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Manufacturing Optimization and Automation (MOA): New Tool of Smart Manufacturing

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I. Overview

The COVID-19 pandemic has sped up the development of smart manufacturing, and industrial internet, big data analysis, artificial intelligence and other technologies are deeply integrated with advanced manufacturing technologies. It is predicted that the global smart manufacturing market will reach USD576.2 billion in 2028, and the compound annual growth rate (CAGR) from 2021 to 2028 is expected to reach 12.7%.

Smart manufacturing enters the critical "window of opportunity", and demonstrates the trends of automation, digitalization, large-scale development, ecosystem collaboration and green development. At the same time, manufacturing enterprises are subject to multiple challenges on the road of intelligent transition: Improving agility to cope with labor shortage and supply chain instability, shorten product launching cycle while safeguarding and improving product quality, build the integration capability of technologies to deploy smart factories, realize upstream and downstream connection and coordination, and meet ever-strict ESG compliance requirements.

In the face of the abovementioned challenges, manufacturing enterprises diligently pursue for the optimization of product design, production process and supply chain. When digital technology and digital governance evolve into the necessary tools for manufacturing enterprises to manage future factories, understand data and maintain their competitive edge, the concept of manufacturing optimization and automation (MOA) emerges at the right moment. Based on the original optimization concept of the manufacturing industry, MOA of the manufacturing industry suggested herein puts more emphasis on looking for the best alternative based on data analysis and insight, and on achieving precise execution by virtue of digital twin, deep learning and intelligent equipment. Its core lies in more efficient and sustainable optimization capability free from human intervention.

MOA not only can cut back on manpower, energy consumption and equipment operation and maintenance costs, but also has updated the definition and framework of commercial value. We can reflect on the commercial value and opportunity developed by MOA from the three perspectives of financial indicators, operational indicators and performance improvement. By combining the challenges faced by the manufacturing industry and the analysis from the three perspectives mentioned above, we can find that the commercial value of MOA can be manifested by efficiency optimization, quality optimization, cost optimization, supply chain optimization and brand optimization.

The report also discussed a set of technologies empowering MOA, and demonstrated how the optimized and innovative solutions based on these technologies create value: When the sensor of the Internet of Things (IoT) collects data, industrial knowledge and artificial intelligence algorithm can be utilized to comprehensively analyze big data sets and use rich digital environment, so as to achieve the optimization of efficiency, cost, quality, supply chain and brand of the manufacturing industry.

II. Smart Manufacturing Enters the Critical "Window of Opportunity"

Manufacturers had already started to adopt various technologies to transit to smart manufacturing before the outbreak of the pandemic. But undoubtedly, the trend has significantly accelerated due to the impacts of the pandemic. The post-pandemic era signifies that for a long time to go, the circulation of manpower, resource and goods will still be subject to limitations, spurring many manufacturers to speed up automated and intelligent arrangement. Many industry insiders believe that the pandemic has brought the industrial automation course five and even ten years forward.

On the other hand, smart manufacturing—the core of Industry 4.0—enters the current critical "window of opportunity" featuring deepening application and comprehensive promotion after experiencing the preliminary stage of concept popularization and the stage of pilot and demonstration. Alongside the deep integration of industrial internet, 5G, big data, artificial intelligence and other technologies with advanced manufacturing technologies, smart manufacturing demonstrates the trends of automation, digitalization, integration and ecologicalization. Meanwhile, the development of smart manufacturing also faces supply chain shock and labor shortage challenges, as well as business difficulties not deeply involved in the past, such as flexible production, process optimization and ESG compliance.
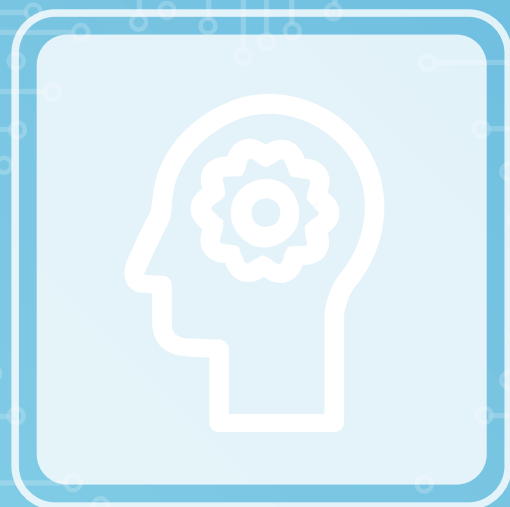
2.1 Developmental Stages and Core of Industry 4.0

Industry 4.0 stands for the fourth wave of industrial revolution. Different from the previous three industrial revolutions, its fundamental change lies in the organic integration of the production system by virtue of the integration between physical technologies and digital technologies, thus achieving the Intelligentization of the production process and greatly lifting human productivity. Deutsche Akademie der Technikwissenschaften (acatech) presents the Industry 4.0 Maturity Model, and divides the development of Industry 4.0 into six stages, including computerization, connectivity, visualization, transparency, predictability and self-adaption (Chart 1).

Chart 1: Industry 4.0 Maturity Model and Corresponding Stages of Smart Manufacturing
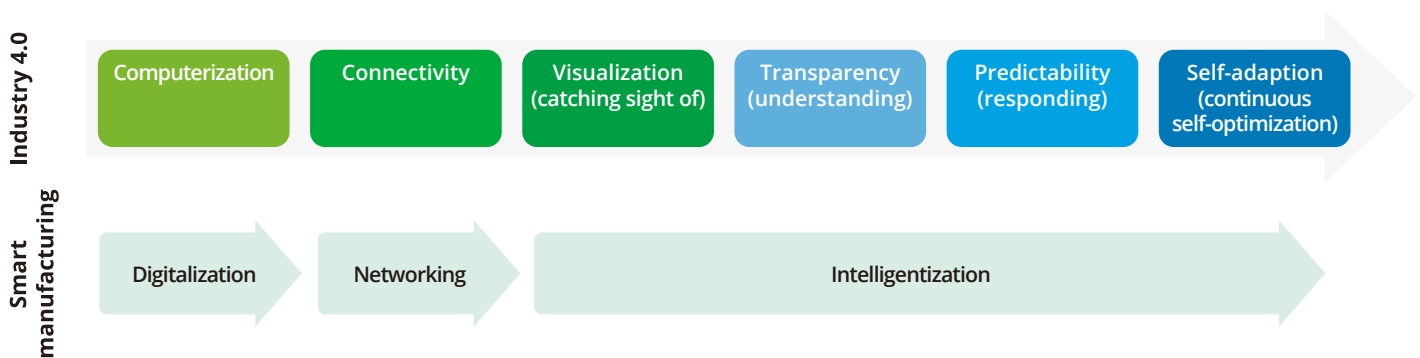
Source: acatech, Deloitte Research

- **Stage 1:** Computerization. Information-based and automated systems are set up within industrial enterprises to deal with repetitive work efficiently via computer. But different systems are independently run within the enterprises, without achieving interconnectivity.

- **Stage 2:** Connectivity. Isolated computerized equipment and information system are interconnected. Now, enterprises realize the connectivity and interoperability of the operating technology (OT) system and information system (IT) by adding sensor, API and the like.

- **Stage 3:** Visualization. Enterprises acquire mass real-time data via fieldbus, sensor and other IoT technologies, establish the "digital twin" of factory, and catch sight of various production information of the factory, so as to make management decisions.

- **Stage 4:** Transparency. Big data analysis tool and machine learning are used to analyze various issues of the production process, and explore the reasons of the events, so as to achieve the transparency of the production process.

- **Stage 5:** Predictability. Digital twin is projected to the future, so as to simulate different scenarios and predict future development, make decisions in good time and take proper measures.

- **Stage 6:** Self-adaption. The status Industry 4.0 ultimately reaches is that when enterprises can understand the status quo, analyze reasons and predict the future, they can automatically process the things that will happen in the future based on the production process, and achieve autonomous response via continuous automation, so as to adapt to the ever-changing business environment.

Driven by the wave of Industry 4.0, the manufacturing industry once again becomes the impetus of improving productivity and mobilizing economic growth, and develops towards Intelligentization gradually through digital and network-based upgrading. A perfect smart manufacturing system will be well-positioned to cover the value chain of the full product lifecycle, utilize advanced digital technologies and manufacturing technologies to achieve flexible and smart manufacturing process and service mode. Meanwhile, precise prediction can be made via the information acquired on a real-time basis, and continuous optimization can be achieved based on cost, resource consumption, availability and other indicators.

Smart manufacturing has also become a main direction of the manufacturing industry in various countries, manifested by the "National Strategic Plan for Advanced Manufacturing" proposed by the United States, Germany's "Industry 4.0 Strategy and Implementation Plan", Japan's "Value Chain Plan", and the China Manufacturing 2025

released by China in 2015. Despite the different focuses of different countries, the strategies all aim to promote industrial upgrading and industrial chain remodelling via new-generation technologies, and to seize the commanding height of the new-generation manufacturing industry.

2.2 Trends of Smart Manufacturing
The market value of global smart manufacturing stood at USD245.9 billion in 2021, which is predicted to reach USD576.2 billion by 2028. The CAGR from 2021 to 2028 is expected to amount to 12.7%. Major driving forces of the smart manufacturing market include the increasing popularization of Industry 4.0, more importance attached to industrial automation during the manufacturing process, increased participation of the government in support of industrial automation, more complicated supply chain and the surging demands for software systems reducing time and cost (Chart 2).

