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Establishing Automobile Power in China Based on Development of Intelligent and Connected Vehicles

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Abstract: The intelligent and connected vehicle (ICV), a trendy and promising form of industry, has evolved with the development of information technology. Benefiting from the disciplinary crossing and integration of the emerging technologies of various industries and fields, related industries will be witnessing collaborative growth through the industrialization of ICVs. China, as the most productive nation in terms of automobiles worldwide, desires to promote industrial transformation and upgrading to become a powerful nation in the automobile industry. In this study, the connotation and significance of establishing automobile power is illustrated, current conditions and future challenges faced by China in the development of ICVs are analyzed, and a top-level strategic design is proposed.
Keywords: Intelligent and connected vehicle (ICV); automobile power; industrial transformation and upgrading; top-level design

1 Introduction

The global automobile industry is currently experiencing a period of profound change, showcasing the integration of automobile and information technology industry innovation. Intelligent and connected vehicles (ICVs) are a new product in the context of the current round of technological reform and industrial transformation. The development of ICVs drives technological innovation and industrial upgrading in areas such as automobiles, electronics, communication, and Internet technology. Furthermore, it gives rise to a new driver of economic growth and can potentially generate a series of significant social influences through integration with intelligent transportation systems.

Overall, China's automobile industry is already an important component of the global automobile industry, and the use of intelligent and network technologies in automobiles has led to a new wave of international competition [1]. With the revolutionary breakthroughs in this new era of information technology, ICVs are transforming industry, innovation, and value chains within the structure of the global automobile industry. Amidst this industrial transformation, China's automobile industry is using the integration of advantageous resources to promote joint collaborative innovation across sectors. The aims are to master key generic technologies to overcome difficulties in the ICV industrial chain and lead the development of the global automobile industry in the era of intelligent and network technology. In this way, China will achieve its goal of transforming from a major automobile-producing country to an automobile power.

2 Fundamental implications of establishing an automobile power

With developments in science, technology, and productivity, China's automobile industry has made significant advances. In March 2017, China's automobile ownership surpassed 200 million vehicles. In 2016, the country's automobile production and sales volume totaled 28 million, the eighth consecutive year China ranked first worldwide according to this metric. As such, China has already been established as a major force in the global automobile industry [2]. However, the country struggles with the unavoidable reality that it lacks complete and independent intellectual property rights for core technologies related to complete

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vehicles and some key component parts, making it impossible to avoid the monopoly exercised by suppliers of high-end foreign products [3]. This has led to long-term reliance on imports or joint-venture manufacturing. In the 40 years since the reform and opening of China's automobile industry, it has been unable to avoid introducing advanced technologies, products, and manufacturing equipment from abroad, and has yet to develop a top-tier company with global influence. Furthermore, the country lags significantly behind global automobile powers. Members of China's automobile industry have been consistently frustrated with their large, but weak industry. The establishment of China as an automobile power is a necessary path in the transformation and upgrading of its manufacturing industry in the context of the current wave of technological revolution. However, it is also an urgent necessity within the control of China's industrial system.

Based on the current state of China's automobile industry and the problems faced, the country must tackle the issue in the following four ways to establish itself as an automobile power [4]:

(1) China should establish a interdisciplinary collaborative technological innovation system to develop world-class innovation capabilities. In the context of the current wave of technological transformation, China must harness opportunities for the development of electric, intelligent, and network-linked vehicles to achieve independent breakthroughs in core technologies for complete vehicles and key components, thus establishing cutting-edge advantages in Chinese technology.

(2) China must improve its industrial chain and form an autonomous and controllable product supply chain system. It should also strengthen corporate capacity for product development through independent innovation and increase the development of key technologies for which companies hold independent intellectual property rights. In addition, an independent supply chain for core automobile components should be established through manufacturing foundation strengthening projects to overcome the situation in which outside actors control China's automobile industry.

