# Automotive Industry APP Development Strategy in the Prospect of Digitalization

Zongwei Liu[1,2]
[1]The State Key Laboratory of Automotive Safety and Energy, Tsinghua University
[2]Tsinghua Automotive Strategy Research Institute, Tsinghua University
Beijing, China, 100084

Fuquan Zhao[1,2 *]
[1]The State Key Laboratory of Automotive Safety and Energy, Tsinghua University
[2]Tsinghua Automotive Strategy Research Institute, Tsinghua University
Beijing, China, 100084
[*] Corresponding author: zhaofuquan@tsinghua.edu.cn

Baolei Zhang[1,2]
[1]The State Key Laboratory of Automotive Safety and Energy, Tsinghua University
[2]Tsinghua Automotive Strategy Research Institute, Tsinghua University
Beijing, China, 100084

***Abstract*: The connotation of automotive industry digitization was elucidated systematically based on the tide of intelligent upgrading of automotive industry. The deep impact of Automotive Industry APP (AIAPP) on automotive industry was introduced with a digitization prospect after the analysis of definition and effects of Industry APP (IAPP). Main types of AIAPP were expounded with detail aiming at the application areas of AIAPP. Development elements of AIAPP were analyzed in detail from the point of digital upgrading of automotive industry. Major difficulties of developing AIAPP were summarized by dissecting process characteristic of the development and application of AIAPP. The main strategies were proposed on carrying forward the development of AIAPP from the aspects of division and cooperation of participants, labor division between OEMs and auto parts companies, collaboration between automotive technicians and software technicians, and nurture of an industrial ecosystem.**

***Keywords: digitalization; Automotive Industry APP(AIAPP); big data; cloud computing; machine intelligence Introduction***

## I. INTRODUCTION

With the continuous penetration of information technology into the manufacturing industry, the traditional manufacturing model is undergoing a rebirth. The traditional production method based on equipment islands in discrete manufacturing industry is being replaced by the connected production method based on the Industrial Internet of Things (IoT) [1-3]. Various types of data such as equipment data, process data, material data, and demand data are becoming flowing manufacturing resources, driving the manufacturing industry to provide more efficient production with a new look [4, 5]. As the leader and typical representative of the manufacturing industry, the automotive industry is undergoing disruptive changes [6]. Data and intelligence have spawned flexible production lines, making the goal of personalized customization increasingly close to reality [7]. The information systems of OEMs and auto parts companies are interconnected to create a more efficient supply chain [8-10]. The ubiquitous connection has led to further platform-based development of the OEMs, and the R&D of automotive technology is more undertaken by auto parts companies. New energy, intelligence, connectivity, and sharing have brought the automotive industry into a state of unprecedented changes in 130 years. Automotive products have also shifted from traditionally simple mobility tools to data terminals with multiple functions.

Subject to the above, automobiles are changing from hardware-based products to hardware and software integrated products, and the role and value of software are becoming more and more important. Therefore, in all links throughout the full life cycle of automotive R&D, manufacturing, application, and service, the application volume and importance of software continue to increase [11-13]. And the industrial application software supporting the automotive industry, namely the AIAPP, is expected to usher in a booming development. Digitization enables the production and service elements of the automotive industry chain to enter the digital space, thereby enabling machine intelligence to optimize the allocation of all elements [14-16], and promoting the development of the automotive industry collaboration model to a new stage. Therefore, the transformation and upgrading process of the automobile industry is also the development process of AIAPP, which is changing the operation models of automakers. However, the AIAPP also faces its own development constraints and its future growth is bound to be a tortuous process. This paper starts from the connotation of automotive industry digitalization, discusses the automotive industry's demand for IAPP, analyzes the difficulties of developing AIAPP, and finally proposes strategies for the development of AIAPP based on the characteristics of the automotive industry, providing path and strategy references for the intelligent transformation and upgrading of the automotive industry.

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## II. CONNOTATION OF AUTO INDUSTRY DIGITALIZATION AND ITS DEMAND FOR IAPP

### A. Connotation of automotive industry digitalization

The automotive industry digitalization must first be based on IoT. From Internet to IoT, the upgrading and application of network technology in the automotive industry has brought all elements, including man, car, and environment, into a digital space. In this process, standardized communication protocols and data interfaces become necessary conditions for the IoT of the automotive industry. Through the IoT, the automotive industry can achieve vertical integration within the industry, horizontal integration between enterprises in the industry, and end-to-end integration between any links involved in the industrial development. With full integration of the elements, product data, operation data, value chain data, and other external data can flow freely, thereby driving value generation.