Chart 2: Size of Global Smart Manufacturing Market (USD100 Million)

2021-2028 CAGR: 12.7%

2019	2020	2021	2028E
2,159	2,257	2,459	5,762
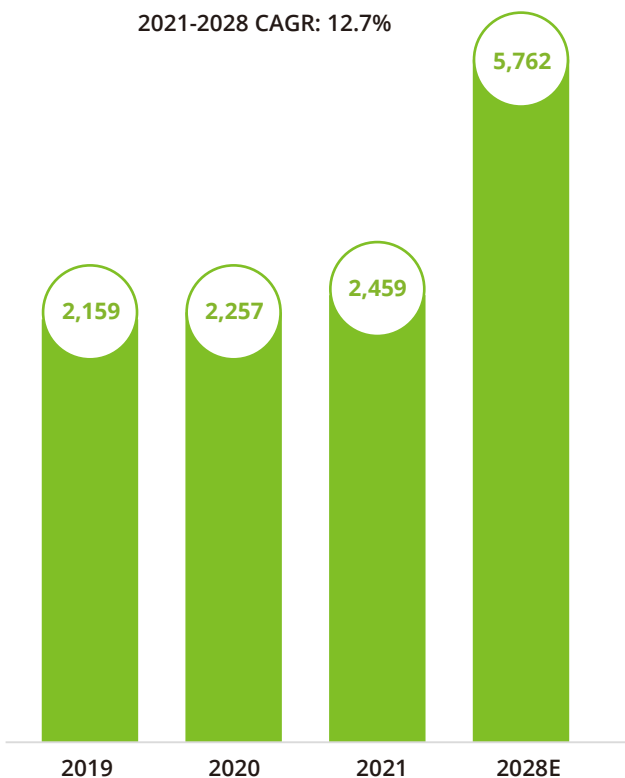
The pandemic incurs the reevaluation of the production process by the manufacturing industry, and promotes its digital transformation and smart manufacturing practices, such as adopting Intelligent quality control, replacement of manpower by automation, and digital transformation of the supply chain.

The deployment of smart manufacturing in the future will be mainly driven by the increase in real-time data analysis and application demands. The IoT and artificial intelligence become the major fields of investment in the large-scale deployment of smart manufacturing.

ESG requirements are elevated. For example, the application of ISO50001, the international standard for environmental management, is becoming evident, propelling the manufacturing industry to invest in ESG compliance and energy conservation and emission reduction strategies.

The Asia Pacific region leads global growth, and its driving forces mainly come from the demands for lifting the degree of industrial automation, the growing demands for optimizing productivity and lowering cost, and the support of governments of various regions for advancing smart manufacturing.

Source: Fortune Business Insights, Deloitte Research

As industrial internet, 5G, big data, artificial intelligence and other technologies get deeply integrated with advanced manufacturing technologies, and worldwide policies and investment push forward sustainable development, **smart manufacturing demonstrates the trends of automation, digitalization, large-scale development, ecosystem collaboration and green development** (Chart 3). New-generation smart manufacturing is characterized by the "learning" ability of the manufacturing system, and by applying deep learning, reinforcement learning and other technologies, the knowledge generation, acquisition, application and inheritance efficiency in the manufacturing field will undergo revolutionary changes. The ultimate goal of smart manufacturing is to achieve a zero-fault and predictive production system, and rapidly meet users' customized demands at a low cost in a careless production environment.

Chart 3: Trends of Smart Manufacturing

Automation
The manufacturing industry continuously pursues efficiency and cost optimization, and the pandemic speeds up the automatic upgrading of the manufacturing industry

Digitalization
Data supports the production and utilization of manufacturing knowledge, digital twin establishes the quasi-real-time contact between the physical world and the digital world, and digital security plays an increasingly prominent role

Large-scale development
Transforming from the use case of a minority of Intelligent factories to large-scale deployment of Intelligent factories

Ecologicalization
Forming the interconnectivity between the full industrial chain and the supply chain on the premise of guaranteeing digital security

Greenization
Intelligent technology and ESG support the sustainable development of the manufacturing industry and create value

Source: Deloitte Research

Automation: The manufacturing industry continuously pursues for efficiency and cost optimization, and the pandemic speeds up the automated upgrading of the manufacturing industry

Either out of the constant pursuit for efficiency improvement and cost reduction, or due to the impacts of the pandemic on staff turnover, the global manufacturing industry is definitely subject to the pressure of skill and labor shortage. Automation is the answer that helps manufacturers fill up skill gap, eliminate time-consuming process in the warehouse and improve product quality. Automation here refers to adding some hardware (such as manipulator, track, transport device, vision imaging and other devices) and programming of relevant hardware by reasonably planning production process, and processing rhythm and node action, so as to attain the goals of labor saving, quality stability and efficiency promotion. The future will be a world featuring man-machine collaboration, where robot and mankind coexist and collaborate in factories and warehouses. We have seen the ever-growing number of unmanned workshops and unmanned factories. Going forward, more manufacturers will invest in collaborative robots to undertake boring, dangerous and repetitive work so that people can concentrate on creative work. Such collaboration can improve efficiency, add to productivity and reduce cost. Under such expectation, the global market of collaborative robot is expected to grow from USD1.2 billion in 2021 to USD10.5 billion in 2027, with a CAGR of 43.4%[1].

Digitalization: Big data supports the generation and utilization of manufacturing knowledge, digital twin establishes the quasi-real-time contact between the physical world and the digital world, and digital security plays an increasingly prominent role

The relationship between big data and smart manufacturing can be summarized as follows: Mass data will be generated during the problem occurrence and settlement process in the manufacturing system. Analyzing and mining such data helps understand the generation process, impacts and solutions of the problems. After abstract modeling, the information will be transformed to knowledge, which will be used to identify, address and avoid problems. The core is to shift from relying on personal experience to relying on the invisible clues in data mining, so that manufacturing knowledge can be generated, utilized and inherited in a more efficient manner[2]. Digital twin is to dynamically showcase the previous and current behaviors or processes of a certain physical entity in a digital manner, which is to the benefit of improving corporate performance. Its real function is that it can comprehensively establish a quasi-real-time contact between the physical world and the digital world, so as to continuously create value for enterprises. Data has become a basic production factor, which is as important as physical capital and human capital. As increasing data are shared, made available to the public and subject to cross use, digital security plays an increasingly prominent role.

Large-scale development: Transforming from the use cases of a minority of intelligent factories to large-scale deployment of intelligent factories

Global "lighthouse" factories pointed to the possibility of large-scale smart manufacturing. Cloud computing and other basic technologies can realize computing power, visibility, large scale and high speed. 5G deployment may also be expanded alongside the progress of technology and use case in 2022. As more start-ups join, video analysis, artificial intelligence, network security, autonomous mobile robot and other technologies become more cost-effective. The way of Intelligent transformation of factories is changing from simplex equipment upgrading, software application and network laying to the execution of factory-wide system integration solution. According to the research findings of the 2021 survey of Deloitte on senior executives of the global manufacturing industry, 45% of the senior executives interviewed plan to improve operational efficiency by investing in the industrial IoT that connects machine and automated processes in 2022.
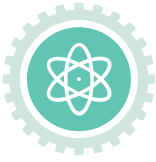
Ecosystem collaboration: Forming the interconnectivity between the full industrial chain and the supply chain on the premise of guaranteeing digital security

Under the context of smart manufacturing, ecosystem collaboration means connecting the upstream and downstream sectors of the supply chain on the basis of digitalization, integration and on the premise of guaranteeing digital security, thereby realizing interconnectivity across the whole industrial chain and achieving synergy. Open and interconnected platform will be established on this basis, which will connect all stakeholders and form an ecological system. The ecological system can bring higher output and flexibility to manufacturing enterprises. The success of the many-to-many friendship in the ecological system can benefit all participants of the system, so as to achieve the multi-win result. The survey of more than 850 senior executives of manufacturing enterprises worldwide launched by Deloitte and the Manufacturers Alliance for Productivity and Innovation (MAPI) shows that the probability that manufacturing enterprises in the ecological system benefit from the additional network and ability brought by their partners is more than two folds of other enterprises.

Greenization: Intelligent technologies and ESG support the sustainable development of the manufacturing industry and create value

The sustainable development of the manufacturing industry matters to all stakeholders. Undoubtedly, manufacturing enterprises need to create value for customers and shareholders, and also need to invest in employees, trade with suppliers fairly, and support their host communities. They may boost sustainable development with more resources and higher rigidness, enhance digital governance capacity, and adopt Intelligent technologies in a more proactive manner to reduce environmental impacts, and convey the value of their sustainable commercial practices, such as optimizing energy consumption and tracking, ensuring work safety and developing green products. The survey by Deloitte and MAPI indicates that 95% of the senior executives of the manufacturing industry interviewed predict that their investment in ESG in 2022 will exceed that in 2021.

2.3 Challenges of Manufacturing Enterprises

Chart 4: Challenges of Manufacturing Enterprises

Agility
Labor shortage and supply chain instability challenge enterprises to improve agility

High quality
Shortening product launching cycle while improving the product quality and the security of product lifecycle

Integration
The way of Intelligent transformation expands from single link to system integration solution across the factory, and needs to guarantee industrial data security and enhance the productization and system integration ability of the technology

Ecology establishment
Requirements for the connection and coordination between manufacturing enterprises and upstream and downstream sectors are elevated, and risks to the security of digital supply network are increased

Sustainability
ESG compliance requirements become stricter, but face information collection and analysis constraints

Source: Deloitte Research

Agility: Labor shortage and supply chain instability challenge enterprises to improve agility
Labor shortage resulting from the pandemic has exerted profound impacts, and the job vacancy of the manufacturing industry in 2021 in the US was more than two folds of that before the pandemic. It is estimated that there will be 2.1 million technical post vacancies in 2030. Talent scarcity has forced more manufacturers to consider elevating salary. Purchasing bottleneck and global logistics deadlock still remain as challenges, while cost pressure and inflation risk still exist. The prices of iron & steel, aluminum and other bulk commodities have rocketed due to shortage. Labor shortage and supply chain instability are reducing operational efficiency and profit, under which condition manufacturers must have the agility so that they can adapt to the rapid changes of things. Enterprises must possess correct technologies and processes to address manpower replacement, capacity improvement, abnormal halt prevention, inventory optimization and other business difficulties.

