, re-integrated by Fiat, GM and Ford continued to spin off their own sub-brands. Rolls-Royce was resold by the British to BMW, Land Rover and Jaguar have thrown themselves on the Tata Group of India, and Volvo was sold again by Ford to be owned by Geely of China. A series of changes have led to a new "6 + 3 + X" pattern in the global automotive industry. The new six groups include Toyota, Volkswagen, new GM, Ford, Renault-Nissan Alliance and the new Fiat-Chrysler Alliance. The three small groups include Hyundai—Kia, Honda and PSA. In addition, Daimler-Benz, BMW, a number of Japanese car companies including Suzuki, and growing car companies in emerging markets such as China and India are also indispensable forces in the global auto map.

Vertically, the world's major auto makers have implemented global production and global sourcing, from sourcing from multiple auto parts manufacturers to sourcing from a few system suppliers; from single auto part procurement to module procurement; from domestic procurement to global procurement. The globalization of auto industrial chain is increasingly evident, and the re-division of the value chain is increasingly prominent. The globalization of the industrial chain has resulted in a refinement of the division of labor in the automotive industry, aggravating the dissociation between vehicle assembly and parts production.

With the degree of specialization, it has become possible for a parts and components company to present OEMs with multi-series and large-scale production products. The auto parts are developed from a single component to a modular and integrated product. The regionalization of the component industry is shifting to internationalization, and more and more multinational parts manufacturing companies have emerged. European auto parts manufacturers have invested overseas to carry out international production; North American auto parts manufacturers have invested in Europe to expand the Eastern European market; Japanese auto companies are also constantly establishing their own branch production facilities on a global scale. The Asian market is the focus of competition among major auto parts multinationals, where China is a major player.

The reform of the procurement system of OEMs requires auto parts manufacturers to constantly keep up with changes. It not only requires auto parts manufacturers to expand their own strengths, improve product development capabilities and design in the form of sub-assembly, but also requires them to shorten development cycle and provides quality and cheap products. Under the circumstance of this internationalization, component suppliers are both competitors and partners. In order to meet the ever-increasing demands of customers, sometimes they have no choice but to work together to provide innovative solutions. The global auto parts industry is increasingly engaged in strong alliances, acquisitions, cooperation, transformation, and the divestiture of traditional businesses to betterserve customers.

In May 2015, ZF completed the acquisition of TRW. TRW was incorporated as a new business unit–the Active and Passive Safety Technology Division, fully operated by ZF. The deal has made ZF a larger and more diversified global industry giant, with a better focus on future powertrain, transportation and safety solutions for the automotive industry. Two years later, in early May 2017, two “friends” of ZF and Faurecia announced to cooperate in a strategic partnership for the development of disruptive and differentiating interior and safety technologies for autonomous driving. Within this special advanced engineering partnership the two companies will identify and develop innovative safety and interior solutions linked to different potential occupant positions. One of the highlights of this cooperation is that it will be based on the sharing of expertise between the two parties, and does not involve capital transactions.

On May 3, 2017, Delphi announced in the UK that it would fully spin off its powertrain division. The original company would focus on the electrical and electronic business, especially in the areas of autonomous driving, smart technology and safety technology. It employed 15,000 engineers and 145,000 employees worldwide. After Delphi announced the news, its share price soared 12%. The global auto parts giants have realized that the electric wave is hard to contain, so they decided to seek change actively and embrace industrial transformation. Almost simultaneously, Bosch also announced the sale of its starter and generator business, together with 7000 employees in the business unit, to a Chinese consortium.

This evolution of globalization has directly produced two outcomes. On the one hand, the production of auto parts has become increasingly specialized, and the resulting economies of scale have significantly reduced production costs and promoted the allocation of global resources. On the other hand, the links between auto parts manufacturers and automakers are closer, especially in terms of technical cooperation. Auto parts manufacturers have begun to assume more R&D and manufacturing responsibilities, and are able to intervene more deeply in the development of new models of vehicles, so that the vertical depth of production is continuously improved to meet the needs of OEMs. For example, Audi’s development depth in 1996 was 80%. By 2000, its development depth was reduced to 55%, and the rest was completed by component manufacturers.