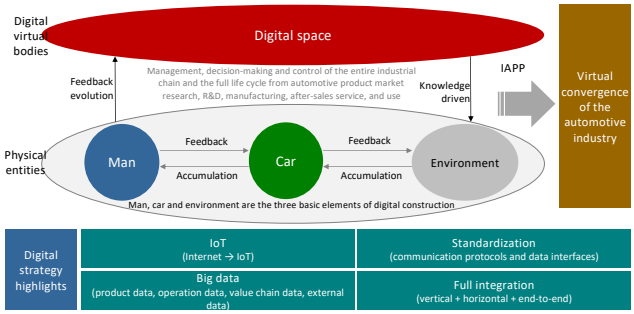


Figure 1. Characteristics of the automotive industry in the prospect of digitalization

Human, vihicle, and environment are the three basic elements of digital construction and constitute the physical entities of the automotive industry. Through digitization, all physical entities enter the digital space in the form of data, forming digital virtual bodies for the automotive industry [17]. Driven by data models, market research, product R&D, manufacturing, after-sales service, and maintenance of automotive products can all run virtually in digital space. The management measures, control schemes, etc. derived from the digital space can be re-acted on the physical entities via the digital virtual bodies. Through the organic interaction of physical entities and digital virtual bodies, the automotive industry can achieve a virtual-real integration, and machine intelligence can play a role. In the repeated iterations of physical entities and digital virtual bodies, the automotive industry will be able to make the most of resources. And this kind of virtual convergence of the automotive industry must rely on AIAPP. The characteristics of the automotive industry in the prospect of digitalization are shown in Figure 1.

### B. Definition and application of IAPP

IAPP is an industrial application software that is based on the Industrial Internet and carries industrial knowledge and experience to meet specific needs. It is an important achievement of software-based industrial technology and a collective name for industrial application software. IAPP makes tacit and scattered knowledge explicit, organized and systematic, promotes knowledge precipitation, transmission and reuse, enlarges value creation, and gives play to software's role of "enabling capability, value, and intelligence", optimizes the operation of the physical world and promotes the quality improvement, efficiency enhancement and upgrading of industries [18].

IAPP is oriented to industrial application scenarios and is a knowledge product of software-based industrial technology. It adopts the Industrial Internet for development, application and sharing, excavates and encapsulates industrial knowledge, and provides intelligent support for specific problems in the production and operation of enterprises. It is a common crystallization of human industrial civilization and information technology [19, 20]. IAPP can integrate the industrial knowledge, experience, and technology that humans have accumulated over hundreds of years, and continuously improve and optimize it with the assistance of machine intelligence [21]. Based on data and machine intelligence, IAPP gives industrial accumulation new life and realizes sublimation of value. The knowledge and capabilities possessed by IAPP are continuously updated and amplified with the help of the information network, and no human individual can compete with it.

As a leading industry in the manufacturing industry, the automotive industry boasts a deep accumulation and a very mature R&D and manufacturing system after a century of development. AIAPP is a branch of the IAPP in the automotive industry. The automotive industry must carry out full application of AIAPP in order to upgrade from a traditional manufacturing industry to a modern intelligent one.

### C. Application of AIAPP in the mobility context

In the mobility context, the IoT facilities based on men, equipment, products and environment have incorporated vehicle operating scenarios into the data collection system, thereby expanding the application scenarios of AIAPP to a wider range. AIAPP will play a more important role in the automotive industry and the overall transportation (see Figure 2). The traditional big data of OEMs mainly include R&D data, production data, logistics data, and service data. In the mobility era, the HMI data, traffic data, vehicle data, and grid data are also included in the collection range. Mobility has greatly expanded the data processing scope, thus providing a wider space for the application of AIAPP. Through the application of AIAPP, mobility data can be further used to promote the upgrade of products and services in the automotive industry.