(3) China should strengthen its brands and develop a global benchmark in the automobile industry. An indicator of the performance of a country's automobile industry is whether it boasts an automobile company with global influence. As such, the country should not only establish a world-class Chinese brand for complete vehicles, but also develop world-class independent brands that produce automotive components. Given the current development of information technology and electronics, China should also cultivate global benchmark companies in the IT sector. In summary, it is necessary to create a group of "supercarriers" in the Chinese automobile industry to create global influence and competitive advantages.

(4) Finally, China should establish a new type of automotive societal ecology and seize opportunities for shared economic development. Automobiles have gradually penetrated each element of people's daily lives, and China has already become an automotive society. For the automobile industry to develop, it must be capable of overcoming the social problems stemming from increased car ownership, such as transportation safety, traffic congestion, energy shortages, and environmental pollution. In addition, it must form new modes of economic growth and social ecology. As such, China should give full play to the in-depth integration of multiple industries and sectors in future automobile products during the new era of information technology and to the unique characteristics of these long industrial chains. It should strengthen and enlarge its automobile industry to stimulate the coordinated development of related industries, and completely transform and upgrade its manufacturing industry to form a globally competitive industrial system that can undertake the central tasks of China's national development strategy.

3 Significance of ICVs in establishing an automobile power

The future technological development orientation of the automobile industry involves electric power, smart technology, and network technology. New energy vehicles (NEVs) and ICVs will pose two major strategic opportunities for the future development of China's automobile industry. With the help of revolutionary breakthroughs in the new generation of information technology such as mobile Internet, big data, and cloud computing, ICVs will become smart, interconnected terminals for safe, comfortable, and convenient mobility. Research shows that in the initial stage of intelligent vehicles, the use of advanced intelligent driving assistance technologies can help to reduce road traffic safety incidents by 50%–80% [5]. In addition, in the driverless stage of intelligent vehicles, it may be possible to completely avoid traffic accidents and remove people from the driving process. At the same time, ICVs can effectively strengthen the linkages between vehicles, roads, and users, forming a comprehensive transportation system, which guarantees safety, increases efficiency, improves the environment, and saves energy. This is an important step in the process of establishing smart urban transportation networks and a key factor in constructing environmentally friendly automotive societies. This is not only significant for upgrading automobile products and technologies, but can also transform the value chain systems of the automobile and related industries, and reshape business patterns across these industries [1].

In the era of smart technology, ICVs are important expressions of advanced technologies such as artificial intelligence (AI), the Internet of things (IoT), cloud computing, and energy storage. This not only disrupts traditional industrial, technology, and value chains, but also provides a major opportunity for China's automobile industry to catch up. This will promote the continuation of innovation breakthroughs and industrialization of new technologies, encourage deep levels of integration between industries, and form a completely new industrial ecosys-

tem with an economic value exceeding one trillion yuan, which will profoundly influence the future. According to predictions by the American Institute of Electrical and Electronics Engineers (IEEE), before the middle of the 21st century, driverless vehicles will constitute 75% of vehicle ownership, and ICVs may disrupt the current operation mode of the automobile transportation industry. Of the 12 disruptive technologies outlined in a report by McKinsey and Company, *Disruptive Technologies: Advances that will Transform Life, Business, and the Global Economy*, intelligent vehicles ranked 6th, and it was forecasted that by 2025, intelligent vehicles will have an economic influence of between $200 billion–$1.9 trillion [5].

ICVs are the next generation of automobile products and collection terminals and interactive platforms for individualized requirements and data. In addition, ICVs constitute a central link in the all-new smart manufacturing system and industrial value chain that will provide strategic support for transformation and upgrading in China's automobile industry or the entire manufacturing sector. Ultimately, ICVs will transform the concept of vehicles from a transportation tool to a mobile living space and platform for information services. They will lead to the prevalence of car sharing and advanced public transportation systems in the field of transportation. With less ownership and more use of shared vehicles, the way people travel and use transportation will change and the automobile transportation and service industries will be restructured to form a new kind of automotive society and culture. At the same time, massive automobile industry user groups and various environments in which automobiles are used will produce big data with important commercial values, which will influence the restructuring of industry chains and change methods of realizing value and business model innovation. In this way, the entire automobile industry will experience disruptive change on an unprecedented scale. The advantages of traditional automobile firms with regard to industry and value chain control will be severely influenced, and automobile industry value chains will gradually shift towards service elements. In this process of dramatic change, ICVs represent the form of future automobile products, and will occupy a central status in the future.