# 3 Autonomous Driving: The New Battlefield

## *3.1 New Heights of Industrial Competition*

According to the Florida Transportation Authority, "Autonomous driving technology" refers to "the technology that is installed on a vehicle to achieve automatic vehicle travel, in the case where the human factor does not actively manipulate or monitor the vehicle." In recent years, with the rapid development of the Internet, Internet of Things, big data computing, intelligent control, artificial intelligence and other technologies, the trend of autonomous driving has become more and more distinct. Auto makers and emerging technology companies in Europe, America, Japan and China are making great efforts to promote the research and testing of autonomous driving technology. In 2010, the VisLab Laboratory at the University of Parma in Italy launched the VisLab International Autonomous Challenge (VIAC). They organized a fleet of cars to depart from Parma on July 20, four of which were equipped with GPS and GOLD obstacles and lane detection systems. On October 28, after a long journey of 13,000 km, they successfully arrived at the European Pavilion of the Shanghai World Expo. This event made people, especially those in China, begin to notice how autonomous driving is impacting the automotive industry.

The triumph of auto digitalization has irrevocably impacted the car; some even refer to modern cars as "high-performance computer at a speed of 113 km per hour." Peripheral players like Google and Uber now have spared no efforts in the development of autonomous driving technology, not to mention traditional auto makers. Although fully self-driving cars are still in the experimental stage, there is no doubt that other major changes are emerging in the automotive industry.

Digital tools have changed the way people socialize, learn and navigate. Networks, sensors, mobile communications and artificial intelligence have developed rapidly over the past 20 years, and have gradually entered the urban space. These technologies collect and integrate real-time information at all levels. For example, Internet-based interactive visualization system HubCab records 170 million routes taken annually by New York taxis, clearly defining the operation of urban traffic.

Traditional cars are gradually becoming information receptors, from both the riders and the environment. Systems within the car can detect the fatigue and stress level of the driver. Outside the car, radars, camera and LiDAR can "read" the surrounding environment and react accordingly.

These two trends have been synchronized in autonomous driving systems, thanks to the rapid development of artificial intelligence, vehicle interconnection and intelligent transportation infrastructure.

According to IHS and McKinsey, by 2020 autonomous driving technology will be implemented in highways and fleet operations, and relevant laws and regulations and industry standards will also be introduced. By 2025, autonomous driving will increase the industry's worth from 200 billion to 1.9 trillion US dollars. Global sales of autonomous vehicles will reach 300,000–600,000 units, of which about 50,000–100,000 units will be sold to China. By 2035, world sales of self-driving cars will reach 15 million–20 million, and the number of self-driving cars on the road will reach 50–70 million. 25% of the market share will be in China, 29% in North American and 20% in the EU. With such projected growth, it's wonder major OEMs have turned their attention to this field.

At present, many countries are trying to make autonomous vehicle a competitive industry. In September 2016, the US Department of Transportation issued the *Federal Automated Vehicles Policy*, establishing an institutional framework in four areas, from vehicle performance guidance for automated vehicles, model State policy, National Highway Traffic Safety Administration (NHTSA)'s current regulatory tools to modern regulatory tools. After the release of "*Automatic and Connected Driving Strategy*" in 2016, the German Federal Ministry of Transport and Digital Infrastructure (BMVI–Bundesministerium für Verkehr und digitale Infrastruktur) established an interdisciplinary and inter-departmental autonomous driving roundtable system for the technical, regulatory and social issues that autonomous driving may face. In conjunction with the state governments, industry associations, research institutes and consumer associations, they have discussed and reached consensus on some important issues. Germany and France have demonstrated confidence by jointly launching a cross-border road test for self-driving cars. The Japanese Prime Minister has announced that high-tech autonomous driving technology will be part of its economic policy, encouraging the country's auto industry to develop this technology.

In October 2016, China released the "*Technology Roadmap of Intelligent & Connected Vehicles*" to guide the research and development of auto makers and related parties. Some provinces and cities in China have also fully considered the Internet of Vehicles (V2X) and autonomous driving in terms of urban planning and policy support. According to the *Outline of the Shanghai Urban Master Plan (2015–2040)*, Shanghai is preparing space for future new modes of transportation. The city plans to "strengthen the sharing of space resources by various modes of transportation… [to] optimize technical specs on transportation infrastructure and land use, [and to]create conditions for the development of new transportation means such as seaplanes and automated vehicles in the future." Chongqing has made great efforts to promote these vehicle networking applications, through a three-and-a-half-year demo project implemented in two phases. The first phase would be at the comprehensive test site, while the second phase would focus on designated social roads. Simulation and tests will be run on vehicle networking collaborative communication under different communication standards. It will test semi-autonomous and fully autonomous driving vehicles for 5G communication, high-precision digital map, Beidou navigation, cloud computing, under various road situations and multiple traffic scenarios.

