SESEC IV Translation

Guidelines for the Construction of the National Intelligent Manufacturing Standards System (2021 Version)

December | 2021

Introduction

On 3 December 2021, State Administration for Market Regulation (SAMR) and Standardisation Administration of China (SAC) announced the release of Guidelines for the Construction of the National Intelligent Manufacturing Standards System (2021 Version).

The translation offered by SESEC is as follows.

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Guidelines for the Construction of the National Intelligent Manufacturing Standards System (2021 Version)

I Intelligent manufacturing system architecture

Intelligent manufacturing is based on the deep integration of advanced manufacturing technology and new generation information technology. It goes across the whole life cycle of products such as design, production, management and services. It is an advanced mode of production featured by self-sensing, self-decision making, self-execution, self-adaptation and self-learning, aimed at improving the quality, efficiency, effectiveness and flexibility of the manufacturing industry.

The intelligent manufacturing system architecture describes the activities, equipment and characteristics involved in intelligent manufacturing. It does so from three perspectives, namely life cycle, system hierarchy and intelligent features, which are mainly used to define the standardization demands, objects and scope of intelligent manufacturing. The intelligent manufacturing system architecture is shown in Figure 1.

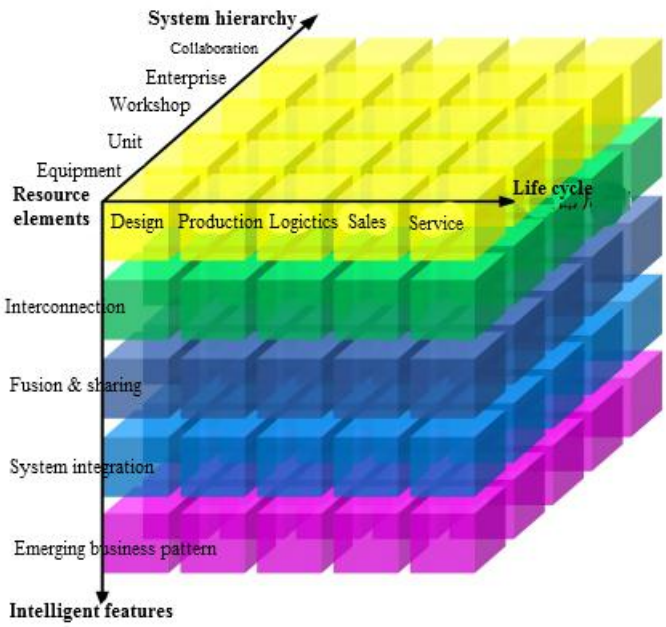

Figure 1. Intelligent manufacturing system architecture

1. Life cycle

Life cycle covers every stage, starting from R&D of product prototype, to product recycling and re-manufacturing, and including a series of interrelated value creation activities such as design, production, logistics, sales and services. The various activities throughout the life cycle can be optimized iteratively and in a sustainable way. Different industries tend to have varying life cycle composition and time sequence.

(1) Design refers to the process of realizing and optimizing the demands according to all the constraints of the enterprise and the selected technologies;

(2)Production refers to the process of processing, transporting, assembling and inspecting materials to create products;

(3)Logistics refer to the physical flow process of goods from the supplying place to the delivery place;

(4)Sales refer to the business activities of products or commodities transferred from enterprises to customers;

(5)Services refer to the processes and results of a series of activities generated throughout the interaction between the product provider and the customers.

2. System hierarchy

System hierarchy refers to the division into levels of the organizational structure related to enterprise production activities, including equipment level, unit level, workshop level, enterprise level and collaboration level.

(1)Equipment level refers to the level where the enterprise realizes the actual physical process, and perceives and controls the physical process by using sensors, instrumentation, machines, devices, etc.;

(2)Unit level refers to the level used to process information, and monitor and control physical processes in an enterprise;

(3)Workshop level is the level where the production management for the factory or workshop is realized;

(4)Enterprise level is the level of enterprise operation and management;

(5)Collaboration level is the level in which enterprises realize the interconnection and sharing of internal and external information, and realize the business collaboration between enterprises.

3. Intelligent features

(1)Intelligent features refer to the representation of self-sensing, self-decision making, self-execution, self-learning, self-adaptation and other functions of manufacturing activities. It includes five levels of intelligent requirements, namely resource elements, interconnection, fusion and sharing, system integration, and emerging business patterns.Resource elements refer to the resources or tools that enterprises need to use when they are engaged in production and the level of their digital model;

(2)Interconnection refers to the level of data transfer and parameter semantic exchanges between resource elements, through wired or wireless networks, communication protocols and interfaces;

(3)Fusion and sharing refer to the level of information collaborative sharing based on interconnection, using new generation information communication technologies such as cloud computing and big data;

(4)System integration refers to the level of data exchange and functional interconnection among equipment, production units, production line, digital workshop and smart factory, as well as among intelligent manufacturing systems in the process of realizing intelligent manufacturing;

(5)Emerging business patterns refer to the level which covers the functions of cognition, diagnosis, prediction and decision-making, supporting the virtual-real iterative optimization on the basis of data, models and systems, integrated and fused by the resource elements of different levels in physical space and digital space.

II General requirements

1. Basic principles

Strengthen overall planning and take targeted measures. Improve the top-level design of national intelligent manufacturing standards, and coordinate the development and implementation of national and sector standards, domestic and international standards. Combined with the technical characteristics and development needs of key industries (fields), orderly promote the construction of intelligent manufacturing standards system for subsectors.

Lay a solid foundation and strengthen coordination. Accelerate the development of key standards for general use, key technologies, and typical applications. In light of the characteristics of intelligent manufacturing, such as cross-industry, cross-field and system integration, promote all links of the industrial chain and all parties of the industry, university, research and use to jointly develop standards. Open and cooperate based on China's national conditions. Combined with the status quo of China's intelligent manufacturing technology and industrial development, encourage domestic enterprises and institutions to actively participate in international standardization activities. Strengthen exchanges and cooperation with the global industry, actively contribute China's technical solutions and practical

experience, and jointly promote the development of international standards for intelligent manufacturing.