From the proposal of a national strategy based on the "Internet plus" transformation and upgrading of the manufacturing sector, to development plans for the next-generation automobile industry and smart, environmentally friendly cities characterized by smart technology, Internet of Things (IoT), and electronics technology, China is for the first time in-step with countries with developed automobile industries such as the United States, Europe, and Japan. Compared with the large historical gaps between China and these countries in the traditional automobile industry, where China was a passive follower, this new stage of technological revolution offers the country's automobile industry an opportunity to surpass others and maintain leading global advantages as an automotive power. From this perspective, the establishment of China as a global automotive power through the development of ICVs has a profound long-term strategic significance.

4 Challenges facing China's development of ICVs

Since the start of the 21st century, ICVs have been the core element of the next generation of intelligent transportation systems and been treated with a high level of importance by various national governments. In view of the state of development of global ICVs, countries and regions such as the United States, Japan, and Europe have accumulated decades of experience in the fields of smart, network-linked vehicles, especially with respect to core microchips, advanced sensor systems, key components, cyber-physical systems, artificial intelligence technology, R&D systems, and standards systems. Compared to China, such countries have a clear head start. In recent years, China has made great progress in the commercialization and application of smart driver-assistance technologies and in the R&D of high-level autonomous driving technologies. However, the country remains generally weak in terms of core technologies, R&D, and industry chains for key component systems in the field of ICVs. China also still lags behind developed countries in terms of product development and industrialization. In terms of the development of ICVs, China faces severe challenges and exhibits distinct shortcomings.

4.1 Lack of national strategy for the development of ICVs

At present, the use of smart technology and network technology in automobiles has become a development strategy for developed countries and regions such as the United States, Japan, and Europe. A new pattern in which the development of smart technologies and network connected technologies in automobiles stimulates the development of the traditional automobile, information and communication, and electronics industries has begun to emerge. In addition, China has yet to clarify top-level planning of a national strategy for the development of ICVs, making it difficult to focus the development orientation of the industry or to integrate development resources. Some firms have yet to recognize the disruptive and revolutionary influence of ICV development on automotive technology and the automobile industry, and as such, have not conducted long-term planning or invested sufficient resources for development.

4.2 Prominent ICV cross-sector integration problems and lack of unified coordination mechanisms

ICVs are new products that integrate automotive information technology and safety technologies, and have obvious

cross-sector integration characteristics. From the perspective of industry promotion, it is difficult for a single industry or sector to complete such a product; thus, it is necessary to conduct national-level coordinated development planning and establish multi-sector coordination promotion mechanisms to form a unified development path for ICV technologies, standards, and laws. This pathway should integrate resources from different sectors to conduct collaborative research to promote the rapid development of ICVs and intelligent urban transportation systems. Countries and regions such as the United States, Europe, and Japan have established promotion agencies centered on government departments and set up mechanisms to stimulate entire industry chains. In comparison, China has yet to form an effective cross-industry organization management body or unified promotion mechanism. As such, automobile, information technology, and communication firms are in competition with one another, and have not come together to combine their strengths, thereby harming their competitiveness in the current wave of transformation in the global automobile industry.

4.3 Weak independent technological foundation in key area of ICVs

At present, foreign companies monopolize the core technologies and products for key fundamental components such as advanced specialized sensors, automotive electrical circuits, operating systems, and dedicated chips used in on-board vision systems, laser radar, and millimeter wave radar. Independent Chinese companies have not accumulated enough mastery over these technologies and have long been dependent on imports. Consequently, they are over-dependent on foreign technology and suffer severe technological deficits. Independent components firms lack sustainable independent R&D systems, and China has yet to form a coordinated innovation system comprised of governments, industry, academia, and research organizations. In addition, the automobile industry lacks effective mechanisms for coordinating R&D and has yet to form combined strengths.