High quality: Improving the product quality and the security of product lifecycle
Industrial sectors have put forward increasingly high requirements for products, production process becomes more complex, product lifecycle appears ever-shorter, and energy consumption and safety requirements go stricter, all of which propose tests for product cost and quality. Challenges are also posed to the security of product lifecycle. The moves to cope with such challenges include manufacturing operable security devices by safely utilizing security software during product design and development, quickly mitigate and eliminate the effect of attacks during use, and guaranteeing industrial data security throughout the entire data lifecycle. In addition, in terms of regions, added value improvement of enterprises in the Asia Pacific region is particularly important for manufacturing enterprises in this region. Data shows that the gross profit margin of industrial enterprises listed on the American stock market is nearly double that of Chinese listed companies. A number of manufacturing enterprises in China, the largest manufacturing power, still concentrate in those parts with lower added value in the value chain.

Integration: The way of Intelligent transformation expands from single link to system integration solution across the factory

System solutions of Intelligent factories allow manufacturing enterprises to conduct comprehensive operation management and control, assist enterprises in aspects of big data analysis, decision-making board, risk warning, etc., such as improving the efficiency of the production work via production line design simulation and full lifecycle management. However, the technical difficulty of system solutions of Intelligent factories does not simply come from a certain technology. This also calls for the productization and system integration ability of the technology. Besides, the issues faced by the manufacturing industry are highly specialized and starkly different, and know-how of the manufacturing industry and the degree of plan customization possessed by technology providers need to meet the precise and personalized scenario demands of the manufacturing industry, so as to ultimately achieve the deployment optimization of Intelligent factories. Intelligent factories also require a high degree of security and resilience, which signifies higher requirements for the operability, reliability and integrity of the system, as well as the security of industrial data.

Ecosystem collaboration: Requirements for the connection and coordination between manufacturing enterprises and upstream and downstream sectors are elevated, and risks to the security of digital supply network are increased

Manufacturing enterprises increasingly tend to establish the data channel among upstream and downstream partners of multiple industrial chains that transcend organizational boundaries, thus achieving ecosystem coordination and optimal resource allocation. Take supply chain coordination as an example. Enterprises hope to acquire the exact supply-demand relationship, evaluate the impacts of supply fluctuation on real orders, and achieve resource allocation optimization by order analysis, all of which raised challenges to enterprises in data security and visualization of digital supply network, and supplier management.

Sustainability: ESG compliance requirements become stricter, but face information collection and analysis constraints

Take energy conservation and emission reduction as an example. Under the precondition that production and manufacturing are driven by data, how can enterprises find the link with high potential in carbon reduction by connecting the whole industry via artificial intelligence, digital twin and other technologies? As for energy consumption data, how can enterprises collect energy consumption data, conduct multi-dimensional energy consumption analysis and equipment efficiency analysis, and then achieve the real-time transparency of energy consumption data of enterprises? Meanwhile, by combining energy data with other system data, enterprises will enhance data governance capability, and tap into process, quality, production and other issues, which will enable them to conduct process optimization, preventive equipment maintenance and other work.

III. MOA: Technology Solutions Supporting Complex Optimization Tasks

Generally, the optimization of the manufacturing industry refers to finding the best alternative from many possibilities under the specific standards in the environment of the manufacturing industry, so as to realize faster and better output with fewer resources and wastes.

"Optimization" is not strange to manufacturing enterprises which have been diligently seeking for the methods to optimize product development, production process and supply chain. Traditional optimization often includes large one-off consulting activities, where expert teams may be invited to analyze enterprises' product development and manufacturing procedures and recommend the list of improvement opportunities. Currently, the deployment scope of digital transformation of factories has expanded, and digital analysis tools progress rapidly, allowing manufacturing enterprises to conduct MOA. Moreover, the scope of optimization is not merely limited to a single procedure; instead, it expands to the entire factory, and even transcends the complex supply chain.
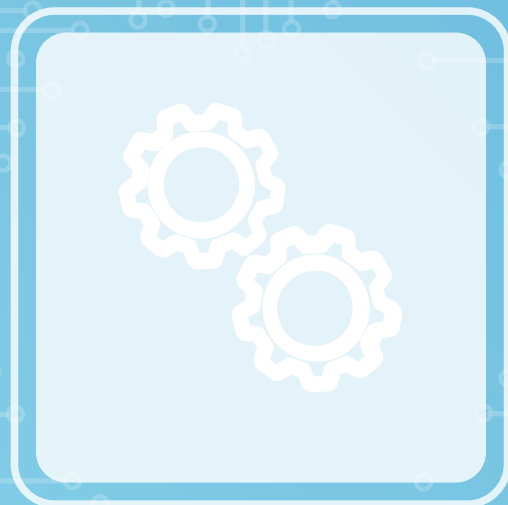
3.1 Conceptual Meaning of MOA

As shown in the chart of Industry 4.0 maturity in the opening part of the report, self-adaption or continuous MOA that it represents is the most mature stage of Industry 4.0, and also the ultimate goal of smart manufacturing. In the process of achieving self-adaption, Industry 4.0 definitely experiences vertical integration and horizontal integration. Vertical integration focuses more on the integration of internal equipment layer, control layer and workshop management layer of manufacturing enterprises, with a view to converting the data, events and information of the physical world to the digital world, and vice versa. Horizontal integration focuses more on the integration of terminals and users at all links of the full lifecycle, such as product research & development and design, production planning, production engineering, production execution and services, as well as the upstream and downstream coordination of the industrial chain.

Requirements of vertical integration:

- Planning, scheduling and operational tasks are interdependent, need integrated plan and address the questions of different tasks simultaneously;

- It is necessary to collect and process more and more data, so as to continuously provide feedback and support real-time optimization.

Requirements of horizontal integration:

- It needs those tools that can optimize scheduling, production, maintenance, logistics and other different tasks;

- It needs those tools that can optimize the entire supply chain.

The development of Industry 4.0 solution is related to task optimization, and the manufacturing industry faces higher flexibility and complexity, which means that the manufacturing industry needs to address multi-objective optimization problems that are more challenging. In addition to the features of interconnectivity, decentralized decision-making, data transparency and technical support, Industry 4.0 solutions also need to have continuous optimization performance.

On the basis of the original optimization concept, MOA of the manufacturing industry herein puts more emphasis on finding the best alternative based on data analysis and insight, and realizing precise execution by digital twin, deep learning, intelligent equipment and the like. Its core lies in the ability of more efficient and continuous optimization free from human intervention. It provides technical solutions for manufacturing enterprises to achieve multi-objective optimization: MOA helps precisely understand market and customer demands, recognize the relevance among parameters of various manufacturing links and find the best process parameter, schedule production in a flexible manner, predict and prevent supply suspension, inventory imbalance and other issues, tackle pain points in the product design and development, production and manufacturing, and supply chain management of the manufacturing industry, which, in turn, is reflected by the optimization of cost, efficiency, quality, supply chain, ESG governance and brand.

Chart 5: MOA—One of the Industry 4.0 Solutions
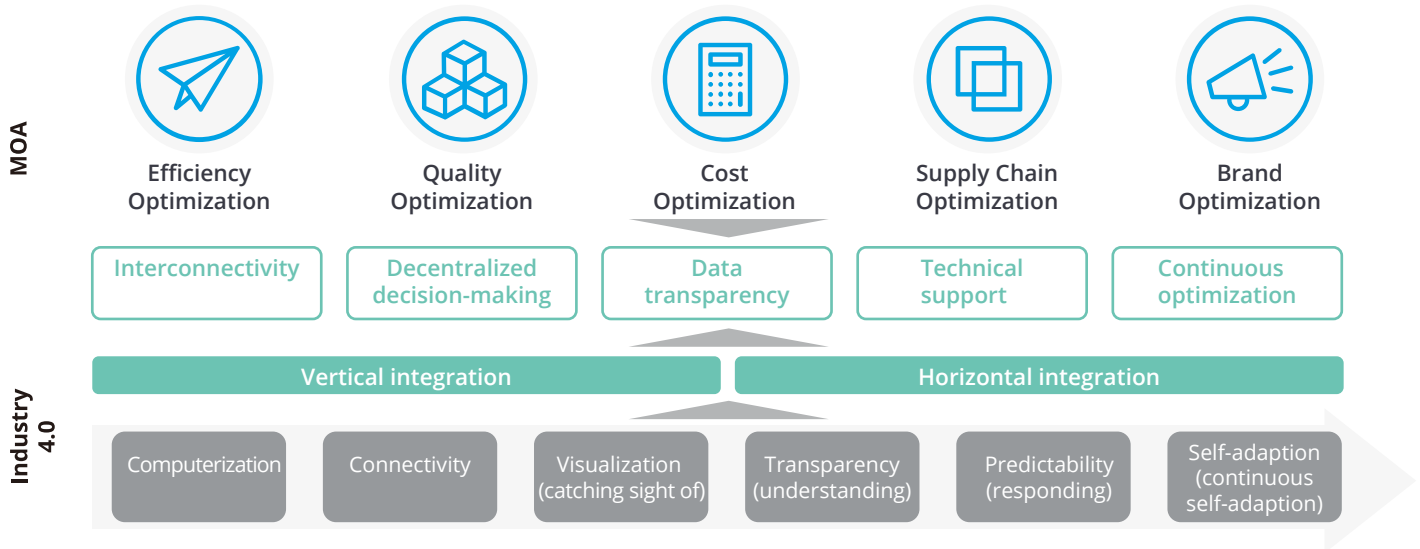
Source: Deloitte Research

3.2 Value Manifestation of MOA

MOA not only can cut back on labor, energy consumption, and equipment operation and maintenance costs, but also has updated the definition and framework of commercial value. We can reflect on the commercial value and opportunities developed by MOA from the following indicators (Chart 6).