2. Construction objectives

By 2023, more than 100 national and sector standards will be formulated and revised; an advanced and applicable intelligent manufacturing standards system will be established and improved; speed up the development of (i) intelligent equipment standards on human-machine collaboration system, technological equipment, inspection and testing equipment, (ii) smart factory standards such as smart factory design, integration and optimization, (iii) intelligent supply chain standards such as supply chain collaboration, and evaluation, (iv) intelligent service standards such as networked collaborative manufacturing, (v) intelligent enabling technology standards such as digital twin and artificial intelligence application, and (vi) industrial network standards such as industrial network integration; to support and promote the development of intelligent manufacturing to a new level.

By 2025, a relatively complete standard cluster will be formed in digital twin, data dictionary, human-machine collaboration, intelligent supply chain, system reliability, cybersecurity and functional security, and gradually build an intelligent manufacturing standards system that adapts to the trend of technological innovation, meets the needs of industrial development and meets the international advanced level.

III Construction train of thought

1. The intelligent manufacturing standards structure includes three parts, namely “A - basic generality”, “B - key technology”, and “C - industry application”. These mainly reflect the composition relationship of each part of the standards system. The structure of intelligent manufacturing standards is shown in Figure 2.

A Basic generality	Generality	B Key Technology	BA Intelligent equipment	Sensor & instrumentation	C Industry application	Shipbuilding & ocean engineering
	Security			Auto identification equipment		Building material
	Reliability			Human-computer collabration system		Petrochemical
	Testing			Control system		Textile
	Evaluation			Additive manufacturing equipment		Steel
	People capability			Industrial robot		Rail transit
				Numerical machine tool		Aerospace
				Technological equipment		Automobile
				Test & inspection equipment		Nonferrous metal
			BB Smart Factory	Smart factory design		Others
				Smart factory delivery		
				Intelligent design		
				Intelligent production		
				Intelligent management		
				Intelligent logistics		
				Business integration & optimization		
			BC Intelligent supply chain	Supply chain data sharing		
				Supply chain collaboration		
				Supply chain risk management		
				Supply chain evaluation		
			BD Intelligent Service	Mass Customization		
				Operation & maintenance service		
				networked collaborative manufacturing		
			BE intelligent enabling technology	Artificial intelligence		
				Industrial big data		
				Industrial software		
				Industrial cloud		
				Edge computing		
				Digital twin		
				Blockchain		
			BF Industrial network	Industrial wireless network		
				Industrial wired network		
				Industrial convergence		
				Industrial network resource		

Figure 2 Intelligent manufacturing standard system structure

Specifically, A - basic general standards fall into six categories, namely generality, security, reliability, testing, evaluation, and people capability. These are located at the bottom of the intelligent manufacturing standards system structure, and support B - key technology standards and C - industry application standards.

B - key technology standards are the projection of the intelligent feature dimension of the intelligent manufacturing system architecture on the manufacturing plane, composed of life cycle dimension and system hierarchy dimension. BA - intelligent equipment standards, mainly focuses on the resource elements of the intelligent feature dimension; BB - smart factory standards, mainly focuses on the resource elements and system integration of the intelligent feature dimension; BC - intelligent supply chain, corresponds to the system integration of the intelligent feature dimension; BD - intelligent service, corresponds to the emerging business patterns of the intelligent feature dimension; BE - intelligent

enabling technology, corresponds to the integration and sharing of the intelligent feature dimension; BF - industrial network, corresponds to the interconnection of intelligent feature dimension.
C - industry application standards are located at the top of the intelligent manufacturing standards structure, addressing the specific needs of the industries, refining and implementing A - basic general standards and B - key technology standards, and guiding various industries to promote intelligent manufacturing.

2. Intelligent manufacturing standard system framework

The intelligent manufacturing standards system framework includes several basic components of the intelligent manufacturing standards system, and covers three parts, namely A - basic generality, B - key technology, and C - industry application, as well as the further decomposition of each part, as shown in Figure 3.

Intelligent Manufacturing Standard System Frame	A Basic Generality	AA Generality	AAA Terms & definition
			AAB Reference model
			AAC Metadata & data dictionary
			AAD Identification
		AB Security	ABA Functional safety
			ABB Information security
		AC Reliability	ACA Engineering management
			ACB Technicai method
		AD Testing	ADA Test requirement
			ADB Test method
			ADC Test technology
		AE Evaluation	AEA Indicator system
			AEB Capability maturity
			AEC Evaluation method
			AED Implementation guide
		AF People capability	AFA Capability requirement
			AFB Capability evaluation
	B Key Technology	BA Intelligent equipment	BAASensor & instrumentation
			BAB Auto identification equipment
			BAC Human-computer collabration system
			BAD Control system
			BAEAdditive manufacturing equipment
			BAF Industrial robot
			BAG Numerical machine tool
			BAH Technological equipment
			BAI Test & inspection equipment
		BB Smart Factory	BBA Smart factory design
			BBB Smart factory delivery
			BBC Intelligent design
			BBD Intelligent production
			BBE Intelligent management
			BBF Intelligent logistics
			BBGBusiness integration & optimization
		BC Intelligent supply chain	BCA Supply chain data sharing
			BCB Supply chain collaboration
			BCC Supply chain risk management
			BCD Supply chain evaluation
		BD Intelligent Service	BDA Mass Customization
			BDB Operation & maintenance service
			BDC Networked collaborative manufacturing
		BE intelligent enabling technology	BEA Artificial intelligence
			BEB Industrial big data
			BEC Industrial software
			BEDIndustrial cloud
			BEE Edge computing
			BEF Digital twin
			BEG Blockchain
		BF Industrial network	BFA Industrial wireless network
			BFB Industrial wired network
			BFC Industrial convergence
			BFD Industrial network resource
	C Industry application	CA Shipbuilding & ocean engineering	
		CB Building material	
		CC Petrochemical	
		CD Textile	
		CE Steel	
		CF Rail transit	
		CG Aerospace	
		CH Automobile	
		CI Nonferrous metal	
		CJ Others	

Figure 3 Intelligent manufacturing standard system framework

IV Construction contents

1. Basic general standards

Basic general standards mainly include six parts, namely generality, security, reliability, testing, evaluation, and people capability, as shown in Figure 4. These are mainly used to unify the related concepts of intelligent manufacturing, and to solve the common key problems of intelligent manufacturing.

