

# Research on New Mode and Business Model of Manufacturing Led by New-Generation Artificial Intelligence Technology

Study Group for Research on *New Mode and Business Model of Manufacturing Led by New-Generation Artificial Intelligence Technology*

**Abstract:** Because of the new-generation artificial intelligence (AI) technology, the production technology, organization mode, and competitive strategy of the manufacturing industry are facing major changes. This provides opportunities for the formation of new modes and business models for the manufacturing industry. Consequently, these are being generated by the intelligent services and emerging in practice in the manufacturing industry. Focusing on the new modes and business models generated by the implementation of intelligent services, this study analyzes their development trends, typical types, and supporting and key technologies for the AI technology. It also proposes the development guidelines, goals, and approaches for these new modes and business models. According to the basis and present situation of manufacturing in China, remote operations and maintenance service as well as mass customization service are selected as examples and the development directions, goals, and policy suggestions for two business models in related fields are proposed.

**Keywords:** artificial intelligence; manufacturing industry; new mode; new business model

## 1 Introduction

Because of the new-generation artificial intelligence (AI) technology, the manufacturing technology, production organization modes, business management methods, and competitive strategies are facing major adjustments that enable the formation and development of new modes and new business models for the manufacturing industry. The new-generation AI technology is driving the manufacturing industry to continue to find new modes and new business models, which are formed by the implementation of intelligent services.

The new-generation AI technology is leading to the cultivation and development of new modes and new business models of the manufacturing industry, which is transforming the difference between the insufficient and unbalanced demand and supply in the new era into an opportunity to promote the development of high-quality manufacturing industry. Thus, this is redefining the

competitive advantage of the manufacturing industry of China, which will affect it in the new era significantly.

## 2 AI technology leading manufacturing industry to develop new modes and new business models

The current mainstream production mode in the manufacturing industry was formed in the early 20th century marked by the assembly line production. It effectively increases the labor productivity and reduces the production costs through assembly lines and a distinct division of labor, thus forming a structure of “large-scale production and consumption.”

In this mode, the enterprise competition strategies are primarily product diversification and cost control. Regardless of the competition strategies, production and supply lack sufficient flexibility. Limited by the standardized production processes, it is difficult to satisfy the increasing individualized needs of the

**Received date:** June 20, 2018; **Revised date:** July 17, 2018

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**Funding program:** CAE Advisory Project “Intelligent Manufacturing Led by New-Generation Artificial Intelligence” (2017-ZD-08-03)

**Chinese version:** Strategic Study of CAE 2018, 20 (4): 066–072

**Cited item:** Study Group for Research on New Mode and Business Model of Manufacturing Led by New-Generation Artificial Intelligence Technology. Research on New Mode and Business Model of Manufacturing Led by New-Generation Artificial Intelligence Technology. *Strategic Study of CAE*, <https://doi.org/10.15302/J-SSCAE-2018.04.011>

consumers with precision. With the upgradation of consumption, the necessity and urgency of improving the quality of supply in the manufacturing industry are increasing.

### 2.1 Transformations of manufacturing industry led by new-generation AI technology

AI technology underwent a technological breakthrough and large-scale application stage in the 21st century [1].

The driving force for the development of AI primarily arises from four aspects: (i) data, i.e., the data foundation provided by big data, Internet of Things (IoT), cloud computing, and other technologies; (ii) machine-learning algorithms, which have made major breakthroughs; (iii) powerful computing power represented by the graphics processor units (GPU); and (iv) the acceptance and recognition of AI technology by the entire society. Because of these factors, the application of AI technology has developed rapidly in recent years.

The integration of the new-generation AI technology and manufacturing industry is going to introduce new opportunities for efficiency improvement and value creation in the manufacturing industry [2]. First, it allows products to become intelligent and networked, and the “Hardware + Software + Network interconnection” is gradually becoming the primary component of products. Second, it encourages the transformation of the production and management processes into intelligent ones. Digital-networked and intelligent internal manufacturing processes and the interconnected machines and data information can provide support for optimization of decisions. Third, it promotes a networked collaborative development of the R&D design. This not only improves the efficiency and shortens the design cycle for R&D but also enables the customers to participate in online design for integrating their personalized requirements through the network. Fourth, it promotes organizational changes in the enterprises. Different levels of data and information can be transmitted through a high-speed network conveniently. Therefore, the enterprise organization becomes levelled. Finally, it promotes the transformation of manufacturing enterprises to services. Enterprises can obtain consumer demand through the Internet in a timely manner, allowing them to achieve service-oriented manufacturing. Thus, service models such as “on-demand customization” and “network customization” will become more common.