## 3.2 The Future has Come, Along with Fierce Competition

In September 2016, Uber launched a driverless car passenger service on the roads of Pittsburgh, USA, making it the first company to do so in the US. On that day, four Ford Fusion driverless cars, equipped with cameras, LiDAR, radar and other sensors, were sent on the road to transport passengers. To ensure safety, there were two engineers on each driverless car; one sitting in the driver's seat, ready to take over the vehicle when necessary and the other monitoring in the back seat. Pittsburgh has complex roads, narrow streets, steep slopes, and tunnels and bridges. Uber believes that if its driverless car can handle Pittsburgh roads, then it could also handle road conditions in most other cities. Prior to this, Uber's driverless car had been tested on these roads for nearly two years. Test results indicated that performance rates no different from traditional vehicles driven by human drivers.

Despite the trial run, some experts predict that Uber's completely autonomous plan will take years or even decades to achieve. "If a driverless car runs at a speed of about 118 km/h on the road, the situation can get very bad in the event of a breakdown." Prof. Raj Rajkumar at Carnegie Mellon University said, "This technology must be fairly reliable in order to allow the driver to leave the car completely."

Autonomous driving is becoming an investment hotspot, inciting competition from global auto industry and Internet companies. Chinese auto companies have long been in this area, and the R&D process accelerated by foreign auto companies. Changan iconically completed a 2000-km long autonomous car journey from Chongqing to Beijing over five days in April 2016.

The ultimate goal of autonomous driving is to drive unmanned. Companies have already moved forward towards this goal, yet the debates have never stopped. Some do not believe that automated vehicles are a possibility for the foreseeable future. At the SAE 2016 Automotive Electronics Conference, Jeff Owens, Chief Technology Officer (CTO) of Delphi, stated that "Automated driving is right before us, "to wide approval. Ford Vice President Ken Washington agreed with Owens. "Looking of the history of the automotive industry, the speed of maturity of new technologies will always surprise those who are skeptical. It is well known that technology companies are innovating at an amazing speed. Coupled with Moore's Law, the era of driverless cars may arrive sooner than you would think." General Motors has begun to test autonomous vehicles in the United States. Yet skeptics, Jon Lanckner, Vice President of General Motors, joke: "I can assure you that we are not going to test it endlessly."

Phillip Eyler, Vice President of Harman International, argued that the arrival of driverless cars may be faster than expected—however, mass adoption is another issue. This author is agrees. The large-scale popularization of autonomous driving may take some time, but some level of ADAS function could become a new selling point for competition between auto companies. Having these capabilities not only helps car companies build their unique advantages, but also to and influence consumers' choices. GM, Ford, BMW, Mercedes-Benz, Volvo and other mainstream car companies are working hard to build these capabilities.

At the same time, R&D in autonomous driving largely focuses on only the perception and decision-making process, and not the execution process. Emerging companies and traditional high-tech companies, such as Google and Baidu, use their existing knowledge of images and data to build their AI capabilities. The breakthrough of a single technology, computer vision, or deep learning algorithms, still plays an important role.

In the future transportation industry, autonomous driving technology will undoubtedly lead to revolutionary changes; fierce competition among countries and companies has already begun.

## 3.3 Detroit Versus Silicon Valley: Who Will Come Out on Top?

Rick Snyder, the governor of Michigan, was one of the main driver's of Detroit's bankruptcy a few years ago. Detroit has since embarked on the road to recovery. Since he took office, he has visited China once a year. In his 2016 trip, he looked forward to meeting Chairman of Great Wall Motors Wei Jianjun, because he noticed that the company was scouting potential locations for its North American R&D Center. The two options were Detroit—the old front—and Silicon Valley—the new battlefield of the auto industry.