A Basic Generality	AA Generality	AAA Terms & definition
		AAB Reference model
		AAC Metadata & data dictionary
		AAD Identification
	AB Security	ABA Functional safety
		ABB Information security
	AC Reliability	ACA Engineering management
		ACB Technicai method
	AD Testing	ADA Test requirement
		ADB Test method
		ADC Test technology
	AE Evaluation	AEA Indicator system
		AEB Capability maturity
		AEC Evaluation method
		AED Implementation guide
	AF People capability	AFA Capability requirement
		AFB Capability evaluation

Figure 4 Basic general standards subsystem

(1) General standards

General standards mainly include four parts, namely terms and definitions, reference model, metadata and data dictionary, and identification. Standards on terms and definitions are used to unify the related concepts of intelligent manufacturing, and to support the formulation of other standards, including terms, vocabulary, symbols, codes and other standards. Standards on reference model are used to help all parties understand the objects, boundaries, hierarchical relationship, and internal relationship of the various parts of intelligent manufacturing standardization, including reference models, system architecture and other standards. Standards on metadata and data dictionary are used to specify the classification, naming rules, description and representation, registration, management and maintenance requirements of industrial data, such as industrial products and manufacturing processes during the design, production and circulation of intelligent manufacturing products, as well as the establishment method of data dictionary, including metadata and data dictionary standards. Identification standards are used for the identification and resolution of all kinds of objects in intelligent manufacturing, including identification coding, coding transmission rules, object metadata, resolution system and other standards.

(2) Security standards

Security standards mainly include functional safety and information security. Functional safety standards are used to ensure that the control system can correctly and reliably perform its safety functions in case of danger, so as to avoid production accidents caused by system failure or conflict of safety facilities, including safety collaboration requirements for intelligent manufacturing, design and implementation of functional safety system, functional safety test and evaluation, functional safety management, functional safety operation and maintenance standards. Cybersecurity standards are used to ensure the availability, confidentiality and integrity of relevant information systems in the field of intelligent manufacturing, so as to ensure the safe and reliable operations of the systems, including network equipment security, controlling system security, network (also identity resolution system security, industrial Internet platform security, data security, information security products evaluation, security maturity evaluation, application guide for cryptography, and other standards.

(3) Reliability standards

Reliability standards mainly cover engineering management and technical methods. Engineering management standards mainly plan, organize, coordinate and supervise the reliability activities of the intelligent manufacturing system, including standards on reliability requirements, reliability

management, comprehensive support management, life cycle cost management of the intelligent manufacturing system and its various system hierarchical objects. Technical method standards are mainly used to guide the specific reliability assurance and verification of the intelligent manufacturing system and its various system levels, including standards on reliability design, reliability prediction, reliability test, reliability analysis, reliability growth and reliability evaluation.

(4) Test standards

Test standards mainly include three parts, namely test requirements, test methods, and test technology. Test requirement standards are used to guide the scientific sorting and effective management of intelligent equipment and systems during testing processes, including the standards on indicators or requirements of test items, such as consistency and interoperability, integration and interconnection, system energy efficiency, and electromagnetic compatibility of different types of intelligent equipment and systems. Test method standards are used for testing different types of intelligent equipment and systems, including standards on test contents, methods, steps, processes, calculation and analysis, as well as performance, environmental adaptability and parameter calibration. Test technology standards are used to regulate the testing technology for intelligent manufacturing, including standards on judgment test, information test, and causation test. The testing means are not limited to software and hardware testing, online monitoring, simulation testing, etc.

(5) Evaluation standards

Evaluation standards mainly consist of four parts, namely indicator system, capability maturity, evaluation methods, and implementation guidance. Indicator system standards are used to evaluate the performance and results of intelligent manufacturing implementation, and to promote enterprises to continuously improve the level of intelligent manufacturing. Capability maturity standards are used to plan the intelligent manufacturing framework, improve the capability of intelligent manufacturing, and provide reference for enterprises to identify gaps, establish goals and implement improvements. Evaluation method standards are used to provide consistent methods and basis for stakeholders, to regulate the evaluation process and to guide stakeholders to conduct the evaluation of intelligent manufacturing. Implementation guidance standards are used to guide enterprises to improve manufacturing capacities, and provide reference for enterprises to carry out intelligent construction and improve productivity.

(6) People capability standards

People capability standards mainly cover two parts, namely capability requirements and capability evaluation. Capability requirements standards for intelligent manufacturing practitioners are used to regulate the capability management of practitioners, and to define the requirements of occupation classification, capability level, knowledge reserve, technical capability and practical experience, including standards on capability requirements and capability training. Evaluation standards for intelligent manufacturing capability are used to regulate the capability level of different occupational categories, and to guide the evaluation of the capability level of intelligent manufacturing practitioners, including practitioner evaluation, appraiser evaluation, and other standards.

2. Key technology standards

Key technology standards mainly consist of six parts, namely intelligent equipment, smart factory, intelligent supply chain, intelligent service, intelligent enabling technology, and industrial network.

(1) Intelligent equipment standards

Intelligent equipment standards cover ten main parts, namely sensors and instrumentation, automatic identification equipment, human-machine collaboration system, control system, additive manufacturing equipment, industrial robots, numerical control machine tools, technological equipment, testing and inspection equipment, and others – as shown in Figure 5.