Chart 6: Measurement Dimensions of the Value of MOA

	Financial indicators	The revenue, expenditure and asset of an enterprise maintained its operational balance. Reducing cost, improving asset efficiency, elevating the return on investment, reducing liabilities and expanding the sources of revenue have long been the objectives pursued by enterprises.
	Operational indicators	The core operational procedures of manufacturing enterprises include product lifecycle, equipment lifecycle and customer lifecycle. Currently, the optimization investment of most enterprises focuses on equipment lifecycle (such as equipment operation optimization, increase of utilization rate, etc.). As for customer lifecycle and product lifecycle, MOA not only can provide new analysis and performance, but also can help enterprises conduct product development, process improvement, product tracking, customer service provision, supply chain coordination, etc.
	Performance improvement	The performance improvement of enterprises often merely focuses on specific issues. By virtue of effective data management and application, enterprises can integrate data and business scenarios, or manage and coordinate the data of affiliated enterprises, so as to conduct long-term and continuous performance improvement. Only by doing so, can enterprises compare previous and future performance, and realize continuous appreciation.

Source: Deloitte Research

Based on the challenges faced by the manufacturing industry and analysis of the abovementioned three dimensions, the commercial value of MOA will be reflected by efficiency optimization, quality optimization, cost optimization, supply chain optimization and brand optimization. Numerous benefits can be attributed to them (Chart 7).

Chart 7: Manifestation of the Commercial Value of MOA

	Efficiency optimization	• Improvement of the insights into the market and customer demands • Reduction of research & development and test periods • Improvement of asset utilization ratio • Improvement of the batch processing ability of quality control • Elevation of the detectable rate of quality control
	Cost optimization	• Order management and prediction • Flexible production scheduling • Manpower replacement • Operation monitoring of production line equipment • Reduction of downtime
	Quality optimization	• Process improvement and analysis • Analysis and test of research & development data • Simulation and measurement of the best product design parameters • Defect inspection • Ensuring product safety • Effective management of warranty and recall • Improvement of asset safety
	Supply chain optimization	• Reduction of the risk of supply chain suspension • Shortening of delivery path • Real-time follow-up of logistics information • Ensuring the accuracy of out-put and in-put of warehouse of goods
	Brand optimization	• Energy consumption and carbon footprint visualization • Reduction of energy consumption and carbon footprint • Improvement of working environment safety • Improvement of employee health and operation convenience • Improvement of data governance capability

Source: Deloitte Research

IV. Applications of MOA of the Manufacturing Industry

Unquestionably, the manufacturing industry has been trying to optimize equipment management and production process, and an increasing number of tech start-ups have joined the market to develop innovative application, promote the manufacturing industry to develop towards MOA. In this Chapter, we will mainly focus on relevant empowerment technologies and the innovative solutions of start-ups.
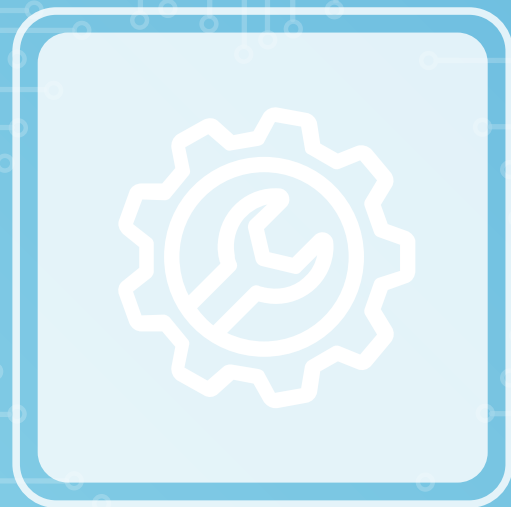
4.1 Major Technologies and Trends of MOA

MOA involves many critical technologies, such as digital twin, artificial intelligence and the IoT. The Chart below shows the prediction of some international research institutions on major technology application markets (Chart 8).

Chart 8: Major Technologies of MOA of the Manufacturing Industry and the Market Application Scale

It is predicted that by 2030, the global market of **Modern Manufacturing Execution System (MES)** will approach USD48.4 billion, with a CAGR of 13.2% from 2021 to 2030[3]. Modern MES is mainly applied in data collection and review, scheduling, production scheduling and other tasks. The popularization of the IoT in industrial sectors and the combination of MES with Warehouse Management System (WMS), Supply Chain Management (SCM) and other optimization plans provide more development opportunities for the market.

It is predicted that by 2026, the global market size of **IoT application in the manufacturing industry** will amount to USD136.83 billion, with a CAGR of 22.1% from 2018 to 2026[4]. The digital transformation of the manufacturing industry promotes the application and popularization of the IoT, and the transformation of manufacturing operation to flexible, efficient, high-quality, safe, and large-scale customization.

It is predicted that the global market of **digital twin** will grow from USD3.21 billion in 2020 to USD185.4 billion in 2030, with a CAGR of 50%[5]. The popularization of IoT application and enterprise demands for the maintenance of Intelligent assets, product development optimization and process optimization are the major drivers for the growth of the digital twin market.

It is predicted that by 2026, the global market size of the **application of artificial intelligence in the manufacturing industry will** reach USD4.8 billion, with a CAGR of 28.1% from 2021 to 2026[6]. This will be mainly driven by the increase in data size and complexity, improvement in hashrate, industrial IoT and automated development, and increase in risk investment, among other factors. The value of artificial intelligence in cost reduction and efficiency improvement becomes increasingly apparent, which will be widely applied in factory automation, order management, quality control, predictive maintenance and other scenarios.

It is predicted that the global market of **Robotic Process Automation (RPA)** will grow from USD1.63 billion in 2021 to USD7.67 billion in 2027, with a CAGR of 25% from 2021 to 2027[7]. Drivers that promote the market mainly include the rising demands for business process automation by using artificial intelligence and software robot, and the adoption of RPA technology by more enterprises, etc.

Blockchain, 3D printing and other technologies will also empower the MOA of the manufacturing industry. The investment of worldwide manufacturers in blockchain is predicted to grow from USD0.3 billion in 2019 to USD9.3 billion in 2025, with a CAGR of over 77% from 2019 to 2025[8]. The global 3D printing market is predicted to reach USD62.79 billion in 2028, with a CAGR of 21% of the overall market from 2021 to 2028[9].

Source: Deloitte Research

4.2 Industry Applications

Taking the pain points of industries and customers as breakthrough points, technology start-ups develop modularized and integrated solutions based on complete technical capabilities to achieve project delivery; or intensively work on the application of a single technology, forming a unique advantage.

Automobiles and Auto Parts

SmartMore: Facilitating quality optimization with machine vision

SmartMore is a Chinese start-up focusing on smart manufacturing. It aims to build integrated solutions based on detection algorithms using deep learning.

Pain points

For automakers, even a minor quality defect can result in costly recalls. Moreover, as the auto industry is relatively mature, it is difficult to optimize the process. Automakers have an urgent need to reduce the number of visual inspectors so as to lower the cost of quality control staffing. It's hard for automakers to strike a balance between quality and cost. A leading European auto parts manufacturer wants to reduce labor costs of the production line while improving manufacturing precision and quality. Challenges posed to the client in visual inspection in the production line and operations are mainly reflected in the following aspects:

- **Slow manual inspection:** The speed of manual quality inspection is below the required 40,000 pieces per day, limiting the manufacturer's productivity and output. Inefficient manual inspection also leads to overstock of materials, which constraints the production. In order to improve the inspection efficiency, the customer raises several requirements: 2 seconds/piece for the quality inspection response, 1.5 seconds/piece for the mechanical action response, and 0.5 seconds/piece for the algorithm response.

- **Low consistency and stability:** The low efficiency and high uncertainty of manpower greatly reduce the output efficiency and income, which is worsened by the high turnover rate of employees.

- **High quality standards:** The customer has higher requirements for quality inspection. It requires automated identification of a range of different defects and needs support for its continuous process improvement.

- **High inspection costs:** The productivity is seriously affected by human processing, which is limited by different production processes. In order to ensure adequate manpower for inspection, an extra labor cost of 9 quality inspectors is needed for each production line on average.

Solution

In order to meet the client's demands, SmartMore needs not only to identify and classify various product defects, but also to completely replace all manual inspections to achieve MOA of the inspection process. To this end, it has designed an SM-Insight industrial intelligent inspection software. This new advanced imaging system is able to detect 21 defects at as few workstations as possible. Oxidation, fracture and depression on the industrial plate, as well as scratches, black spots and carburizing on the outer diameter surface and edge surface can be located and identified by this image design software. The detection solution provided by SmartMore is unique in the integration of hardware, algorithm and software services during the development of automation processes:

- **Hardware:** Installation and design of complex rotary operating mechanism, design of electric mechanism, optimization of visual workstation, improvement in electric standards.

- **Software:** The solution covers display of real-time detection, display of module version, one-click switch of detection parameters, dynamic image view of NG items, data classification and statistics, display of the status of connected devices, and parallel operation of multiple algorithms.