According to German magazine of "Automobil Produktion", Matthias Müller, CEO of VW Group, Dieter Zetsche, Chairman of Daimler and Harald Kruger, Chairman of BMW discussed the transformation of the automotive industry towards autonomous, electric and customized cars, in a meeting in Munich on November 9, 2016. They agreed that German car companies must prepare accordingly, or risk becoming Silicon Valley suppliers. Dr. Dieter Zetsche said that the German automotive industry faced tremendous changes. Mr. Harald Kruger added that the German car industry could be more confident: "Reviewing the past, any disruption has promoted human progress." Mr. Matthias Müller pointed out that being cautious and avoiding mistakes have led to the success of "Made in Germany", but that "Valley has begun to build the Internet of Vehicles."

Silicon Valley, the city of IT technology, is becoming the auto city that Detroit once was, becoming the favored location for cutting-edge automobile laboratories.

Whether it's a small office "laboratory,"a formal R&D center, or investment fund, car companies vie for at least one house number along the 101 Highway in southern San Francisco. German automakers Mercedes-Benz and Volkswagen set up teams in Silicon Valley in the late 1990s. Ford, Renault-Nissan, Toyota and Honda are relative newcomers, joining only in the last five years. During this period, more than a dozen car companies took root in Silicon Valley, all working towards solving the two major challenges in the automotive industry: the rapid development of autonomous driving technology, and the transition from car "owning" to car "leasing".

Toyota has set up a Silicon Valley R&D center dedicated to artificial intelligence and robotics, led by Gill Pratt, a strongman in the field of artificial intelligence. The company was apparently seeking cooperation with Google, yet the two companies are fiercely competing for the development of a new generation of cars.

Automakers have begun to realize that the driving force for innovation from outside the industry is even stronger than those from within. Establishing laboratories in California can help car companies better cope with this threat from tech companies, as it enables them to poach the best engineers and developers. After all, it is hard to persuade an Apple employee to leave sunny Cupertino and go live in the suburbs of cold Detroit. Furthermore, car companies in the area will can establish long-term relationships with start-ups and universities in the region—especially Stanford University, a center for cutting edge developments in autonomous driving, artificial intelligence and human–computer interaction (HCI).

Jeremy Carlson, an analyst at IHS Automotive Information, believes that Silicon Valley's R&D cycle at odds with the usual "long cycles" of the automotive industry, but is necessary for car companies to adapt to the speed of Silicon Valley. It takes the automotive industry 5–7 years to develop a new vehicle, while it takes tech companies only 6–8 months to develop a new smartphone, and just one hour to design a website. To comply with this faster pace, car companies have begun to cooperate with technology companies to create a travel ecosystem. Ford has set up a 130-person lab in Palo Alto, CA, and partnered with Amazon to integrate Alexa voice assistant into its in-vehicle intelligence system. Mercedes-Benz is working with Google's smart furniture company Nest to integrate its intelligent temperature control system into the car, allowing users to remotely control the temperature at home while driving.

Detroit has fought back as Silicon Valley stepped up. On November 18, 2016, Governor Snyder arrived in Beijing for his sixth visit to China since he took office. He tried to attract the attention of the Chinese auto industry from Silicon Valley to Detroit. As an old car manufacturing center, Michigan was introduced emotionally by Governor Snyder while introducing initiative PlanetM. He said: "PlanetM is Michigan's mobility initiative representing the collective mobility efforts across the state. PlanetM connects you to Michigan's mobility ecosystem—the people, places and resources dedicated to the evolution of transportation mobility."

Mcity is the first real-world automated vehicle testing ground in the city in Michigan. Governor Snyder said: "Mcity is very popular and there is no more space available. We will open a new car test center in the near future, covering ten times the floor area of Mcity." Meanwhile, an intelligent corridor in the southeast Michigan brings together smart car technologies, including construction and road facilities, and will use big data to measure and analyze connected vehicles and autonomous driving test methods. It is foreseeable that neither Silicon Valley or Detroit will surrender this battle ti be the future center of automobile development.

As to the rise of Silicon Valley, Zhao Fuquan, Director of the Institute of Automotive Industry and Technology Strategy of Tsinghua University, commented very well: "who will be the winner in the future development of the automotive industry? Detroit or Silicon Valley? To develop safe, convenient, energy-saving and environmentally-friendly intelligent vehicles, both Detroit and Silicon Valley's capabilities are indispensable. No one alone could afford to build a perfect car in the future. Therefore, competition and cooperation between the two are needed. In fact, this is precisely the embodiment of Internet thinking—competing in collaboration, and profiting from sharing. In the future for a long period of time, cross-industry mergers and acquisitions will occur repeatedly, as the marriage of the two industrial forces of Detroit