BA Intelligent equipment	BAA Sensor & instrumentation	BAAA General technology
		BAAB Interface & communication
	BAB Auto identification equipment	BABA Geberal technlogy
		BABB Interface & communication
	BAC Human-computer collabration system	BACA Text, graphics & images
		BACB Interaction collaboration
	BAD Control system	BADA General technology
		BADB Interface & communication
		BADC Programming
	BAE Additive manufacturing equipment	BAEA General technology
		BAEB Interface & communication
		BAEC Test & Evaluation
	BAF Industrial robot	BAFA General technology
		BAFB Interface & communication
		BAFC Collaboration
		BAFD Test & Evaluation
	BAG Numerical machine tool	BAGA General technology
		BAGB Interface & collaboration
		BAGC Test monitoring
	BAH Technological equipment	BAHA General technology
		BAHB Interface & monitoring
	BAI Test & inspection equipment	BAIA General technology
		BAIB Integration
		BAIC Equipment management
	BAJ Others	BAJA General technology
		BAJB Interface & communication

Figure 5 Intelligent equipment standard subsystem

The standards mainly specify the requirements of information model, data dictionary, communication protocol and interface, integration and interconnection, operation and maintenance services, performance evaluation, and test methods for intelligent equipment.

A. Sensors and instrumentation standards mainly include characteristics and classification, reliability design, life prediction, system and component life cycle management, performance evaluation, and other general technical standards; as well as information model, data interface, field device integration, semantic interoperability, communication protocol, protocol consistency, and other interfaces and communication standards.

B. Automatic identification equipment standards mainly consist of data coding, performance evaluation, equipment management, and other general technical standards; as well as interface specification, communication protocol, information integration, fusion perception and collaborative information processing, and other interface and communication standards.

C. Human-machine collaboration system standards mainly include the classification and definition of graphic symbols, acquisition and recognition of visual images, display of virtual-reality fusion information, and other text graphics and image standards, such as virtual reality/augmented reality (VR/AR); as well as interactive collaboration standards on cooperation mode requirements, task assignment requirements, and human-computer interface in the process of human-computer collaboration.

D. Control system standards mainly include control methods, data acquisition and storage, human-machine interface and visualization, testing and other general technical standards; in addition to control equipment information model, clock synchronization, interface, system interconnection, protocol consistency, and other interface and communication standards; as well as engineering data exchange, control logic program, control program architecture, control tag and data flow, function block, and other programming standards.

E. Additive manufacturing equipment standards mainly include model data quality and processing requirements, establishment and classification of technological knowledge base, data dictionary and coding requirements, and the general technical standards on multi-material and array additive manufacturing, composite and micro-nano structure additive manufacturing; in addition to system and equipment information model, communication protocol, and other interfaces and communication standards; as well as test methods, performance evaluation, and other test and evaluation standards.

F. Industrial robot standards mainly cover data format, object dictionary and other general technical standards; interface and communication standards among information model, programming system, user and industrial robots; collaboration standards between industrial robots and humans, environment, system, and other equipment; as well as performance, site adaptability, and other testing and evaluation standards.

G. Numerical control machine tool standards mainly include language and format of machine tools and functional components, fault information dictionary, classification, control requirements, and other general technical standards; programming interface, physical mapping model, interconnection and other interfaces and collaborative standards; as well as test based on the industrial cloud manufacturing, status monitoring and optimization, and other testing and monitoring standards.

H. Technological equipment standards mainly cover general technical standards on casting, forging, welding, heat treatment and special processing, which are applied to the technical requirements of process and discrete manufacturing technological equipment; as well as data interface, status monitoring, and other interfaces and monitoring standards.

I. Testing and inspection equipment standards mainly consist of general technical standards on data format, performance and environmental requirements of on-line detection system; integration standards on interconnection and interfaces between testing and inspection equipment and other production equipment and systems; as well as equipment management standards on effectiveness status detection and calibration, fault diagnosis, etc.

J. Other standards mainly consist of general technical standards on data coding, data format, performance and environmental requirements for intelligent equipment, such as warehousing, logistics, packaging and printing; as well as interface and communication standards on information model, interconnection, interface specification, communication protocol and protocol consistency.

Key points of intelligent equipment standard construction

Sensors and instrumentation standards: general technical standards on reliability design and performance evaluation; interface and communication standards on information model, data interface and protocol consistency.

Automatic identification equipment standards: general technical standards on data coding and performance evaluation; interface and communication standards on interface specification, fusion perception, and collaborative information processing.

Human-machine collaboration system standards: text graphics and images standards on visual image acquisition and recognition; interactive collaboration standards on cooperation mode requirements, task assignment requirements, and human-computer interface.

Control system standards: interface and communication standards on control equipment information model, system interconnection and protocol consistency; programming standards on engineering data exchange, control tag and data flow, and function block.

Additive manufacturing equipment standards: general technical standards on model data quality and processing requirements, data dictionary and coding requirements; interface standards on system and equipment information model, and communication protocol.

Industrial robot standards: general technical standards on data format and object dictionary; interface and communication standards among programming systems, users and industrial robots; collaboration standards between industrial robots and humans, environment, systems, and other equipment.

Numerical machine tool standards: general technical standards on language and format of machine tools and functional components and fault information dictionary; interfaces and collaborative standards on programming interface, physical mapping model and interconnection; as well as testing and monitoring standards on status monitoring and optimization.

Technological equipment standards: general technical standards, interface and monitoring standards on data interface, status monitoring, etc.

Testing and inspection equipment standards: general technical standards on data format, performance and environmental requirements of online detection system; integration standards on interconnection and interface; as well as equipment management standards on effectiveness status detection and calibration, fault diagnosis, etc.

Other standards: general technical standards on data coding, data format, performance and environmental requirements; interface and communication standards on information model, interconnection, interface specification, and protocol consistency.