### 2.2 Evolution trends of innovations of manufacturing modes and businesses models

Under the guidance of AI technology, the manufacturing mode in general has exhibited a certain evolution trend [3]: First, the rigid production system has been transformed into a reconfigurable flexible production system, and the customer demand management capability has become increasingly important with the core of the manufacturing industry shifting from products

toward customers. There has followed a shift from large-scale production to large-scale customized production (services). The producer-led economic models are shifting to consumer-led economic models. The importance of the competitive strategy in which enterprises rely on the economies of scale to reduce costs has declined, being replaced with satisfying consumer-personalized demand. Subsequently, the internal organizational structure of enterprises has flattened and the added value of the data elements has increased. More companies have changed from providing a single product to providing an integrated solution to respond to the customer needs rapidly and accurately and are saving decision-making time by reducing the organizational hierarchy. Enterprises are also emphasizing more on data collection, analysis, and evaluation. Factory manufacturing has transformed into socialized manufacturing. Production capacity in some industries has demonstrated trends of decentralization. “Socialized manufacturing” has emerged, thereby enabling product development, design, screening, and improvement by online communication. In some areas, “online factories” have been created to provide manufacturing and production services for online designers and users. The decentralization of production the capacity is conducive to alleviating the problem caused by its concentration and surplus.

## 3 Types and key supporting technologies of new modes and new business models

Under the guidance of the new-generation AI technology, the manufacturing industry has evolved from focusing on mass production to being customer demand-oriented. The premise that cost advantages are maintained by large-scale production results in a production model that satisfies individual needs. As production models continue to evolve, some new modes have emerged gradually. They primarily include digital manufacturing, networked collaborative manufacturing, new-generation AI manufacturing, large-scale customized production services, “cloud platform plus” manufacturing, remote operation and maintenance services, e-commerce, and software-defined manufacturing. The outstanding characteristic of the new business models is service-oriented manufacturing.

### 3.1 Typical types of new modes

#### 3.1.1 Digital manufacturing

A cyber-physical system (CPS) realizes the integration of the sensor and control data from the factory/workshop with the information system of the enterprises, allowing the transmission of production big data to a cloud computing data center for storage, analysis, decision-making, and production guidance.

#### 3.1.2 Networked collaborative manufacturing

Based on the advancement of the network technology,

manufacturing technology, and other related technologies, a network-based manufacturing system for specific needs is constructed. Therefore, the constraints of space are defied by the scope and modes of the production and operation, vertical integration of each link within an enterprise is realized, and collaborative manufacturing is enabled by the “horizontal integration” of the upstream and downstream of the supply chain.

### 3.1.3 New-generation AI manufacturing

Emerging technologies such as new-generation AI, internet communication, precision sensors, and global positioning system are applied jointly to make products such as automobiles, construction machinery, and agricultural machinery intelligent.

### 3.1.4 Large-scale customized production service [4]

Design and production are made more flexible to form a flexible, highly efficient, and large-scale production model that satisfies individual needs. It strengthens the connection and collaboration of all the links in the supply chain and improves the design, production, warehousing, distribution, and sales efficiencies.

### 3.1.5 “Cloud platform plus” manufacturing

Through the establishment of a cloud platform, joint product design and manufacturing can be achieved worldwide through the Internet. The comprehensive advantages of the industry, regional core enterprises, or enterprise groups allow agile and rapid response to market demand, thus improving the utilization of the global manufacturing resources.

### 3.1.6 Remote operation and maintenance service

Technical approaches such as sensing, communication, and big data analysis are employed. Through an equipment remote operation and maintenance platform, the key parameters of the production process and equipment can be monitored in real time, thus enabling timely alarms in case of failure.

### 3.1.7 E-commerce

With the help of the Internet and browser/server method, buyers and sellers do not have to meet in person to perform various business activities or relevant comprehensive service activities. Commerce can be generally divided into the following: agents–businesses–consumers (ABC), business-to-business (B2B), business-to-consumer (B2C), consumer-to-consumer (C2C), business-to-manufacturer (B2M), manufacturer-to-consumer (M2C), business-to-administration (B2A), consumer-to-administration (C2A), and online-to-offline (O2O) [5].