4.4 Low level of integration between the information technology and automobile industries

Although China has strong foundations in the Internet industry, integration with the automobile industry has not progressed past information services and aftermarket areas. Thus far, the Internet industry has been unable to access the decision-making and control levels related to the application of smart technologies and network technologies in automobiles. Furthermore, they have been unable to form teams to compete internationally and have no voice in the establishment of international standards. Smart transportation and smart cities have yet to achieve coordinated development with the automobile industry, and cross-industry integrated technological innovation systems have yet to be established for fields such as automobiles, information technology, transportation, and the Internet.

4.5 Need to strengthen the construction of intelligent infrastructure

The development of ICVs requires the interconnection of road transport infrastructure, communication and network infrastructure, and other types of infrastructure. The initial stages of intelligent infrastructure construction require large investments, and the return period is long. Compared to developed countries, China's ICV infrastructure is relatively backwards, and the current lack of national-level construction plans is an important factor restricting the large-scale application of ICVs.

5 Strategic plans to establish an automobile power based on industrial development of ICVs

The central task for the establishment of a modern automobile power is accelerating the in-depth integration of next-generation information technology with the automobile industry and seizing important opportunities to promote the implementation of strategies such as China's "Made in China 2025" and "Internet plus." In addition, establishing China as an automobile power depends on the ICV industry, the accelerated transformation and upgrading of the automobile industry, comprehensive improvement of core industrial competitiveness, and realizing a historical shift from size to strength in the country's automobile industry. To realize these objectives, a multi-pronged and jointly executed national strategy is required.

5.1 Using national strategy as a driver for the execution of top-level system planning

Using the implementation of national strategies such as energy use, manufacturing strength, artificial intelligence, and information security as a guide, China can take advantage of the large customer scale, independent control of key technologies, and advantages in global standard-setting of its NEV, communications, and Internet industries. The NEV industry can be used to promote the establishment of an industrialized system for ICVs, construction of an intelligent transportation system, and Internet of vehicles (IoV) industry applications. By combining the resources of relevant industries and fields, breakthroughs can be made in core technologies for independent systems related to ICVs, including key technologies, supporting technologies, information and communication technologies, big data application platform technologies, and comprehensive transportation management technologies. To establish a complete engineering implementation system, key tasks such as the manufacturing foundation strengthening project, the industrial cluster construction project, the infrastructure informatization construction

project, and the cross-sector big data management platform construction project must be completed. At the same time, to achieve the transformation and upgrading of the automobile industry with "new energy + smart technology + network connectedness + system autonomy" characteristics, and the establishment of a new social ecology of the automobile industry with "universal connectedness + smart transportation + smart cities + sharing economy" characteristics, general top-level planning and a serialized implementation strategy should be executed.

The central thinking of this top-level planning can be summarized as follows. The resource chain should be arranged around the value chain, while integration of the resource chain creates the innovation chain. The technology chain is dependent on its interconnectedness with the innovation chain, and the industry chain is dependent on the distribution of the technology chain. Finally, the overall planning of the industry chain forms the ecological chain. The transformation and upgrading of the automobile industry and establishment of a new automobile society ecology will stimulate the coordinated progress of other related industries and the restructuring of the national economy, highlighting the important status of the automobile industry in the process of overall national development. Fig. 1 shows the thinking underlying the achievement of the strategic objective of establishing China as an automotive power.

5.2 Establishing an integrated and coordinated cross-sector technological innovation system

ICVs relate to various industries such as the automobile, communications, transportation, and information technology industries. The industrial chains for ICVs are long, and involve many technological fields. Therefore, the development of ICVs cannot be completed by a single industry or organization. The establishment of an integrated cross-sector technological innovation system can effectively coordinate resources across industries and sectors, forming a joint and coordinated innovative force. In addition, independent breakthroughs in key technologies related to ICVs can drive the comprehensive distribution of the industrial chain, while exploration of new industrial patterns and management models can help to implement and carry out development strategies to establish China as an ICV power.