(2) Smart factory standards

Smart factory standards mainly consist of seven parts, namely smart factory design, smart factory delivery, intelligent design, intelligent production, intelligent management, intelligent logistics, and integration and optimization – as shown in Figure 6. The standards mainly specify the design and delivery processes of smart factory, as well as the design, production, management, logistics and system integration in the factory.

BB Smart Factory	BBA Smart factory design	BBAA Overall planning
		BBAB Physical Virtual factory design
	BBB Smart factory delivery	BBBA Digital delivery
		BBBB Acceptance requirement
	BBC Intelligent design	BBCA Product design & simulation
		BBCB Technological design &simulation
		BBCC Test design & simulation
	BBD Intelligent production	BBDA Planning & scheduling
		BBDB Production execution
		BBDC Quality control
		BBDD Equipment operation and maintenance
	BBE Intelligent management	BBEA Procurement management
		BBEB Sales management
		BBEC Asset management
		BBED Energy management
		BBEE Safety management
		BBEF Environmental protection management
	BBF Intelligent logistics	BBFA Intelligent warehousing
		BBFB Intelligent distribution
	BBG Business integration & optimization	BBGA Integration requirement
		BBGB Optimization requirement

Figure 6 Smart factory standard subsystem

A. Smart factory design standards mainly include the overall planning standards on the design requirements, design model, design verification, depth requirements of design files and collaborative design; as well as physical/virtual factory design standards on physical factory data acquisition, factory layout, virtual factory reference architecture, process flow and layout model, production process model and organization model, simulation analysis, and information interaction between physical factory and virtual factory.

B. Smart factory delivery standards mainly include digital delivery standards on general requirements, content requirements and quality requirements of digital delivery in the design and implementation stages, as well as completion acceptance requirements of smart factory projects.

C. Intelligent design standards mainly include product design and simulation standards on data-driven parametric modular design, model-based system engineering (MBSE) design, collaborative design and simulation, multi-field coupling simulation and optimization, and digital design of formula products; technological design and simulation standards based on manufacturing resource digital model; as well as test design and simulation standards on test methods, test data, and process management.

D. Intelligent production standards mainly include the planning and dispatching standards on plan modeling and simulation, multi-level plan collaboration, visual production scheduling, dynamic optimization and dispatching; production execution standards on automatic distribution and execution of operation files, design and manufacturing collaboration, dynamic organization of manufacturing resources, process simulation, production process control and optimization, exception management and error prevention mechanism, etc; quality control standards on intelligent online quality monitoring, early warning and optimization control, quality archives, and quality traceability; as well as standards on knowledge-based equipment operation status monitoring and optimization, maintenance, fault management, etc.

E. Intelligent management standards mainly cover the procurement management standards on quality inspection and analysis of raw materials and accessories; sales management standards on sales forecast and customer service management; asset management standards on equipment health, reliability management and knowledge management; energy management standards on energy flow management and energy efficiency assessment; safety management standards on operation process

control, emergency management and hazardous chemicals management; as well as environmental protection management standards on real-time monitoring, prediction, and early warning.
F. Factory intelligent logistics standards mainly include intelligent warehousing standards on material status identification and information tracking, task assignment, dispatching and optimization, and functional requirements of warehousing system; intelligent distribution standards on material sorting, distribution path planning and management.
G. Integration and optimization standards mainly include standards on software and hardware integration and on system solution integration services, to meet the needs of business activities in the factory; as well as standards on operation and control optimization, and data-driven whole life cycle business optimization.

Key points of smart factory standard construction
Smart factory design standards: overall planning standards on functional requirements and collaborative design requirements of smart factory; standards on information interaction between physical factory and virtual factory. **Smart factory delivery standards**: delivery standards on general requirements, content requirements and quality requirements for digital delivery in design and implementation stages, as well as completion acceptance standards for smart factory projects. **Intelligent design standards**: product design and simulation standards based on data-driven parametric modular design, MBSE design, collaborative design and simulation, etc; technological design and simulation standards based on manufacturing resource digital model. **Intelligent production standards**: planning and dispatching standards on plan modeling and simulation, multi-level planning collaboration, etc; production execution standards on design and manufacturing collaboration, dynamic organization of manufacturing resources, and production process control and optimization; quality control standards on online quality monitoring and early warning, quality archives, and quality traceability; as well as standards on knowledge-based equipment status monitoring and optimization, maintenance and fault management. **Integration and optimization standards**: standards on software and hardware integration and on system solution integration services, to meet the needs of business activities in the factory; standards on operation and control optimization, and data-driven whole life cycle business optimization.

(3) Intelligent supply chain standards

Intelligent supply chain standards mainly include three parts, namely supply chain construction, supply chain management, and supply chain evaluation – as shown in Figure 7. These mainly specify the technical and management requirements for data, process and evaluation in the process of cooperation between upstream and downstream enterprises in the supply chain, guiding the design and development of the supply chain management system and platform, and ensuring the horizontal integration and efficient collaboration of the supply chain.

BC Intelligent supply chain standards	BCA Supply chain construction	BCAA Data sharing
		BCAB System construction and deployment
		BCAC Integration and improvement
	BCB Supply chain management	BCBA Supplier management
		BCBB Business coordinated management
	BCC Supply chain evaluation	BCCA Risk evaluation
		BCCB Capacity evaluation

Figure 7 Intelligent supply chain standard subsystem

Supply chain construction standards mainly include standards on data sharing, system construction and deployment of the upstream and downstream of the supply chain, as well as standards on resource integration and improvement inside and outside enterprises. Supply chain management standards mainly include supplier classification and grading, performance evaluation and other supplier management standards, as well as the upstream and downstream of the supply chain design, production, logistics, sales, service and other collaborative management standards. Supply chain evaluation standards mainly include supply chain risk identification and evaluation, risk warning and prevention and control risk evaluation standards, supply chain performance index system, testing and evaluation methods and other performance evaluation standards.