### 3.1.8 Software-defined manufacturing

With the development of cloud computing, IoT, big data, and AI, more Internet companies have become members of the manufacturing IT ecosystem, with cloud computing, big data, and O2O platforms serving as a point of entry for traditional

manufacturing companies. Thus, this provides manufacturing companies with collaborative, customized, and platform-based manufacturing services.

## 3.2 Service-oriented manufacturing as new business models

To gain competitive advantages, manufacturing companies have shifted the center of their value chain from manufacturing to services. More manufacturing companies are developing and evolving. They are no longer production- and product-oriented but “products and services”-oriented. They focus on the entire life cycle of products, and the proportion of “services” in the manufacturing value chain is increasing [6].

## 3.3 Key and supporting technologies for new modes and new business models

The groundbreaking development of the new-generation AI technology renders it a key technology for supporting the development of new modes and new business models. The development of the new-generation AI technology is based on digitization and networking and has evolved through revolutionary advances in technical fields such as big data mining, algorithms, and computing power and through its wide application in the manufacturing industry. Hence, the new modes and new business models have evolved gradually. The continuous development of many key technologies is the technical basis and important support for the continuous evolution of new modes and new business models.

### 3.3.1 Key technologies

(1) Construction of multisource cross-media heterogeneous databases. This involves heterogeneously integrating products, use environments, solutions, and production process databases and developing an online intelligent measurement system for customer data and online collaboration platform for customer requirements. These infrastructures can construct customer data, design data, virtual manufacturing data, and production data in the cloud, providing the basis for the operation of neural networks and deep-learning algorithms.

(2) Construction of a mining system for the design needs characteristics based on big data. First, the source information, basic information, personalized demand information, and customized product service information are collected from customers. These are then matched with the heterogeneous databases using various intelligent analysis techniques such as machine-learning algorithms, deep-learning models, three-dimensional model recognition, and product usage environment model matching. Therefore, deep data mining can be achieved, thus enabling intelligent solution recommendation, intelligent optimization of product design, and intelligent raw material procurement forecast.

(3) Virtual experience system and virtual manufacturing. The virtual simulation of design solutions is implemented rapidly using various virtual reality (VR) technologies, cloud rendering platforms, and VR interactive experience technologies to achieve customer product experience during the design phase. Using different scheduling models and solving algorithms, orders for different materials and different types of customized products are divided rapidly and subsequently organized reasonably into batches to implement order management and intelligent scheduling in a virtual manufacturing system.

(4) Construction of a system for automatic acquisition, production management, and coordination optimization of the entire manufacturing process. Information of the production process, production plan, production equipment, and quality analysis can be controlled in real time by using micro/nano sensors, bar code labeling, and other methods during flexible multiplexing manufacturing for large-scale customized products. It can optimize warehousing, equipment, quality, logistics management, and sales, thus completing the data feedback on the R&D design process and achieving a collaborative optimization of the entire process.

### 3.3.2 Supporting technologies

(1) Data mining technology: Data mining technology is used to screen, classify, analyze, and verify the collected information to ensure that the equipment abnormalities are identified rapidly when an equipment failure occurs and that the fault location and fault mechanism are determined accurately.

(2) Sensor technology: It is the basis for the realization of remote monitoring as well as remote operation and maintenance technology. The monitoring accuracy and data transmission efficiency affect the accuracy and response speed of remote operation and maintenance directly.

(3) Embedded monitoring system: An embedded monitoring system adopts the client/server mode. An embedded Web server is installed into devices, enabling them to interconnect through the Internet. It implements network management functions in the monitoring center, allowing users to remotely monitor, manage, and control devices through browsers.

(4) Fault prediction algorithm: It is the core technology of the predictive maintenance of equipment. By the prediction of the equipment status, it provides the development trend analysis of the equipment status and early fault warning. Thus, it enables the operation and maintenance personnel to perform equipment operation and maintenance with a clear target and avoids sudden failure and consequent equipment downtime.

(5) Machine vision technology: Machine vision technology is important in AI technology. The computer simulates the human vision. After acquiring the image of the target object, the information in the image is analyzed, processed, and understood through an intelligent system. Moreover, the device is monitored and controlled according to the processing result, thereby realiz-

ing intelligent operation and maintenance.