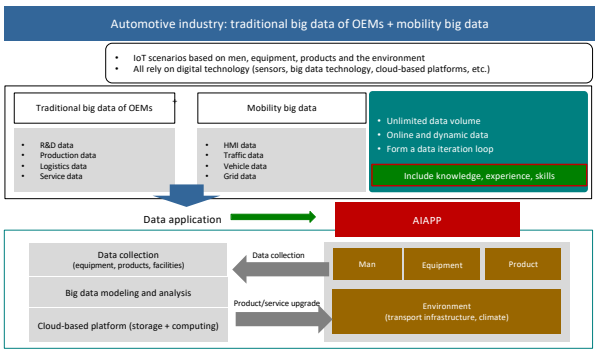


Figure 2. Mobility further expands the role of AIAPP

### D. AIAPP drives the transformation of auto parts companies

The increasing proportion of software in auto parts is an obvious development trend of the current automotive industry. However, traditional auto parts companies mainly design and manufacture tangible auto parts, and they have little involvement in software business and lack corresponding technical personnel. AIAPP development is a rare opportunity for auto parts companies to transform from the original pure hardware production mode to the hardware and software combined production mode. For traditional software companies, it is also an opportunity to further expand cross-domain business space. Traditional auto parts companies and software companies both take advantage of their resources and carry out in-depth cooperation in the form of cooperation and joint venture, which is likely to become a common growth path for auto parts and software companies in the future.

## III. CLASSIFICATION AND DEVELOPMENT ELEMENTS OF AIAPP

### A. Classification of AIAPP

- R&D and design AIAPP

Traditionally, R&D and design is the initial link of the automotive industry. While determining the degree to which a product meets market demands, it also basically determines the cost and delivery time of a product. R&D and design capabilities are also key indicators of whether a company has a competitive advantage. Before the information age, the knowledge and experience required for automotive product design were mainly mastered by some designers, and their sharing and inheritance functions were weak. The success of product development mainly depended on the design team or some members of the team. AIAPP uses data and algorithms to solidify the knowledge, experience, and skills formed in the history of enterprises, and expands applications with the assistance of machine intelligence. By applying the knowledge and experience of all previous designers, each designer can obtain a powerful design ability that is incomparable to the past, which can greatly improve the product R&D capabilities. With the assistance of AIAPP, leading automakers with rich data accumulation will further unleash huge data potential, and those with strong data processing capabilities will be able to further enlarge the gap with their rivals, putting the automotive industry into a situation where the strong get stronger.

- Manufacturing AIAPP

Manufacturing has long been the heaviest link along the automotive industry chain. The automobile manufacturing process involves almost all types of modern manufacturing processes and requires a lot of equipment and manpower. At the same time, this link requires efficient cooperation between OEMs and auto parts companies at multiple levels. Therefore, the automobile manufacturing process has objectively formed a very large system. The world leading automakers with a long history have accumulated rich manufacturing data. Leveraging optimized algorithms to configure manufacturing resources based on manufacturing data is an important way for automakers to tap the potential of resources. Equipment maintenance has always been a major problem faced by manufacturers and is directly related to the smooth operation of the production line, which determines the manufacturing cost and delivery time. The application of AIAPP can enable enterprises to change their maintenance mode from passive to preventive maintenance based on equipment failure prediction, so that enterprises can minimize the negative impact of equipment failure on production [22]. Quality control is also an important area where AIAPP plays a role. Traditionally, the quality control of manufacturers often requires a complex control system, which requires more manpower and material resources. With the assistance of AIAPP, complex quality control tasks can be performed more by machines, which can greatly improve quality control efficiency and further reduce quality control cost.

- Demand forecasting AIAPP

Market demand forecasting is the basis for product development but faces great difficulties due to poor market information channels under traditional operation models. With market big data and AIAPP, product demand forecasting can be directly based on market data and data analytics models, thereby greatly improving the reliability of market decisions.

- Supply chain management AIAPP

The supply chain is the key guarantee for normal operation of the automotive industry. The smoothness of collaboration between OEMs and auto parts companies has also been a key factor influencing automobile production. However, due to the complex structure of automotive products and the inclusion of tens of thousands of parts, the supporting networks faced by OEMs are extremely complicated, resulting in arduous supply chain management tasks. Through the full digitization of OEMs and auto parts companies, a logically integrated virtual network is formed between OEMs and auto parts companies [23]. Supply chain management AIAPP uniformly and intelligently dispatches production factors of OEMs and auto parts companies and can bring a revolutionary improvement in collaboration efficiency between OEMs and auto parts companies.