Key points of intelligent supply chain standard construction
Supply chain construction standards: standards on data format, system construction and deployment of the upstream and downstream of the supply chain; standards on resource integration and improvement. **Supply chain management standards**: standards on supplier classification, performance evaluation, design collaboration, production collaboration, logistics collaboration, sales collaboration, service collaboration of the upstream and downstream of the supply chain. **Supply chain evaluation standards**: standards on risk identification and evaluation, risk early warning and prevention control of supply chain; standards on supply chain performance indicator systems, and testing and evaluation methods.

(4) Intelligent service standards

Intelligent service standards mainly include three parts, namely mass customization, operation and maintenance services, and networked collaborative manufacturing – as shown in Figure 8. These are

mainly used to achieve the integration of products and services, the organic integration of decentralized manufacturing resources, as well as the high degree collaboration of their respective core competitiveness; they aim to solve the problem of comprehensive utilization of all kinds of internal and external resources of enterprises, providing all kinds of standardized and reliable new services.

BD Intelligent service	BDA Mass customization	BDAA General requirements
		BDAB Demand interaction requirement
		BDAC Design requirement
		BDAD Production requirement
	BDB Operation &maintenance service	BDBA General requirement
		BDBB Knowledge base
		BDBC Status monitoring
		BDBD Fault diagnosis
		BDBE Life prediction
		BDBF Operation & maintenance execution
	BDC Networked collaborative manufacturing	BDCA Overall architecture
		BDCB Platform techincal requirement
		BDCC Collaborative interaction procedure
		BDCD Resource model & Optimization Configuration
		BDCE Implementation guide

Figure 8 Intelligent service standard subsystem

Mass customization standards mainly include standards on general requirements, demand interaction requirements, design requirements, production requirements, evaluation and diagnosis. Operation and maintenance service standards mainly consist of standards on general requirements, knowledge base, status monitoring, fault diagnosis, life prediction, operation and maintenance execution. Networked collaborative manufacturing standards mainly include standards on the overall architecture, platform technical requirements, collaborative interaction process, resource model, and optimal configuration and implementation guide.

Key points of intelligent service standard construction
Operation and maintenance service standards: standards on knowledge base, status monitoring, fault diagnosis, life prediction, and operation and maintenance execution. **Networked collaborative manufacturing standards**: standards on the overall architecture, platform technical requirements, collaborative interaction process, resource model, and optimal configuration and implementation guide.

(5) Intelligent enabling technology standards

Intelligent enabling technology standards mainly include seven parts, namely artificial intelligence, industrial big data, industrial software, industrial cloud, edge computing, digital twin, and blockchain – as shown in Figure 9. These are mainly used to guide the integration and application of new technologies within the manufacturing industry, thus improving the intelligent level of the manufacturing industry.

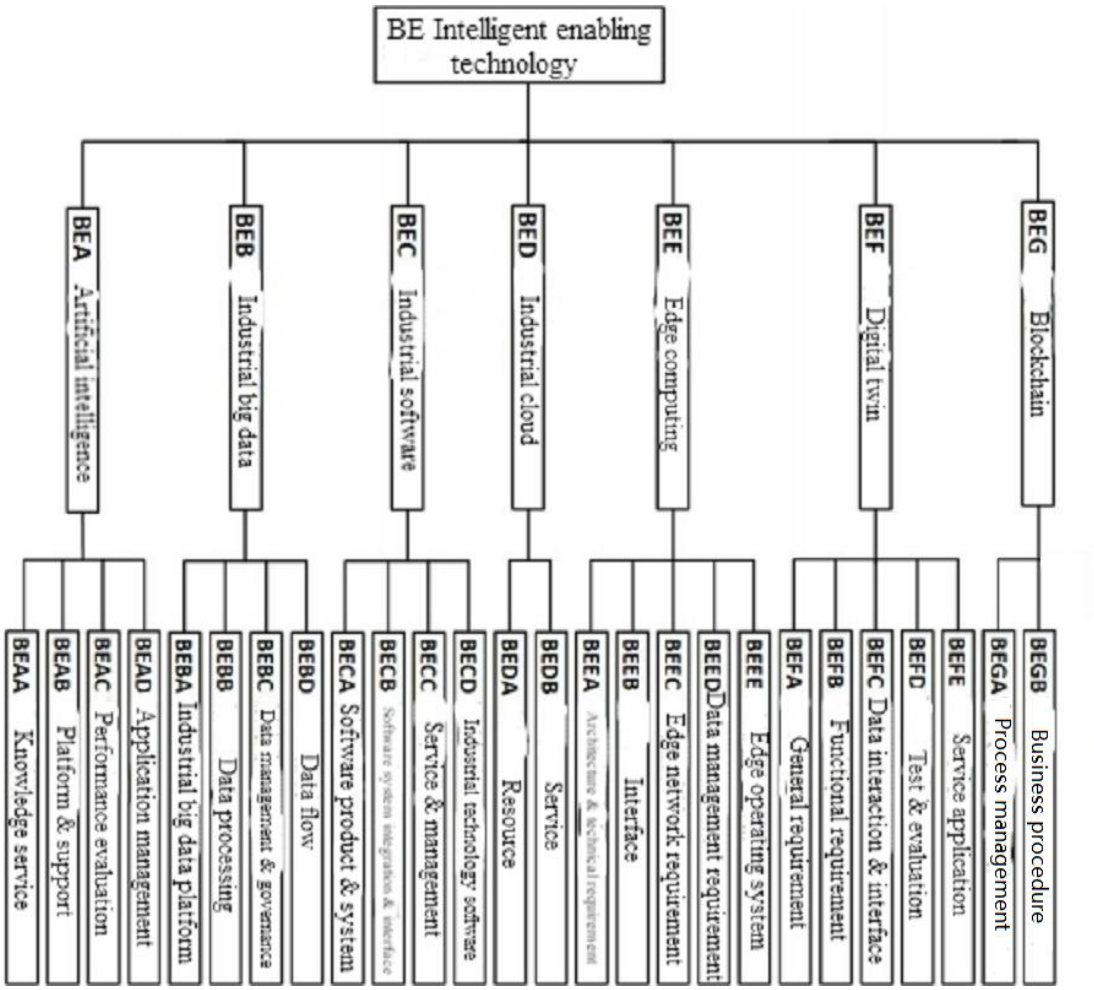

Figure 9 Intelligent enabling technology standard subsystem

A. Artificial intelligence standards mainly include knowledge service standards on machine learning, knowledge representation, knowledge modeling, knowledge fusion, and knowledge computing; platform and supporting standards on application platform architecture and integration requirements; performance evaluation standards on training data requirements, test guidelines and evaluation principles; as well as application management standards for whole life cycle of products for intelligent online detection and operation management and optimization.