To solve the problem of the hollowing out of key ICV technologies and search for key technologies in future emerging industries, based on the principles of top-level national planning and coordinated innovation, China should integrate the development of forward looking, generic, and cross-sector integrated technologies of existing resource development industries. Through mechanism innovation, original innovation, integrated innovation, introduction, digestion, and re-innovation carried out under the coordination and cooperation of industry, academia, and research groups, China can achieve breakthrough developments in core, key, and supporting technologies for the industry. China should promote cross innovation between automobile enterprises and Internet enterprises to make technological breakthroughs in environment perception, intelligent decision-making, and coordinated control, and to promote R&D and industrial application of sensors, vehicle terminals, and operating systems. The chain of technical R&D, technical diffusion, and technology industrialization should be connected, thus to form an achievement transfer and diffusion mechanism centering on the marketization mechanism, thereby helping and supporting enterprises with self-owned brands to occupy the technological command-

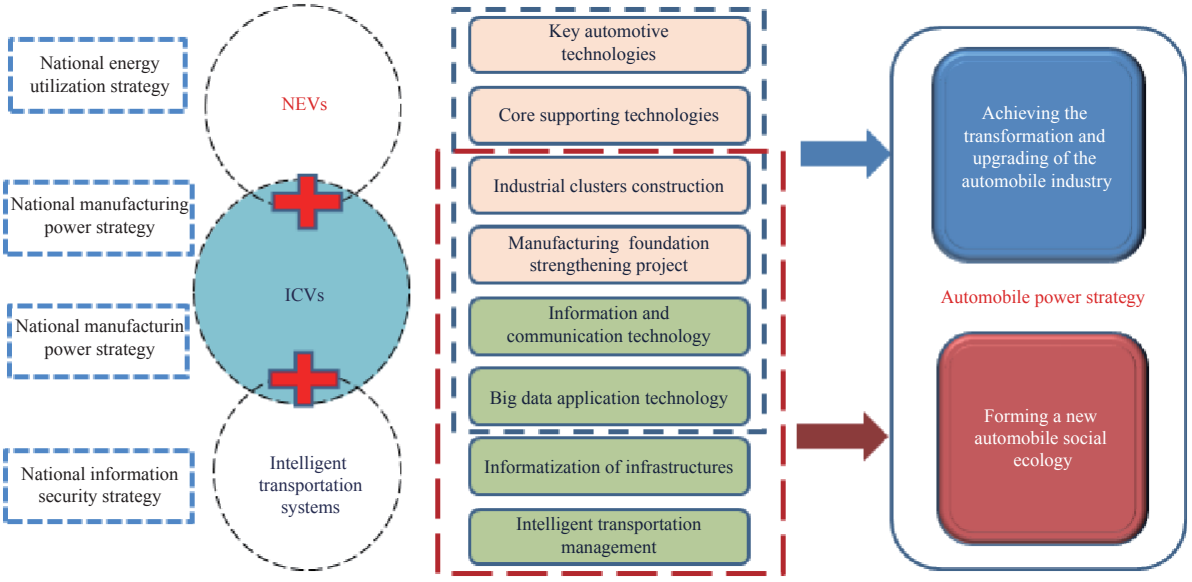

Fig. 1. Top-level design for the automobile power strategy.

ing height in the global competition of ICVs. The framework of the integrated and coordinated cross-sector technological system is shown in Fig. 2.

5.3 Constructing an independent industry chain, and large and strong independent brand companies

Currently, the lack of core technologies needed for key components such as onboard sensors, advanced processing chips, onboard computer platforms, and underlying operating systems means that China relies on imports for these components. Although China has a certain level of technological accumulation and industrial foundation in fields such as embedded onboard systems, high-precision guidance platforms, IoV communications, and onboard electronics equipment, it has not formed competitive advantages in these fields. Thus far, China's ICV industry chain is incomplete and lacks major complete vehicle or component manufacturers with international influence.