- Operation service AIAPP

The routine management and operation of automakers is also a complex system engineering. Especially for OEMs with the basic characteristics of a massive scale, a large number of employees, and complicated businesses, the routine management tasks are burdensome. After the process is digitalized, AIAPP can penetrate into every management link, integrate all the fine-grained tasks of routine management into a unified digital virtual system, replace the paper document flow with electronic information flow, and replace human brain intelligence with machine intelligence, thereby greatly improving management efficiency and reduce error rates.

### B. Development elements of AIAPP

The development elements of AIAPP include data collection, cloud computing infrastructure setup, big data processing, and software development, of which data collection is the basis, cloud computing infrastructure is the support, industrial big data is the core, and software development is the key. The specific content and logic are shown in Figure 3.

In terms of data collection, the work is mainly focused on equipment interconnection and edge computing. The premise of equipment interconnection is that the collection software can perform complete communication protocol analysis on various types of equipment. In order to reduce the central computer processing load and the information transmission load, edge computing technology has also made rapid progress in recent years. Due to little or no consideration for interconnection of traditional equipment, the equipment interconnection in the current automotive industry is generally weak [24]. Edge computing that can play a huge role in reducing the burden on the network is stepwise becoming a key content in digital construction of enterprises. But in general, the automotive industry no longer faces insurmountable technical barriers whether in equipment interconnection or edge computing [25].

In terms of cloud computing infrastructure, China's cloud computing infrastructure market is mature enough. There is no clear gap between China's cloud computing infrastructure and the international advanced one. The continuous investment and deployment by industry giants such as Ali, Huawei, and Tencent have sufficiently improved the cloud computing infrastructure necessary for the development of China's automotive industry.

In terms of industrial big data processing, industrial mechanism models and big data analytics models are the main tasks. However, since different business segments require different mechanism models and analytics models, and there is no need to generalize specific businesses into digital models under the traditional manufacturing model, so this service is still in its infancy. Industrial mechanism models and big data analytics models will become the core content of AIAPP development.

In terms of software development, the traditional software commonly used by automakers, such as Computer Aided Design/Manufacturing (CAD/CAM), Product Lifecycle Management (PLM), and Enterprise Resource Planning (ERP), have become mature. In addition to several internationally renowned software companies from developed countries such as the United States, Germany, and France, a number of Chinese local software companies have also grown rapidly. However, in the current and future software cloudification process, the traditional software cloud-based transformation is still in the hands of several international leading software companies. The AIAPP for enterprises is almost in the blank stage, and its upcoming development boom will provide precious development opportunities for Chinese homegrown software companies.

To sum up, the AIAPP for R&D and design, manufacturing, demand forecasting, supply chain management and operation service is expected to embrace unprecedented development opportunities, and meanwhile bring huge new market space for the communication equipment manufacturing industry and software industry. The development elements of and historical opportunities for AIAPP are shown in Figure 3.

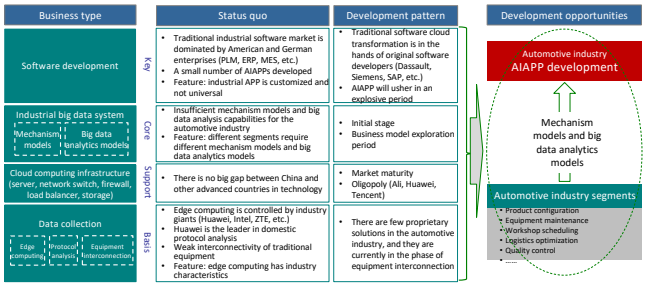


Figure 3. Development elements of and historical opportunities for AIAPP

## IV. DEVELOPMENT DIFFICULTIES OF AIAPP

Although AIAPP has shown huge development potential, due to its own characteristics, its future development still faces a series of unavoidable obstacles, mainly including:

### *A. Difficulties in setting industrial standards*

Due to the characteristics of the automotive industry, the industrial standards for AIAPP are still blank. Compared with the APP for daily use, AIAPP lags behind significantly in standards formulation. In addition to the late start of AIAPP in time, the more important reason is that AIAPP targets at fragmented fields, so it requires a larger number of standards and complicated content, bringing obvious difficulties in standards formulation.