Value

- **Quality optimization:** The project successfully replaces 80% of inspectors in the production line, thereby saving costs and significantly reducing the risk of human error. In addition, the comprehensive statistics and analysis of product defects provides a strong data basis for output analysis, cause tracking and manufacturing process improvement, which supports the manufacturer to continuously improve quality.

- **Efficiency optimization:** The detection speed is increased by 100% with greatly improved detection consistency by reducing manpower detection and shortening defect identification time. After implementing the plan, the identification rate of the same defect on the same sample by the trained staff is lifted from 80% to 100%.

SourceMap: Increasing transparency and traceability of supply chain

Incubated from an MIT lab, SourceMap leverages big data analysis, machine learning, blockchain and other technologies to provide supply chain visualization and traceability solutions, including end-to-end supply chain due diligence, customs compliance, environmental and social sustainability, business continuity and operational planning.

Pain points

An increasing number of manufacturing enterprises hope for access to supplier information to better manage their compliance. In the post-COVID-19 era, they also need end-to-end supply chain transparency at a higher degree to manage and prevent supply chain volatility and find more reliable suppliers. But the clients often face the following problems:

- **Numerous suppliers:** Large automakers often have hundreds of tier 1 suppliers, which are served by hundreds of their own suppliers as well. This doubles the actual number of suppliers that serve the manufacturing enterprises.

- **Difficulty in collecting data of suppliers:** It's hard to collect the data of suppliers, and relevant data should be updated from time to time.

- **Difficulty in assessing the compliance risks of the supply network:** It's necessary to identify compliance risks in a mass of data and information and provide early-warning in a timely manner.

Solution

Main functions of SourceMap's solution are as follows:

- **Supply chain visualization:** Cloud-based software facilitates data collection and integration of the whole supply network, and allows customers to create multiple scenarios, visualize any KPI and present reports in minutes, thus informing customers' decision making (such as reducing inventory, modifying prices or changing distribution centers).

- **Risk heat map:** Material social and environmental risks in the supply chain often occur in the places that are beyond manufacturers' reach and least controlled by them. This function allows manufacturers to view risks based on the goods they select and the risks they focus on, and automatically calculates risk scores.

- **Supplier benchmarking:** With the supplier platform, the customers can invite any supplier to reply to or initiate an information request, before the results are automatically analyzed and reported. Automated big data can be used to analyze and monitor the work progress of suppliers and the degree of alignment with the corporate goals.

- **Supply chain traceability:** Collect a large amount of data from the supply network and analyze the data based on the risks. For example, monitor deforestation of the farms with satellite images, look for evidence of fraud, waste, or abuse in the transaction records with machine learning, record the forced labor events in the places where the Internet connection cannot be guaranteed with mobile apps, or monitor the abnormalities in every shipment and delivery of raw materials. The traceability provides due diligence that is superior to sample-based audit. It ensures the healthy supply chain of a company in real time.

Value

- **Supply chain optimization:** BMW identifies 50 subcontractors and 9,000 raw material sources based on the single raw material purchased from five suppliers. These subcontractors and raw material sources are then correlated with the data from satellites, geographic information systems and supply chains to monitor risk factors in the selected areas in real time. By doing this, continuous optimization of the supply chain is achieved.

- **Brand optimization:** Industries and enterprises practicing clean manufacturing, such as automotive, electronics, photovoltaic, wind power equipment, leverage SourceMap's software platform to find more sustainable suppliers.

Chart 9: Supplier Visualization of SourceMap
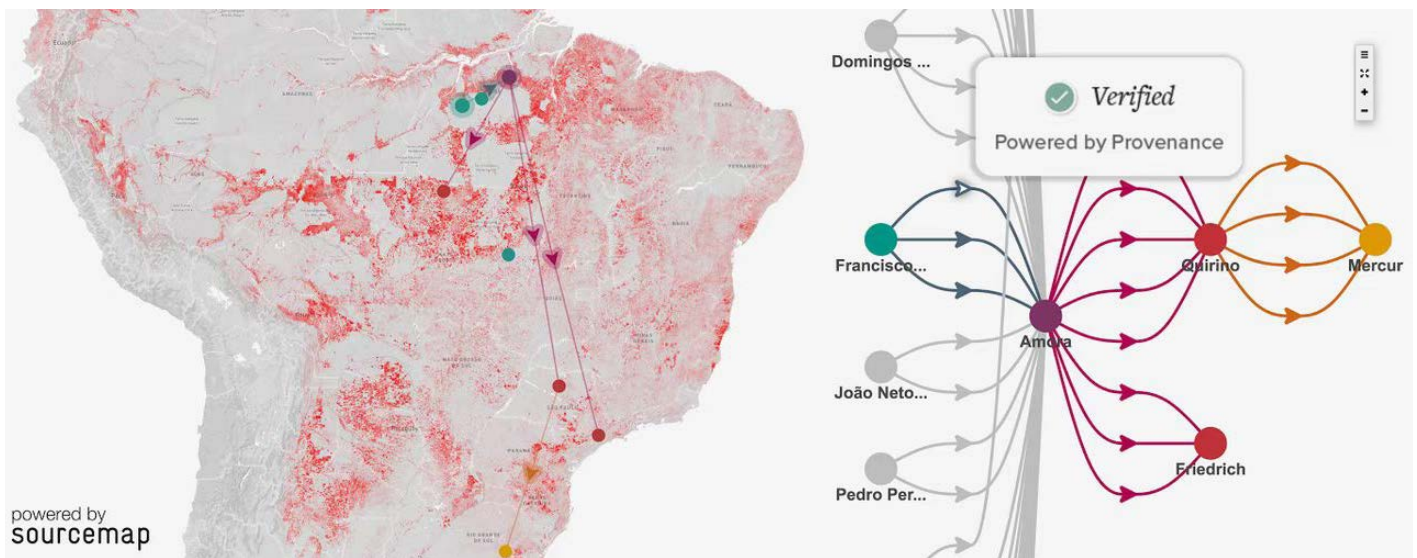
Source: SourceMap

Electronics and Semiconductors

SmartMore: Achieving MOA with digital twin + machine vision

Pain points

To deploy the digital twin, the client needs to continuously collect model data, form visualization board, and keep optimizing the application, in addition to gaining access to 3D model and data of digital twin. However, it is difficult for a single platform to meet the diverse demands of customers. The construction of an industrial digital twin scenario often involves purchasing services from multiple platforms, resulting in high cost and low efficiency in digital twin deployment.

Solution

SmartMore has developed a solution with SMore Light3D industrial digital twin platform as the core. By integrating the 3D high-precision model, process flow, equipment properties, real-time equipment data in the workshop, as well as the operation management data in the factory, this platform intuitively presents the production process of the workshop, thereby realizing the remote control and management of workshop production, and control of equipment and products throughout the entire lifecycle. The efficiency of factory security and operation management is also enhanced. The unique advantages of SmartMore's solution mainly include:

- **Automated modeling:** The platform can construct models rapidly based on group images and videos with the help of automated modeling algorithms. Highly reductive models, together with model repair tools of the platform and artificial modeling capabilities, significantly reduce the modeling costs.

- **Component management:** The platform provides a large quantity of standard models of industrial components to enable the development of various 3D scene models. Built-in data display template brings

lower learning costs to the users. Systematic and professional analysis algorithm modules and auxiliary data models can analyze the existing data of users from multiple dimensions such as time, space, and hierarchical structure. It enables users to continuously exploit data value.

- **Visualization technologies:** In terms of data, the platform supports data acquisition, integration and management. In terms of modeling, it supports diversified modeling parties. In terms of 3D scene construction, multiple modeling schemes are available for matching based on the types of data provided by customers.

Value

- **Efficiency optimization:** Rapid modeling based on the standard model library enables rapid 1:1 model construction of the target within 5-10 minutes. Visualized presentation of production data and production process, and real-time monitoring of equipment operation status in the production line (such as the current production stage of equipment, equipment utilization rate, output, passed yield and other key information) provide data support for continuous efficiency optimization.

- **Cost optimization:** The function of automated modeling cuts the cost of overall modeling scheme by more than 50%. It also effectively prevents the serious consequences caused by field failures and production abnormities.

- **Quality optimization:** The digital twin + algorithm can facilitate MOA of the process in the manufacturing. With the increase of samples, the product quality becomes more stable, and the process optimization capability can be improved by about 5%-10%.

Flexciton: Optimizing the production scheduling of wafer fab

Flexciton, a London-based software start-up founded in 2016, mainly provides solutions to the optimization of production scheduling for the semiconductor industry[10].

Pain points

A reason for the global semiconductor shortage is the complex fabrication process. Before turning into a computer chip, a single wafer must undergo around 1,600 steps under tightly controlled conditions. But it is not easy to meet the surging demands by simply accelerating production. Building a new fab may take more than two years and require at least USD1 billion, sometimes even several billion. For example, how to improve the production efficiency troubles the semiconductor companies such as Seagate.

- **Long chip manufacturing process:** It takes 6 to 9 months because of complex fabrication process.

- **Limited room for productivity improvement:** Seagate has utilized a variety of advanced software to optimize production scheduling, and has also attempted to find the optimal solution through in-house development of algorithms. It is difficult to further improve its efficiency.

- **Ongoing production bottleneck:** Wafer fabs still encounter bottlenecks at different stages of production. For instance, they have to halt precision equipment for maintenance.

- **High risks in building new production line:** The cost of equipment can be extremely high and consumer demand can be unpredictable.

Solution

Flexciton combines Mixed Integer Liner Programming (MILP) with heuristic search and programming to calculate an optimized schedule within several minutes, thereby improving the production scheduling of the fab. What makes the technology unique is that, compared with machine learning, it can quickly offer optimal scheduling plan with mathematical certainty. The solution of Flexciton contains three different levels of scheduling optimization.