B. Industrial big data standards mainly include standards on the requirements, operation, maintenance, testing and evaluation of industrial big data platforms; data processing standards on industrial big data acquisition, pre-processing, analysis, visualization and access; data management and governance standards on data management systems, data resource management, data quality management, master data management, data management capability maturity, etc; as well as data traffic standards on data sharing inside the factory and data exchange outside the factory.

C. Industrial software standards mainly consist of standards on the definition of functions, business models, quality requirements and maturity requirements of software products, tools, embedded software, systems and platforms; software integration and interface standards on industrial software interface specifications, integration procedures and product line engineering; service and management standards on life cycle management, quality management, asset management, configuration management, reliability requirements, and testing and verification; as well as industrial technology software standards on industrial technology software reference architecture and industrial application software packaging.

D. Industrial cloud standards mainly include standards on platform construction, application, access, configuration and management of industrial cloud resources and service capabilities; as well as service standards on implementation guide, capability evaluation, and effect evaluation.
E. Edge computing standards mainly include standards on architecture and technical requirements, interface, edge network requirements, data management requirements and edge operating systems.
F. Digital twin standards mainly include general requirement standards on reference architecture and information models; functional requirement standards for different system levels; data interaction and interface standards for integration and collaboration between digital twin systems; test and evaluation standards on performance evaluation and conformance test; as well as digital twin service application standards for different manufacturing scenarios.
G. Blockchain standards mainly include standards on process management standards for industrial product development and traceability, service and quality management based on blockchain technology; and blockchain-based business process standards on supply chain finance, cross-border trade and electronic contracts, procurement and logistics for manufacturing enterprises.

Key points of intelligent enabling technology standard construction
Artificial intelligence standards: knowledge service standards for whole life cycle of products for intelligent online detection and operation management and optimization, performance evaluation standards, platform and supporting standards. **Edge computing standards**: standards on architecture and technical requirements, interfaces, edge network requirements, data management requirements, and edge operating systems. **Digital twin standards**: standards on general requirements, reference architecture, data interaction and interface, and service application. **Blockchain standards**: blockchain-based standards for industrial product traceability, copyright protection of industrial design, trusted quality management, supply chain finance, electronic contracts, etc.

(6) Industrial network standards
Industrial network standards mainly include four parts, namely industrial wireless network, industrial wired network, industrial network convergence, and industrial network resource management – as shown in Figure 10. These are mainly used to meet the needs of low latency and high reliability within and between different system levels of the factory, to realize the networking between different levels and heterogeneous networks under the industrial network architecture, and to regulate the use of network address, service quality, wireless spectrum and network operation management.

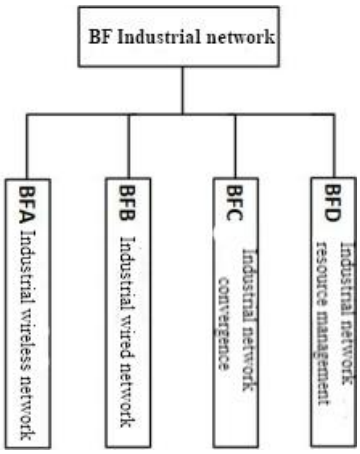

Figure 10 Industrial network standard subsystem

Industrial wireless network standards mainly include standards on Wireless Local Area Network (WLAN), wireless highway addressable remote transducer (WirelessHART), wireless network for industrial factory automation/industrial automation process automation (WIA-FA/PA), narrow-band Internet of things (NB-IoT), 5G application, etc. Industrial wired network standards mainly include standards on fieldbus, industrial Ethernet, industrial passive optical network (PON), and industrial generic cabling. Industrial network convergence standards mainly include standards on deterministic networking (DetNet), information technology/operational technology (IT/OT) convergence, and interconnection between heterogeneous networks. Industrial network resource management standards mainly include standards on network management, network address management, network spectrum management, and software defined network (SDN).

Key points of industrial network standard construction
Industrial wireless network standards: 5G application and other standards. **Industrial network convergence standards**: standards on IT/OT convergence, interconnection between heterogeneous networks. **Industrial network resource management standards**: standards on network management, network address management, network spectrum management, and SDN.

3. Industry application standards

It mainly includes 12 parts, including ships and marine engineering equipment, building materials, petrochemicals, textiles, iron and steel, rail transit, aerospace, automobiles, non-ferrous metals, electronic information, electric power equipment and others, as shown in Figure 11. The objectives of industry application standards are to: give full play to the guiding and supporting role of basic general standards and key technology standards in the formulation of industry application standards; pay attention to the coordination between sector standards and national standards; combined with the characteristics of the industry, focus on the development of specifications, procedures and guidelines for the application standards, further promote or improve the industry intelligent manufacturing standards system; and analyse light industry, food industry, agricultural machinery, construction machinery, nuclear energy, civil explosion and other intelligent manufacturing standardization key directions.