(6) Machine-learning and AI technology: The machine-learning technology allows machines to manage a wide variety of devices of different types and environments, so that the machines can obtain knowledge and experience similar to the users. This allows equipment operation and maintenance to be extended to the various different equipment and environments used in all types of industries, instead of being limited to a certain type of equipment. AI technology enables equipment monitoring and the maintenance system to make reasonable determinations based on the monitored equipment information, thus providing fault prediction solutions and fault repair proposals.

## 4 Pioneers of new modes and new business models

According to research, the manufacturing enterprises of China, particularly equipment manufacturing enterprises, have performed remote operation and maintenance services on equipment with high unit value. Moreover, they have gained some valuable experiences and good results for effectively ensuring equipment safety and stability and providing services to customers. Table 1 lists the typical practices of the remote operation and maintenance services of some enterprises. All the enterprises that perform remote operation and maintenance services possess a digital manufacturing foundation and have already accumulated enormous data. They are attempting to use AI technology to solve the problem of data processing and generation of algorithms for knowledge formation and application. The rapid spread of this practice has formed new production modes and new business models. Similarly, in large-scale customized production, some process-oriented and semi-process industrial enterprises, such as consumer goods companies and clothing and furniture companies, have not only satisfied the market demand for individualization by effective customized production based on digital manufacturing but also reduced the costs effectively. This enables products to satisfy the quality and speed requirements of individual needs at a low cost by mass production. The application cases are presented in Table 2 [7].

## 5 Development objectives and paths of new modes and new business models

The development of new modes and new business models of China led by the new-generation AI should follow a strategic approach characterized by openness, integration, sharing, and innovation to achieve the transformation and upgradation of the manufacturing industry and advance to the front ranks of manufacturing powers.

### 5.1 Development goals

The development of new modes and new business models

**Table 1.** Typical practices of remote operation and maintenance services.

Typical company	Primary practice
CRRC Co., Ltd.	Rail transit equipment fault prediction and health management
FiberHome Telecommunication Technologies Co., Ltd.	Vehicle equipment operation health assessment, intelligent fault diagnosis, risk warning
Shenzhen Huichuan Technology Co., Ltd.	Remote tuning parameter curve combined with on-site maintenance, intelligent identification of equipment problems, improved maintenance response speed, enhanced spare parts, and predictive diagnostic capabilities
Goldwind Technology Co., Ltd.	Wind turbine intelligent operation and maintenance, lifespan prediction, and pre-warning of wind turbine failure
Shenyang Blower Group Co., Ltd.	Remote real-time monitoring and control of the unit, providing instant personalized “nanny” services based on user needs
China Eastern Airlines Co., Ltd. General Motors	Remote diagnosis and maintenance of aircraft engines, prompt reminders to airlines to diagnose and repair possible faults, and propose customized maintenance advice to airlines for different engines

**Table 2.** Typical practices of large-scale customized production companies.

Typical company	Primary practice
Weishang Furniture Manufacturing Co., Ltd.	Through a networked collaborative design cloud platform and virtual reality network cloud computing design service system the production efficiency is increased to 8–10 times the traditional mode; the material utilization rate is 8% higher than the industry average; the error rate is reduced from the industry average of 5%–8% to below 1%
Qingdao Haier Co., Ltd.	Support consumers to customize the appearance, size, and function of the required products through the Internet; produce home appliances for consumers to choose from according to the product style preferences of the consumer; functions, price ranges, and other demand characteristics collected through the big data platform provided by the e-commerce partners
Qingdao Kutesmart Co.	Use computer fitting system, remote fitting system, entire body scanning technology, and clothing computer-aided design / computer-aided manufacturing (CAD / CAM) system to overcome the limits of organization, national boundaries, language, and support the individual designs of global customers, thus achieving global customization. Through the deep-learning platform of the new-generation AI technology provide automatic matching of the layout, style, process, and bill of materials to achieve intelligitization of research and development, design, production scheduling, and implementation.

will become the development strategy of the Chinese industry. It is recommended to divide this into three steps: short-term breakthrough targets (by 2020), medium-term development targets (by 2025), and medium- and long-term strategic breakthrough targets (by 2030). These constitute a dot-and-face combination strategy of AI technology for a wide range of high-level applications, where the dots are the significant breakthroughs.