- Local toolset optimizer at level one: It optimizes the scheduling of WIP for specific toolset and optimizes the KPIs specific to that toolset.

- Global fab optimizer at level two: It is able to optimize the scheduling of WIP globally and ensures the supply of WIP to individual toolsets.

- Release decisions optimizer at level three: It determines when to release WIP into a fab to start production.

Value

- **Efficiency optimization:** The technology has helped Seagate achieve 10% efficiency improvement in POC (proof of concept) projects. Flexciton's solution is now fully integrated into the Springtown fab, and early results show far superior performance than the scheduling algorithm previously employed by Seagate. The tools have shown up to 10-45% improvements in cycle time.

- **Cost optimization:** As per Flexciton's estimation, the solution can achieve 7%-10% efficiency improvement in a typical large fab by a measure of cycle time or the time the fab takes to produce each semiconductor. In addition, it will save USD3 million to USD5 million per month.

Chart 10: Diagram of Levels of Flexciton's Solution

Source: Flexciton

Precision Instrument

SmartMore: Driving the intelligent transformation of process with data intelligence

Pain points

The Chinese factory of a leading optical enterprise upgrades to Industry 4.0, which includes digital and intelligent transformation of the entire process of lens manufacturing. However, it faces two challenges in the key aspects of lens coating quality analysis and process optimization:

- **Complicated and diverse process data:** Firstly, the automated coating equipment will generate and calculate hundreds of thousands of pieces of data in hundreds of items during the coating process of the lens, but the impact and weight of each data on the final quality is not clear. Secondly, diverse processes, various product materials, differences between the machines, machine running times and aging degree also affect the quality.

- **Difficulty in the development of expert system:** Firstly, tracking quality problem depends on the experience of process experts and the judgment of on-site conditions, so it is difficult to form a stable, accurate and quantifiable system for quality prediction and outlier identification and judgment. Secondly, the expert system which judges the coating quality according to the score obtained from the scoring rule based on experience is highly subjective, and the final result is unsatisfactory and poor in practicability.

Solution

To solve the above two problems, SmartMore has developed a restructured big data solution based on big data and machine learning, targeting lens coating quality analysis, prediction and tuning. This solution differs from traditional analysis systems of process big data, which is demonstrated by the following features:

- **"Tool-based" algorithm development:** Traditional algorithm development relies on manual design, and N models are then trained one by one. In contrast, SmartMore's big data solution is based on algorithm templates, and generates and trains N models. Tool-based algorithm development helps users to be deeply involved in the whole process, and makes the subsequent maintenance controllable for IT department. It also makes it easy for users to expand new sites and new products.

- **"Modularized" knowledge precipitation:** Rather than using manpower to summarize business experience, run algorithm process, summarize various problems related to equipment and images, and conduct repeated debugging and model training, SmartMore's solution generates algorithm templates in combination with a variety of knowledge from experts, algorithm engineers, researchers, and external consultants of the customer as well as the experience of the project, conducts training automatically by the system, and compares performance and improvement points.

Value

Through "tool-based" algorithm development and "modularized" knowledge precipitation, the customer attained scalable progress as well as MOA, which is reflected in:

- **Quality optimization:** This solution enables accurate judgment of process quality. After implementing this project, the user has gained the scalability and flexibility to adapt to a variety of substrates, 10+ technologies, 100+ products, and dozens of coating machines.

- **Cost optimization:** The solution optimizes processes and reduces costs, and guides the identification, positioning

and continuous improvement of process defects with data. The manual quality inspection workload is reduced by 80%, which facilitates capacity release and industrial upgrading.

- **Brand optimization:** The solution improves customer's data governance ability. By fully leveraging the enterprise's data value, especially the process big data accumulated in the long term, the customer can constantly optimize the management of data lifecycle, and form data barriers in the industry by virtue of the accumulated experience in big data analysis and management, thus consolidating its leading position in the industry.

Chart 11: Big Data Analysis Process of SmartMore's AR (Anti-Reflection) Coating Process
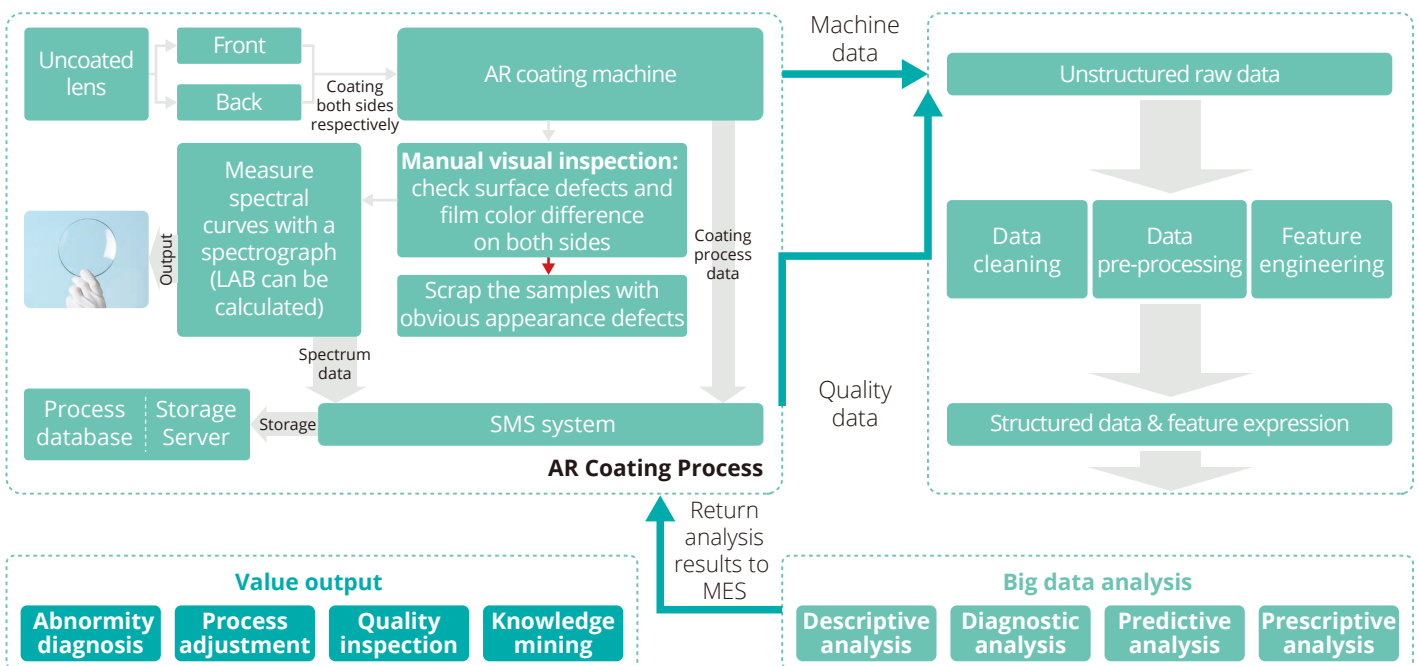
Source: SmartMore

Equipment Manufacturing

iSESOL: Enabling the breakthrough in product bottlenecks

Co-established in 2015 by Shenyang Machine Tool (Group) Co., Ltd., Digital China Group Co., Ltd. and Everbright Financial Holding Asset Management Co., Ltd., iSESOL is an industrial internet platform company with a focus on machining. Based on the industrial internet, it is committed to providing IT services and data services for equipment manufacturing, improving production efficiency and reducing costs.

Pain points

The client is a large national high-tech enterprise which is engaged in the development and manufacturing of generator sets. It is mainly confronted with three pain spots:

- **Capacity bottleneck:** The increasing number of orders puts the customer into a dilemma between capacity expansion and capital pressure. Large amounts of money is needed to purchase equipment and hire operators and technicians, while low utilization rate of equipment will waste manpower and depreciation costs.

- **Management bottleneck:** Worksite management relies on manual labor, which results in higher labor cost and lower management efficiency.

- **Maintenance cost:** The equipment maintenance cost is high.

Solution

Based on the interconnection of equipment manufacturing, iSESOL has lowered the cost and enhanced the efficiency of the customer by deploying "Smart terminal + industrial internet + cloud service". The industrial internet deployment of iSESOL includes platform (iSESOL) and edge computing node (iSESOL BOX). Different from hardware vendors, iSESOL provides services with iSESOL BOX for users in the mode of leasing, and makes profits from the industrial APPs used by the users.

- **Equipment networking:** By installing the industrial edge computing terminal iSESOL BOX in the complete set workshop of cylinder block and cylinder head, iSESOL achieves the networking and data collection of 17 sets of equipment in the production lines of cylinder block and cylinder head. The real-time status information and manufacturing data of the equipment are connected to the iSESOL industrial internet platform.

- **Industrial APP channel:** Synergy APP enables real-time data interaction between the equipment and cloud platform through the edge computing capability of iSESOL BOX, which can optimize process parameters and shorten the processing time of parts. Equipment Cloud Eye APP can realize the real-time collection and display of equipment operation data in the workshop, so that the management personnel holding the post of workshop team leader or above can stay updated on the operating indicators of the production equipment in real time. In addition, by opening the underlying technology interface, iSESOL platform allows enterprises, research institutes and individuals to develop industrial APPs, so as to enrich the industrial APP ecosystem on the platform.

- **Data service:** Through the iSESOL platform, the current operation data of the equipment are compared vertically with the historical data, and the operation and maintenance data are compared between the equipment horizontally. With the authorization of users, these data are channeled to the platform to build a data model, thus providing corresponding data services and continuously optimizing various indicators.

Value manifestation

- **Efficiency optimization:** The product capacity has increased by about 7% on average in the two production lines of cylinder block and cylinder head of engines.