### *B. Difficulties in Technology Integration*

Unlike daily application APP, the automotive industry App emphasizes the organic integration of information technology (IT), operation technology (OT), and communication technology (CT). For a long time, IT, CT and specific technologies of the automobile industry have basically been completely fragmented. For the development of the automotive industry APP, the three types of technology must be interconnected and integrated. However, the vehicle itself is a product with a highly complex structure and also faces stringent safety requirements. Its design and production are very difficult. In addition, due to the huge market size of the automobile, it has a strong driving force for the national industry as a whole, and has become the economic pillar of major industrial powers. The automobile industry has formed a highly specialized technical system after a century of development. Therefore, for the development of APP in the automotive industry, it is difficult for ordinary software developers to complete, and there must be efficient cooperation from automotive technical personnel. The integration of software technology and automotive expertise is a key difficulty facing the development of automotive industry APP. The specific content is shown in Figure 4.

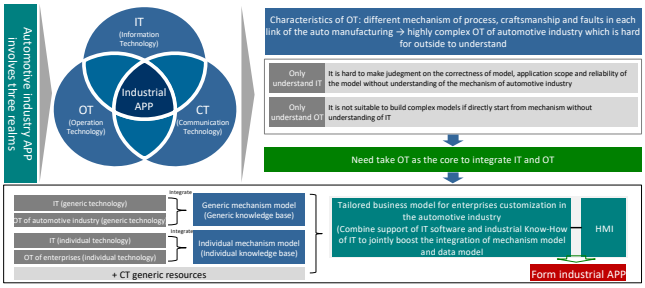


Figure 4. Difficulties in technology integration of automotive industry APP

### C. *Difficulties in Information Sharing*

The development of automotive industry APP means that enterprises digitize their own knowledge, experience, and skills, and finally solidify them in software. It means the risk of information leakage [26] whether for engineers with corporate knowledge, experience, and skills, or for the entire enterprise. At the individual employee level, technical backbone engineers have serious concerns about losing their technological advantage in the enterprise. At the corporate level, there are also huge concerns about the easy loss of technology. Although other conditions required by the automotive industry APP are mature, in terms of this information sharing, there is no safeguard mechanism to satisfy technicians and enterprises. Therefore, individuals and enterprises related to key technologies are currently lacking a strong willingness to share information, which has brought significant difficulties for the development of automotive industry APP.

### D. *Difficulties in Software cost*

Because industrial APP are often targeted at specific industrial segments, they are highly specialized, resulting in a very limited market size. And this market with limited scale inevitably brings a relatively heavy cost burden to software development enterprises, thereby greatly reducing the willingness of software companies to participate. In terms of software maintenance, this industrial app also requires long-term employment of very professional maintenance personnel, which is also an unbearable long-term burden for software companies. Therefore, general non-professional service providers are often reluctant to participate in the operation of such software due to cost, which makes the automotive industry APP face the difficulty of lacking service providers. Major Difficulties in the development of Automotive Industry APP.

## V. Development Strategy for AIAPP

The important role of the AIAPP in industrial development determines that it will become a key task for automobile enterprises. However, due to a series of specific difficulties in its development process, it is necessary to take reasonable promotion strategies. Combining the general status of the automotive industry and the characteristics of the AIAPP, the development strategy is proposed as follows:

### A. *The Overall Division of Labor and Cooperation of Participants*

The development of automotive industry APP involves government's top-level design and macro-planning, as well as various industry standards required by software. It also requires the division of labor and cooperation of different types of enterprises. Therefore, a clear division of labor among government agencies, industry organizations, OEMs, parts suppliers, and software companies is a prerequisite for the smooth development of automotive industry APP.

As overarching planning and overall service agencies, government departments need to do a good job of comprehensive macro support. First of all, government departments need to make industrial positioning, top-level planning for the automotive industry app, and draw up overall development goals based on the national macro industry strategy. Secondly, government departments should organize senior experts to formulate specific policies for the development of the automotive industry APP based on industrial characteristics. Especially in the early stage of the development of the automotive industry APP, the government is particularly required to launch industrial support policies and financial support policies[27] for key and representative areas, and conduct pilot and demonstration of some typical projects.