By 2020, in areas such as rail transit, wind power equipment, aero-engines, new-generation helicopters, construction machinery, general-purpose machinery, and elevators, the remote operation and maintenance service industry should start to explore the application of AI technology, data mining, and construction of self-learning knowledge base. This will help in realizing highly efficient, accurate, and real-time remote self-diagnosis. Standardization of the remote operation and maintenance data should be conducted in China. Numerous industry-specific remote operation and maintenance service data centers should be established according to the different characteristics of the

industry. An operation and maintenance service system based on the industrial Internet should be constructed to ensure the high quality, efficiency, and safety of major equipment manufacturing and operation.

For home appliances, furniture, clothing, and other industries, the application of AI technology should be strengthened. First, large-scale customized platforms should be created for the furniture industry, home appliance industry, and clothing industry. Subsequently, intelligent R&D design platforms should be completed and pilot demonstration of intelligent scheduling based on a virtual manufacturing system should be performed.

By 2025, the application of AI technology should be promoted in two key areas: remote operation and maintenance services, and large-scale customized production services. The technology should reach the international leading level and be demonstrated in other fields. In the home appliance industry, furniture industry, and clothing industry, it is needed to promote AI technology comprehensively. This key technology should reach the international leading level, and it should be strived to conduct pilot

projects in the automotive industry.

By 2030, the overall application of AI technology in achieving intelligent manufacturing is expected, with the technology reaching the international advanced level and international leading level in some areas.

## 5.2 Development path

**Coupling.** “Vertical integration” of the internal R&D, design, manufacturing, marketing, and service departments is strengthened. “Horizontal integration” of the enterprises is promoted. Rapid resource allocation and efficient integration are realized, and inter-enterprise information sharing and business collaboration are achieved in terms of product development, manufacturing, and operation management.

**Complexation.** Organic integration of the existing manufacturing technologies and information technology, production organization modes, and business models is strengthened to eventually form a complex and diversified innovation model eventually.

**Parallelization.** Multistage parallel advancement is emphasized to adapt to the current uneven development of the manufacturing industry of China. Moreover, a full-value chain business model and mode innovation are sought in high-end manufacturing, and micro-innovation and progressive innovation of some modes and business models are sought in the low-end manufacturing industry.

**Evolution.** Because the introduction of information technology is a gradual process, focusing on the gradual development characteristics of the novelty of business models and modes, evolution related to the consumer side is first initiated. This is followed by the dynamic evolution from parts to the whole and from quantitative to qualitative. Finally, a new manufacturing mode and business models are constructed.

**Integration.** System innovation is performed at the ecological level of the industry, innovation in resource reconstruction based on the value chain is implemented, and the value network is relied on for innovation in system integration. By collecting and integrating various resources, enterprises are promoted from single participants to industry definers, platform builders, and system integrators.

## 6 Key application areas for new modes and new business models

Based on the development foundation and current situation of the Chinese industrial sector, among the many new modes and new business models already available for digital manufacturing and networked manufacturing capabilities, the remote operation and maintenance services and large-scale customization services are expected to achieve breakthroughs by the application of the new-generation AI technology.

### 6.1 Remote operation and maintenance service

Based on the requirements of the urgent demand for AI technology, good foundation for the application of technology, and high development efficiency, breakthroughs may be achieved in the following areas: rail transit, aero engines, wind power equipment, construction machinery, general-purpose rotating machinery, thermal and nuclear power equipment, and elevators.

**Rail transit (high-speed rail):** The prediction and health management system (PHM) can be developed and applied to perform remote operation and maintenance service support with the new-generation AI technology. The labor-intensive operation and maintenance service mode can be changed by reducing the labor demand in the operation and maintenance services while ensuring the safety of train operation and guaranteeing the train equipment exports.

**Aero engine:** By the promotion of remote operation and maintenance in the civil aviation industry as an entry point, the domestic airlines and engine suppliers can cooperate to develop a remote diagnosis platform. Based on the existing monitoring and diagnosis and data accumulation, the new-generation AI technology should be introduced into the remote operation and maintenance system for aero engines. It should be further extended to the military aviation engine field to satisfy the major needs of intelligent operation, maintenance, management, operational command, and logistics support in the future.