- **Cost optimization:** The visualization of data and information like equipment status, equipment performance and equipment list helps to reduce maintenance cost. The paperless and unified management regarding links of upload, correlation, transfer and postback of program files in the workshop reduces labor costs and resource waste.

New Energy Equipment
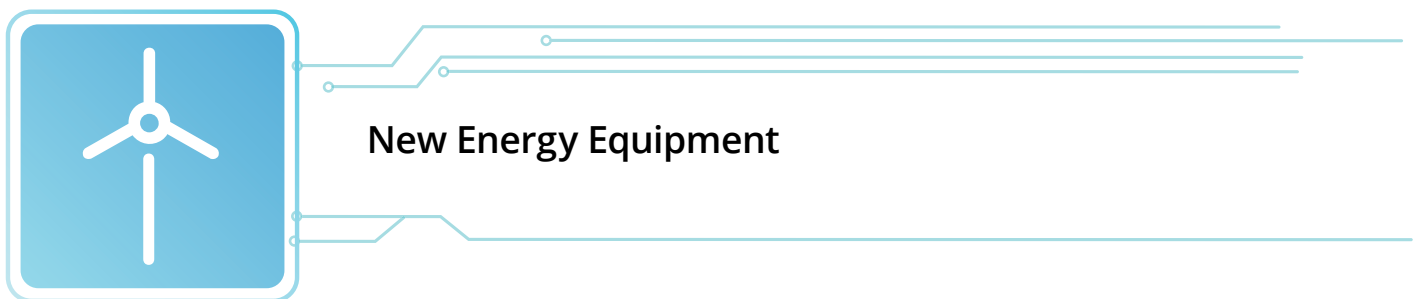
SmartMore: Optimizing quality inspection process of glue dispensing for the button cells

Pain point

The project customer is a manufacturing enterprise focusing on high-end lithium battery technology and products. The customer hopes to make further improvements in unmanned operation, high efficiency and high precision, and puts forward higher requirements for production efficiency, process capability index (CPK) of glue dispensing weight, qualification rate and environmental protection. Difficulties in the quality inspection process of glue dispensing for the button cells are as follows:

- **Various types of defects:** Traditional glue dispensing has defects such as insufficient glue, glue leakage, scattered point, and excessive glue. Accurate defect classification and statistics are also needed based on the characteristics of defects, in order to improve the ratio of materials for glue dispensing.

- **Challenge in glue dispensing process:** Given the special structure of battery materials, it is necessary to conduct even sealant coating on the side wall and at the bottom. The whole glue dispensing process is extremely challenging.

Solution

Regarding the difficulties faced by the customer, SmartMore automatically develops machine vision-based sealant coating quality inspection equipment for button cells in the field of new energy by integrating algorithms, software systems and hardware systems so as to address the abovementioned problems. Key functions of the solution include:

- **Algorithm model:** The independently developed industrial quality inspection training platform can label, train and export the defect detection algorithms, which can ensure that the pass rate is no more than 0.8% and the miss rate no more than 0.01%. The platform can inspect a range of defects, including glue leakage, scattered point, and glue disconnection.

- **Software system:** The industrial quality inspection deduction software features data statistics, authority management, product management and other functions. It enables visualization and Intelligent analysis, thereby assisting enterprises to continuously optimize the quality inspection process.

- **High-precision motion platform:** High-precision integrated welding machine frame ensures long-term stability of motion accuracy.

- **Intelligent glue dispensing system:** Dispensing operations in different directions are designed; dispensing frequency can be dynamically and automatically adjusted according to dispensing speed; dispensing amount can be intelligently and dynamically adjusted to ensure consistency of dispensing effect.

Value

The solution solves the problem of inconsistent dispensing effect caused by manual operation of the customer, as it replaces the complete inspection by manpower. A full inspection of all products is achieved, thus avoiding huge economic losses caused by assembling the vehicles with defective products. In addition, the statistics of defective products improves the production process as well as the operation standards and efficiency of the operators in the workshop.

- **Efficiency optimization:** The previous production mode of manual dispensing and manual quality inspection has been successfully replaced. Peak capacity of the equipment is greater than or equal to 60 pieces/minute. In the whole production line, more than RMB3 million is saved, together with 80% reduction of labor, and 85% improvement in efficiency.

- **Quality optimization:** The Intelligent glue dispensing system perfectly solves the difficulty in dispensing glue on the side wall of steel shell. After the dispensing quality inspection, the proportion of products meeting the requirements for thickness and weight is more than 99.9%. The machine vision-based detection inspects every product, and the pass rate is no more than 1%.

- **Brand optimization:** The solution is in line with the requirements of environmental protection. Equipped with efficient (in cleanliness: no more than 1 million particles larger than 20.5 microns per cubic meter) purification, filtration and air extraction system, the equipment discharges dust and odor in a concentrated manner. As the solvent is flammable, it can only be dried by air drying system.

Hualong Xunda: Enabling intelligent and visualized digital factory

Hualong Xunda focuses on the development of Intelligent device control systems, data acquisition systems, Intelligent HMI systems, and Intelligent terminals for edge computing. It is committed to building an Intelligent and visualized digital factory based on the industrial internet.

Pain points

The customer is a leading manufacturer of lithium-powered equipment in China, with the capacity of whole production line of power batteries. However, it is confronted with difficulties in data management and application in the process of digital factory deployment:

- **Difficulty in data acquisition:** Without the support of MES system, the production line of lithium battery soft pack lacks data source, which makes it difficult to realize the whole-process integrated operation management.

- **Isolated data island:** This problem results in the inability of data to flow freely between physical entities and information systems on each node of the production process.

- **Problem of data application:** Lithium battery production involves various processes, so there is a large scope to be controlled and managed in the whole production line of equipment. The enterprise needs to utilize data to manage the entire life cycle of products, so as to improve production capacity and product quality.

Solution

In view of the above-mentioned difficulties, Hualong Xunda provides a platform-based solution. Data on the personnel, equipment, material, method, and environment on the production site is collected, and modeling, simulation and big data analysis are then carried out based on such data. On-line prediction and early warning are also made regarding product quality problems to improve the homogeneous production capacity and product quality. The management decision making is optimized for enterprise operation driven by the data, which further expands the production capacity.

- **Data collection:** The real-time data of the production line is collected by connecting Ceres, the data collection and edge computing device, to production equipment. The collected data includes real-time status information of processing equipment, fault status data, processing technology data, energy consumption data, and work order data of integrated processing. Meanwhile, the production process data and real-time production status of the enterprise are displayed in real time in the exhibition hall of the centralized control center of the enterprise's digital factory.

- **Unified management and control platform:** The platform integrating equipment as well as the MES, ERP and logistics systems, has a range of functions: Generation of production work orders, online monitoring of energy consumption, real-time monitoring of production, equipment operation and maintenance management, quality monitoring, material tracking, spare parts management, shift management, statistical analysis, board management and office automation, etc.

- **Tracking products lifecycle:** With the production line data collected in real time on the 3D virtual simulation platform, the production line in the virtual space can reflect the operating status of the production line in the physical space in real time by adopting the digital twin technology. A complete management system is built to realize the digital management of the entire process from battery order and production to warehouse entry and delivery from storage.

Value

- **Efficiency optimization:** Through the comprehensive collection and in-depth analysis of all kinds of data related to "personnel, equipment, material, method, and environment" on the production site, the multi-dimensional and all-round control of lithium battery production process can be realized. In so doing, the enterprise can shorten the production cycle by 26%, reduce or eliminate the shift record by 67%, and shorten the production lead time by 22%.

- **Quality optimization:** The digital operation management platform realizes the whole-process tracking of products. It can quickly locate the process quality of abnormal materials and products, thus rapidly tracking the products and improving the production quality.

Logistics and Warehousing

SmartMore: Empowering integrated and intelligent warehousing with machine vision

Pain points

The customer is a world-leading logistics company. Its warehouse management team handles 10,000 to 20,000 pieces of goods in varying packaging sizes per week. The team needs a lot of manpower and time to complete the collection, inspection, classification, selection and distribution. The customer intends to explore intelligent warehousing solutions using the computer vision to reduce the manpower and time required to put products in and deliver them out of storage, thereby improving the productivity. The solution should meet the following requirements:

- Improve the barcode scanning rate of goods that are put in the storage, and automatically load the data of these goods into the inventory management system;

- Confirmable and correct category, quantity and expiration time of the goods out of storage to guide the delivery.

Solution

SmartMore provides practical integrated solutions for the customer. It integrates scanning equipment featuring application software development and optimization to address the customer's pain spots and meet its multi-scenario demands.

- **The software can perform algorithm adjustments and interference control:** During the software development, algorithms need to be adjusted as necessary to adapt to changes in image quality and material complexity. SmartMore has programmed the decoding function of its software so that the software can perform algorithm adjustments as well as interference control based on the source code of the barcode.

- **Hardware equipment has machine vision-based computing power:** Edge computing processor ViAir, display, industrial-grade camera, lens and lighting components with machine vision-based computing power are integrated, so as to realize automated batch scanning and data processing, and adapt to the deployment in a variety of industrial environments. Specifically, the edge computing processor ViAir can be used for data collection, model training and automated data processing. Characterized by PnP and small size, it can save 90% energy consumption compared with traditional industrial computers.

- **Multi-scenario application:** (1) Fixed batch scanning: With the aid of manipulator, conveyor belt and gantry, the batch scanning of up to 100 barcodes can be realized through the automated rotating tray. The scanning will not be affected by such factors as irregular placement of goods and inconsistent directions of labels. (2) Portable scanning: Algorithms and mobile apps for quick recognition and scanning are developed based on mobile devices.