Industry organizations such as industry alliances, industry associations, and industry academies need to give full play to their organizational advantages, and do a good job of uploading, intermediation, and industry service. On the one hand, industry organizations need to cooperate with government agencies to implement policies, and on the other hand, they need to make use of the industry's public platform and provide public services such as standard setting and product evaluation. Especially in the formulation of industry standards, industry organizations should base on the public needs of the industry, give play to their professional advantages, and develop various standards that are suitable for the current level of industry development in view of the complexity and fragmentation of the automotive industry APP business. In addition, with the explicit and structured knowledge in the development of the automotive industry APP, the importance of intellectual property protection immediately became apparent. Industry organizations also need to fully absorb corporate opinions and work with the legislature to promote intellectual property protection related to the development of the industrial APP.

As the subject of the development and application of automotive industry APP, various enterprises should actively explore and make bold attempts according to the actual needs of the enterprises and focus on making deployment in their respective business areas. Based on their own advantages and business requirements, OEMs, parts suppliers, and software companies have innovated collaborative models and made step-by-step breakthroughs in APP development in various subdivisions such as R&D and design, production and manufacturing, and warehouse logistics in the automotive industry.

Universities and research institutes are also important participants in the development of automotive industry APP. They should conduct cutting-edge research, formulate service

industry standards and develop enterprise engineering on key, basic, and common issues in the development of automotive industry APP. Talents are a significant shortcoming in the development of automotive industry APP. Universities and research institutes should also give play to their own advantages in human resources, expand exchanges and cooperation with world-leading scientific research institutions, and shoulder the mission of cultivating talents needed for the development of automotive industry APP[28]. The division of labor and cooperation among the participants in the development of the automotive industry APP is shown in Figure 5.

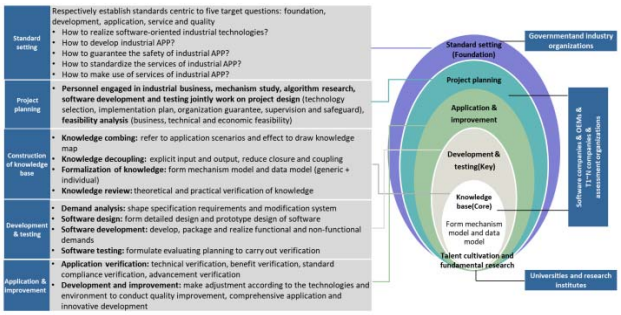


Figure 5. The division of labor and cooperation among the participants in the development of the automotive industry APP

### B. *Division of Labor and Cooperation Between OEMs and Parts Suppliers*

For the development of automotive industry APP, the cooperation between OEMs and parts suppliers is particularly important. OEMs and parts suppliers have a large number of related businesses and independent businesses. During the development of the automotive industry APP, the division of labor must be clearly defined between OEMs and parts suppliers, and between multi-level parts suppliers. OEMs and large parts suppliers should pay more attention to overall business planning and construction of cloud platforms. Small and medium-sized parts suppliers need to undertake professional and technical work in APP development and carry out specific software development with software companies.

### C. *Collaboration between Auto Technicians and Software Technicians*

The development of the automotive industry APP ultimately requires the joint implementation of automotive technicians and software technicians. At the stage of project planning, the technical personnel of the automobile enterprises need to get agreement on business understanding with the software companies' personnel engaged in mechanism study, algorithm research, software development and testing, jointly determine the technology selection, implementation plan, organization guarantee, etc., and analyze business, technical and economic feasibility. For the construction of the knowledge serving as the core, automotive technicians mainly work on knowledge combing and knowledge decoupling. Software technicians are responsible for structuring knowledge and jointly conducting knowledge review. At the most critical stage of forming the mechanism model and data model from industrial knowledge, software technicians need to learn enough and thoroughly understand the principles of industrial technology to achieve accurate model building. After the software technicians complete the development and packaging, the automotive technicians perform detailed functional verification, after which the two parties collaborate to develop and improve.