**Wind power equipment:** Based on the existing foundation for wind power monitoring and diagnosis, vibration monitoring system, manufacturing environment supervisory control and data acquisition (SCADA) system, and big data accumulation, the new-generation AI technology can be used for big data information mining. The vibration monitoring system can be integrated with a SCADA system effectively to realize the intelligent operation, maintenance, and lifespan prediction of wind turbines.

**Construction machinery:** The current maintenance practice of the construction machinery in China, which is post the failure repair and regular maintenance, can be changed. The new-generation AI technology can be introduced in the remote operation and maintenance service of the construction machinery to improve the accuracy, timeliness, and monitoring range significantly and reduce the cost of manual maintenance. This is an exploration of the use of the construction machinery operational data to monitor the domestic and international economic operation.

**General rotating machinery:** Remote monitoring of equipment with strong versatility and good database for blowers, compressors, pumps, valves, and others in petrochemical and coal chemical enterprises can help to realize intelligent remote operation and maintenance and reduce operational risks and equipment maintenance costs. For equipment with good resulting performance, intelligent remote operation and maintenance should be continued and promoted.

Thermal and nuclear power equipment: The new-generation AI technology can be introduced in the relevant equipment to realize entire-life-cycle and real-time dynamic monitoring and early warning, enhance the control over pollutant discharge and safe operation, and increase confidence of the public about safety.

Elevator: The new-generation AI technology can be extensively applied in the elevator industry, alleviating the shortage of elevator maintenance personnel. This will improve the response speed of elevator maintenance and enhance the ability of spare part preparation and predictive diagnosis.

By 2020, the above-mentioned seven industries may be explored and seven remote operation and maintenance centers may be built. By 2025, these may be promoted widely and the technology may be expected to reach the international leading level.

## 6.2 Mass customization service

The new-generation AI technology provides the technical foundation for mass customization services. Through information perception and data accumulation as well as big data-driven system interconnection, the application of AI technology in customized production is realized by self-perception, self-learning, and self-decision. The new-generation AI technology is expected to achieve breakthroughs in three areas: home appliance industry, furniture industry, and clothing industry.

Home appliance industry: A large-scale customized service platform can be established to allow the active participation of users. This will integrate users with the interconnected factories and realizes the integration of production and sales. Production experiences will be solidified through the platform, whereas AI technology will be used to promote the digitization and flexibility of the production system. This will realize highly precise and efficient production of customized products, improving the non-storage rate and shortening the production cycle.

Furniture industry: Targeting the characteristics of multi-variety and small-batch production pattern of personalized products, AI technology can assist the development of customization business, shorten the design cycle, and rapidly develop products that satisfy the market changes and needs. This will help to reduce the costs, increase the production efficiency, increase the material utilization by 10%, and reduce the error rates to less than 1%.

Clothing industry: Consumer demand data can be used to drive the vertical integration of the flows of technology, capitals, talents and logistics. Processes can be re-engineered to make them fully driven by data. This will make the entire process of completing all the customization services successfully based on one single set of consumer data and satisfaction of the personalized needs of global orders within seven working days. Business models can be promoted from dots to faces to upgrade and trans-

form traditional industries.

By 2020, these three industries may be explored and customized service platforms built for the furniture industry, home appliance industry, and apparel industry as a first step. By 2025, the platforms may be fully promoted in these three industries. China can be expected to possess world leading technology by that time. It should also strive to explore and start pilot projects in the automotive industry.

## 7 Policy recommendations

(1) The application of the new-generation AI technology in remote operation and maintenance services and mass customization should be promoted widely as these areas are the two key directions with the highest application value for service-oriented manufacturing.

(2) The process of incorporating AI technology education into the higher education system of China should be accelerated. It is known that the United Kingdom has already introduced the knowledge learning of AI technology in high school education, whereas in the higher education system, AI has been a designated discipline for a long time.

(3) Network security should be strengthened. As China opens up gradually, its social security, financial security, energy security, information security, and major engineering security must be further protected. The local governments at all levels are recommended to clarify the responsibility of the management at the earliest and formulate the access standards for foreign investments into the AI market in China. Furthermore, the government can initiate the standards, laws, and regulations on AI data transmission, data property rights, and data privacy to protect the healthy development of AI technology in China.

(4) The standardization of the application of new-generation AI technology in products and services should be strengthened. It is recommended that the intelligent manufacturing-related standard test/verification projects be inclined to the group standards jointly declared by intermediaries and enterprises so that the intelligent manufacturing standard system becomes more practical.

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