Value

- **Supply chain optimization:** Much of the barcode scanning in the supply chain still relies on handwritten recording, which is highly labor intensive. The solution enables quick code scanning in batch, which will significantly improve the efficiency of putting goods in and delivering them out of storage. This will push for the enterprise to digitally transform its business on a larger scale in the supply chain and logistics links, and cause a ripple effect on the entire logistics industry.

- **Cost optimization:** The customer uses 15 sets of equipment, each of which can reduce 1-2 staff for the logistics department. It is estimated that the customer can save RMB150,000-300,000 in labor cost each year. Hardware equipment occupies a small area and consumes less energy, thus saving space and energy costs for the customer.

EXOTEC: Modularized supply chain optimization solution

EXOTEC, a French startup established in 2015, provides a goods-to-person solution—SKYPOD System—to optimize the order process of retail logistics. At the same time, it customizes supply chain robot systems with varying degrees of automation according to customers' logistics characteristics and distribution channels.

Pain points

Whether it is building supplies or auto parts, the industrial supply industry has complex logistical needs. Therefore, it is necessary to deal with a host of problems more flexibly, such as diverse product categories, scattered distribution places, small order quantity but with frequent transportations, and multi-location organizations.

- **Inefficient warehouse management:** AHS, a leading global transportation and logistics provider, intends to improve the efficiency in its warehouse management and expand its presence in the e-logistics market in the United States.

- **Inefficient process for return of goods:** Despite the increasing pressure of e-commerce on speed and accuracy, 80% of the warehouses are still relying on manual operation. Automation has not been realized yet. Return of goods, which is labor intensive, is more complex than simple picking. The staff must unpack the material for inspection and treatment before the material is prepared for returning to the stock.

Solution

Exotec builds a modularized structure that is over 10 meters high and can hold hundreds of storage containers. Skypods, Exotec's core products, are small square electric robots several centimeters tall that move horizontally and vertically through the honeycomb-type structure. They automatically pick and sort products, and then deliver them directly to the pickers.

The Skypod robot and accompanying system adopt mobile 3D robots, which are capable of three-dimensional movement at a speed of 10 miles per hour. The robot navigates through the warehouse with a laser scanner to deliver the goods collected and transferred to the personnel who manually arrange product delivery. The Skypicker is an articulated mechanical arm able to move solid objects weighing up to 2kg and with a minimum surface of 2x2cm at a speed of 2m/second. It allows for simultaneous preparation of four orders and transfer to the next station for order completion with manual picking or packing.

The robot Skypod has already been put in use at Cdiscount, a leading e-commerce company in France, for executing and preparing orders at the warehouse near Bordeaux. Skypod navigates through the warehouse with a laser scanner to collect and transfer goods, and then deliver the goods to the personnel who manually arrange product delivery. According to Cdiscount, Skypod is capable of picking 400 products per hour, compared with 100 items by typical manual operation.

Value

- **Supply chain optimization:** Exotec's system is fully modularized. By simply adding robots, workstations, or racks, customers can deploy and easily extend their systems within months without interrupting production.

- **Efficiency optimization:** The system processes up to 600 items per hour and ensures the continuous selection of the products that can be picked. Exotec has increased the warehouse throughput of all SKUs by 5 times with a response time of 2 minutes.

- **Brand optimization:** The Skypicker is controlled by Astar (software) in a closed and secure environment, which ensures operators' safety while reducing power consumption by 80%.

V. Conclusion

The pandemic has sped up the course of smart manufacturing, and the optimization tasks of the manufacturing industry have become increasingly complex. All efforts made by manufacturing enterprises, from design to manufacturing and to daily operation, and the way of widely integrating these procedures with the supply chain, face more flexible and complex optimization tasks, and need to meet multiple objectives simultaneously.

MOA finds the best alternative based on data analysis, makes timely adjustment and continuous improvement by monitoring the operation status of the plan, and achieves the automated optimization free from human intervention. It demonstrates the features of Industry 4.0 solutions, such as interconnectivity, decentralized decision-making, data transparency, technology support and continuous optimization, and will speed up the transition of manufacturing enterprises to the self-adaption stage which stands for the most mature stage of Industry 4.0.

MOA has been preliminarily applied in the fields of design and development, production and manufacturing, and supply chain. Going forward, technical progress will allow the parallel management of more and more objectives by relevant solutions. While creating economic value, it is more important to fulfill social responsibilities, which has opened the gate to the wide application of MOA. These changes will shape the pattern of the manufacturing industry in the coming decade. It is the right moment for the manufacturing industry to set the scene, seize opportunities and take next steps.

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Office locations

Beijing
12/F China Life Financial Center
No. 23 Zhenzhi Road
Chaoyang District
Beijing 100026, PRC
Tel: +86 10 8520 7788
Fax: +86 10 6508 8781

Changsha
20/F Tower 3, HC International Plaza
No. 109 Furong Road North
Kaifu District
Changsha 410008, PRC
Tel: +86 731 8522 8790
Fax: +86 731 8522 8230

Chengdu
17/F China Overseas
International Center Block F
No.365 Jiaozi Avenue
Chengdu 610041, PRC
Tel: +86 28 6789 8188
Fax: +86 28 6317 3500

Chongqing
43/F World Financial Center
188 Minzu Road
Yuzhong District
Chongqing 400010, PRC
Tel: +86 23 8823 1888
Fax: +86 23 8857 0978

Dalian
15/F Shenmao Building
147 Zhongshan Road
Dalian 116011, PRC
Tel: +86 411 8371 2888
Fax: +86 411 8360 3297

Guangzhou
26/F Yuexiu Financial Tower
28 Pearl River East Road
Guangzhou 510623, PRC
Tel: +86 20 8396 9228
Fax: +86 20 3888 0121

Hangzhou
Room 1206
East Building, Central Plaza
No.9 Feiyunjiang Road
Shangcheng District
Hangzhou 310008, PRC
Tel: +86 571 8972 7688
Fax: +86 571 8779 7915

Harbin
Room 1618
Development Zone Mansion
368 Changjiang Road
Nangang District
Harbin 150090, PRC
Tel: +86 451 8586 0060
Fax: +86 451 8586 0056

Hefei
Room 1506, Tower A China Resource
Building
No.111 Qian Shan Road
Shu Shan District
Hefei 230022, PRC
Tel: +86 551 6585 5927
Fax: +86 551 6585 5687

Hong Kong
35/F One Pacific Place
88 Queensway
Hong Kong
Tel: +852 2852 1600
Fax: +852 2541 1911

Jinan
Units 2802-2804, 28/F
China Overseas Plaza Office
No. 6636, 2nd Ring South Road
Shizhong District
Jinan 250000, PRC
Tel: +86 531 8973 5800
Fax: +86 531 8973 5811

Macau
19/F The Macau Square Apartment H-L
43-53A Av. do Infante D. Henrique
Macau
Tel: +853 2871 2998
Fax: +853 2871 3033

Mongolia
15/F, ICC Tower, Jamiyan-Gun Street
1st Khoroo, Sukhbaatar District
14240-0025 Ulaanbaatar, Mongolia
Tel: +976 7010 0450
Fax: +976 7013 0450

Nanjing
40/F Nanjing One IFC
347 Jiangdong Middle Road
Jianye District
Nanjing 210019, PRC
Tel: +86 25 5790 8880
Fax: +86 25 8691 8776

Ningbo
Room 1702 Marriott Center
No.168 Heyi Road
Haishu District
Ningbo 315000, PRC
Tel: +86 574 8768 3928
Fax: +86 574 8707 4131

Sanya
Floor 16, Lanhaihuating Plaza
(Sanya Huaxia Insurance Center)
No. 279, Xinfeng street
Jiyang District
Sanya 572099, PRC
Tel: +86 898 8861 5558
Fax: +86 898 8861 0723

Shanghai
30/F Bund Center
222 Yan An Road East
Shanghai 200002, PRC
Tel: +86 21 6141 8888
Fax: +86 21 6335 0003

Shenyang
Unit 3605-3606,
Forum 66 Office Tower 1
No. 1-1 Qingnian Avenue
Shenhe District
Shenyang 110063, PRC
Tel: +86 24 6785 4068
Fax: +86 24 6785 4067

Shenzhen
9/F China Resources Building
5001 Shennan Road East
Shenzhen 518010, PRC
Tel: +86 755 8246 3255
Fax: +86 755 8246 3186

Suzhou
24/F Office Tower A, Building 58
Suzhou Center
58 Su Xiu Road, Industrial Park
Suzhou 215021, PRC
Tel: +86 512 6289 1238
Fax: +86 512 6762 3338 / 3318

Tianjin
45/F Metropolitan Tower
183 Nanjing Road
Heping District
Tianjin 300051, PRC
Tel: +86 22 2320 6688
Fax: +86 22 8312 6099

Wuhan
Unit 1, 49/F
New World International Trade Tower
568 Jianshe Avenue
Wuhan 430000, PRC
Tel: +86 27 8538 2222
Fax: +86 27 8526 7032

Xiamen
Unit E, 26/F International Plaza
8 Lujiang Road, Siming District
Xiamen 361001, PRC
Tel: +86 592 2107 298
Fax: +86 592 2107 259

Xi'an
Room 5104A, 51F Block A
Greenland Center
9 Jinye Road, High-tech Zone
Xi'an 710065, PRC
Tel: +86 29 8114 0201
Fax: +86 29 8114 0205

Zhengzhou
Unit 5A10, Block 8, Kineer Center
No.51 Jinshui East Road
Zhengdong New District
Zhengzhou 450018, PRC
Tel: +86 371 8897 3700
Fax: +86 371 8897 3710

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