### D. *Building of Ecological Environment for the Development of AIAPP*

Building an ecological environment for the healthy development of the automotive industry APP is another focus of future work. From the budding to the development and expansion of the automotive industry APP, it is the key that all stakeholders can realize the expected benefits. Under the current situation, the responsibilities and rights of stakeholders such as OEMs, parts suppliers, software companies, and evaluation agencies still lack a clear boundary. The intellectual property protection mechanism of relevant enterprises and individuals has not yet been formed. As for the protection of property rights, in addition to the restrictions on the data interface of the networking enterprises through the internal access of the software, a mature intellectual property protection mechanism should be formed on the basis of law. In the facet of revenue sharing, it is necessary to further explore the reasonable sharing mechanism of related enterprises and individuals. While realizing the value of industrial APP application, it is also realizing the value of intellectual property rights for knowledge subjects in software promotion.

The development and application of the automotive industry APP requires that many complex links such as standard formulation, product development, and promotion and usage can be carried out smoothly, but currently there are still obvious development obstacles in these links. In order to enable the automotive industry APP to form a benign mechanism for self-driven development, it is necessary to build a model and environment for the common profit of all parties involved. Therefore, aiming to develop the automotive industry APP, except achieving success in specific details, it is also necessary to focus on fostering its complete ecosystem.

### E. *Breakthrough Choices for Developing AIAPP*

Because AI APP involves a complete automotive industrial chain, it is obviously difficult to achieve comprehensive flowering and concurrent development in the short term. Selecting suitable industry links to make key breakthroughs is also an effective strategy to promote the development of AIAPP. Combining the characteristics of each link in the automotive industrial chain, the production and manufacturing link is the most suitable as a breakthrough and entry point for the current development of the automotive industry APP. Production and manufacturing is positioned as the core in the overall deployment of industrial digital construction as it connects R&D with market. The automobile manufacturing process requires vast production equipment, facilities, and production personnel, including a mass of processing links and quality control content. It is also the most complex and burdensome part of the specific business of the automotive industry. The manufacturing process puts forward high

requirements on knowledge and experience, has great impacts on product costs, and is related to product quality and supply cycle. During the long-term development, each process stage in stamping, welding, painting and final assembly has accumulated rich data. These data are the basic resources for the industrial APP to play a role, and also the necessary conditions for enterprises to tap the potential of the industrial APP. The development of industrial APP in the automobile manufacturing process can be roughly summarized into three stages: data preparation, model development, and software packaging. At the data preparation stage, the target data needs to be obtained via the device networking and edge computing. The model development phase mainly establishes industrial mechanism models and big data analysis models. Finally, after the software packaging, the industrial APP is formed and provides the target functions such as state perception, real-time analysis, scientific decision-making, and precise execution. The typical process of the development of the automotive industry APP in the manufacturing link is shown in Figure 6.

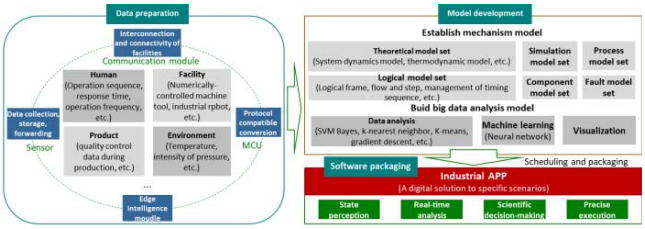


Figure 6. The typical process of the development of the automotive industry APP in the manufacturing link

## VI. CONCLUSION

The AIAPP is a key aspect of the digitalization of the automotive industry which will drive transformation in auto production models and business models. Mobility greatly expands the application scope of the AIAPP. The automotive industry APP also provides important opportunities for auto parts suppliers to achieve business expansion and transformation. Compared with daily APPs, the development of AIAPP faces a series of specific difficulties, like lack of standards, limited application scope, the need for cross-domain technology integration, difficulties in knowledge sharing, and high operation and maintenance costs. The development of AIAPP generally requires a reasonable division of labor and efficient cooperation among government departments, industry organizations, OEMs, parts suppliers, software companies, and research institutes. The development of AIAPP also needs the in-depth collaboration of automotive technicians and software technicians. The manufacturing link is a great breakthrough and entry point for the development of AIAPP. Forming a reliable information security and intellectual property protection mechanism is a prerequisite for the development and application of AIAPP. It is the key to promote rapid development of AIAPP and create an ecosystem that benefits both companies and individuals.

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