As a result, China must give full play to the leadership role of the government, and use tools such as overall planning, policy guidance, and public services to promote the establishment of an environment suited to industrial development. It should also complete the overall advancement of top-level planning, promulgate specialized development plans or guidance policies, establish major projects aimed at supporting industrial development, and establish public service technologies and capacities related to national-level information security such as high-speed communication, digital maps, high-precision positioning technology, and big data application platforms for transportation. In the industry chain, China should use market and capital tools to integrate the automobile, transportation, Internet, and communication industries, and to combine the innovation advantages of China's Internet industry and the scale advantages of the automobile industry. In addition, it should accelerate the integrated development of the information technology and automobile industries and promote the rapid commercial application of key ICV technologies, thereby following an "Internet + automobiles" development path with Chinese characteristics.

By combining China's development strategies for NEVs, breakthroughs in the development of electric vehicles can be employed to achieve the rapid development of ICVs. By combining the construction of China's Beidou Satellite Positioning System with the development of independent high-precision positioning and mapping systems, China can achieve independent and controllable development in the smart car industry.

By strongly supporting technological innovation in key links of the microchip, sensor, and operating system industry chains, China can promote the establishment and improvement of product innovation systems through breakthroughs in core technologies, and thereby improve the independent innovative capacities of key enterprises and increase industrial competitiveness. Policy support, funding support, and other methods of supporting in-

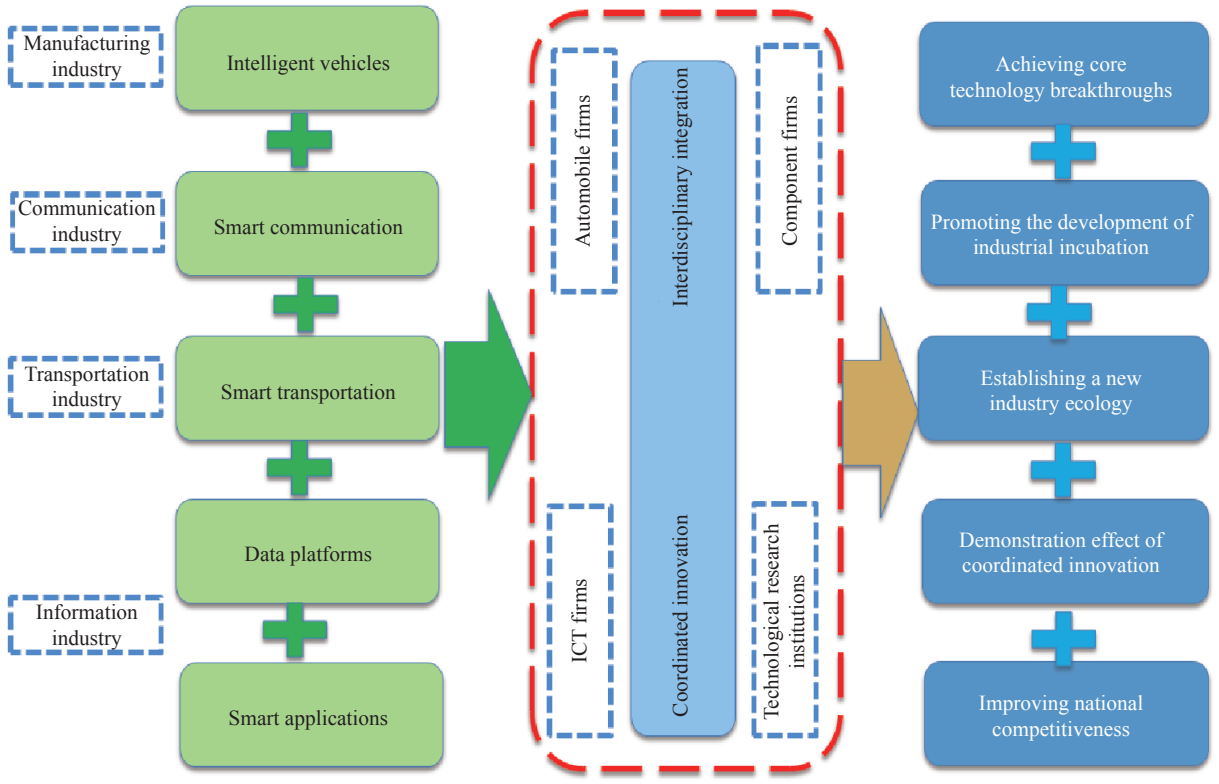

Fig. 2. Integrated and coordinated cross-sector technological system.

dependent firms in merging with or acquiring foreign producers of complete vehicles or vehicle components, which possess core technologies or brand advantages, can be used to gradually create a group of independent Chinese brands with large production and economic scales, which are global leaders in ICV manufacturing. This will help China to achieve absolute advantages in future global competition.

5.4 Promoting industrial applications and establishing the influence of Chinese ICVs

The performance of automobile power nations includes the contribution of the economic scale of the automobile industry to GDP, orientation of the automobile industry and culture to the formation of a social ecology, and domestic and international influence of independent brands. Therefore, China must vigorously promote industrial applications of ICVs, and execute basic supportive projects to encourage the formation of a smart-car social culture and expand the global influence of China's automobile industry.

First, China should employ the coordinating role of its central and local governments. With the goal of promoting the overall allocation of resources, national ICV product applications, and industrial development, China should integrate smart roads in the construction of smart cities and actively develop national ICV demonstration areas, demonstration roads, and demonstration cities. Smart vehicles should be in specific regions, and roads, cities, and inter-city venues should be opened to demonstrate the operation and commercial applications of smart vehicles. To comprehensively prepare for the transition to a smart vehicle society, knowledge of ICVs should be popularized, public awareness improved, ethical issues related to smart vehicles discussed, and independent brand smart vehicles advertised.

Next, it is necessary to integrate important opportunities for the rapid development of smart roads and transportation networks, brought forth by the 2022 Beijing Winter Olympics and construction of the Xiong'an District, to promote industrial applications of smart vehicles. Application demonstration projects for smart vehicles in and between cities should be developed, and smart city and smart transportation integration projects conducted to unify transportation network application demonstration projects.

Finally, China should rely on its advantages in information technology and infrastructure construction and borrow from its "Belt and Road Initiative" strategy to provide "smart vehicle + smart transportation + infrastructure construction" smart urban transportation solutions packages to countries and regions along the economic belt. It must produce and disseminate technologies related to the smart vehicle industry, expand the technological influence of the industry, and achieve its global strategy of establishing itself as an automobile power.

6 Conclusions

China's establishment as an automobile power is an inevitability of the transformation and upgrading of the country's manufacturing industry and restructuring of the national economy in the current era of technological revolution, as represented by advances in information technology. ICVs are next generation automobile products, which deeply integrate multiple industries and fields. This type of product will produce a series of new industrial patterns, modes of economic growth, automotive social ecologies, and car cultures. ICVs are a core link in the industry chain used to establish China as an automobile power. Top-level strategic planning to establish China as an automobile power, which relies on the development of the ICV industry, can be carried out to take advantage of strategic national opportunities provided by significant revolutions in the global automobile industry, promote the transformation and upgrading of the automobile industry, and accelerate China's transformation from a major automobile producing country into an automobile power.

References

[1] The Strategic Advisory Committee for Technology Roadmap for Energy Saving and New Energy Vehicles, Society of Automotive Engineers of China. Technology roadmap for energy saving and new energy vehicles [M]. Beijing: China Machine Press, 2017. Chinese.

[2] China Industrial Development and Research Net. Predications on car ownership and annual sales of China in 2017 [EB/OL]. (2017-09-04) [2017-12-15]. http://www.chinaidr.com/tradenews/2017-09/115440.html. Chinese.

[3] Zhao F Q, Liu Z W, Hao H, et al. A comprehensive evaluation system for automotive industry of different nations [J]. Chinese Journal of Automotive Engineering, 2016, 6(2): 79–86. Chinese.

[4] Dong Y. Study on auto power strategy of China [J]. Shanghai Auto, 2013 (3): 1–8. Chinese.

[5] Kong F Z, Li K Q. The concept, architecture, and the state of the art of intelligent vehicles [N]. China Automotive News, 2014-07-11(03). Chinese.