C Industry application standards	CA Ships and marine engineering equipment
	CB Building material
	CC Petrochemical
	CD Textile
	CE Steel
	CF Rail transit
	CG Aerospace
	CH Automobile
	CI Nonferrous metal
	CJ Electronic information
	CK Electric power equipment
	CL Others

Figure 11 Industry application standard subsystem

(1) Ships and marine engineering equipment

Technical requirements for 5G application shall be formulated with a focus on ship assembly and construction, and according to the characteristics of multi-variety, small batch and customization of shipbuilding and ocean engineering equipment manufacturing, also considering the application requirements of 5G and other digital new infrastructure, standards on coding, and data dictionary. The specifications or standards on information system interface, overall planning of production line and product collaborative design, shall be formulated with the focus on the construction of intelligent shipyards.

(2) Building material

In view of the characteristics of multiple subdivided segments and obvious technological differences in building material industry, smart factory specifications or procedures shall be formulated on factory design, technological simulation, quality control and warehousing management, with particular focus on the fields of cement, glass, ceramics, glass fiber, concrete, bricks and tiles, wall materials and mines. Guiding standards shall be formulated on 5G-based equipment inspection, artificial intelligence-based defect detection, industrial cloud-based supply chain collaboration, and remote equipment operation and maintenance.

(3) Petrochemical

Smart factory design specifications on smart factory information model shall be formulated, in light of the high safety risks, high actual control requirements, high energy consumption and high requirements for environmental protection in petrochemical industry. New technology application specifications or procedures shall be formulated on technological pre-warning, site personnel positioning, equipment health, operation alarm. Standards of application guidelines on equipment remote operation and maintenance shall also be formulated.

(4) Textile

In view of the characteristics of overall discrete and partial process manufacturing of the textile industry, specifications or guidelines for interconnection, information model, remote operation and maintenance technical requirements of special equipment shall be formulated, with a focus on the fields of spinning, chemical fiber, weaving, non-woven, printing and dyeing, clothing and home textile. Specifications or procedures on data, logistics storage and system integration in the process of digital workshop or smart factory construction shall also be formulated, together with new model application specifications or guidelines such as mass customization.

(5) Steel

Due to the characteristics of continuous process, complex technological systems and diversified intermediate state of products involved in steel production, the specifications on 5G application, unmanned driving and special robot application shall be formulated, with a focus on the application of intelligent technology in production scenario. The standards on factory design, digital delivery and digital twin model shall be formulated, with a focus on construction of smart factory. Specifications on quality, logistics, energy, environmental protection, equipment and global optimization of supply chain shall be formulated, with a focus on production intelligent management.

(6) Rail transit

In view of the characteristics of multi-variety, small batch, laying equal stress on manufacturing, operation, maintenance and customization of the rail transit industry, the key technology standards shall be formulated on intelligent equipment inspection and certification, three-dimensional model application specification, industrial robot interface and technological requirements, with a focus on typical business scenarios in smart factory construction of welding, grinding, assembly and debugging and logistics. The application standards on intelligent manufacturing project implementation guide and remote operation and maintenance for G-series high-speed trains shall also be formulated.

(7) Aerospace

In light of the characteristics of multi-variety, small batch, model-based development mode and multi-party collaboration of design and manufacturing of the aerospace industry, the standards on model-based digital design, cloud based collaborative design platform, virtual simulation of production line and environmental monitoring for complex technology shall be formulated, with a focus on the construction or upgrading of smart factory and digital workshop. The application standards on production process status prediction and optimization based on industrial big data shall also be formulated.

(8) Automobile

In view of the characteristics of strong technology intensity, numerous components and parts, long industrial chain, multiple subdivided models and complex production process of the automobile industry, standards on R&D of automobile products, test verification, production line manufacturing and integration based on digital twin shall be formulated, with a focus on the application of intelligent enabling technologies within new energy vehicles, traditional fuel vehicles painting, welding and final assembly. Application guides on R&D, production, marketing and supply chain management for automobile mass customization shall also be formulated.

(9) Nonferrous metal

In view of the characteristics of high safety requirements, huge difference in raw material quality, complex technology, multi-variety and small batch and frequent logistics scheduling in nonferrous metal industry, standards on information coding, information interaction and operation status management shall be formulated, with a focus on special intelligent equipment, smelting and production processes. Application guides on smart factory design, construction and production process monitoring shall also be formulated.

(10) Electronic information

In view of the characteristics of electronic information manufacturing industry, such as high technical complexity, rapid product iteration, obvious characteristics of multiple varieties and small batches, and rapid growth of product personalized and customized demand, to develop standards and specifications for information models and interconnection requirements of special intelligent equipment and systems for the production and processing of electronic information materials, components, and information and communication products and systems; develop construction guidelines and standards and system integration specifications for flexible production lines, digital workshops and intelligent factories; develop guidelines and standards for the application of new models such as personalized customization.

(11) Electric power equipment

In view of the obvious characteristics of the power equipment industry, such as multiple product types, personalized customization and large operation and maintenance needs, the construction guide and standards of smart factories and system integration specifications are to developed around smart grid clients and motors. Develop implementation guidelines and standards for digital simulation of manufacturing process (processing process, production planning and layout, logistics simulation), digital processing of resources, digital process control, digital collaborative manufacturing, remote operation and maintenance of equipment, personalized customization, intelligent manufacturing capacity assessment, etc.

(12) Others

Standards on the interconnection and online detection for special technological equipment shall be formulated for the light industry, with a focus on leather, primary battery and washing products. Mass customization guides for home appliances and furniture shall also be developed. Standards on smart factory design, brewing and filling, technological decision-making, remote operation and maintenance, and identification resolution, shall be formulated for the food industry, with a focus on dairy beverage, wine making, frozen food, and canned food. Design requirements based on digital twin, and implementation guides for mass customization, shall be formulated for the electronic industry. Standards on mass customization design, intelligent operation and maintenance services and monitoring, shall be developed for agricultural machinery and engineering machinery. Standards on flexible printing technological design and information exchange between systems shall be developed for the printing industry. Data-driven intelligent production standards shall be formulated for the nuclear energy industry. Finally, standards on key technological equipment status monitoring, operation and maintenance requirements shall be formulated for the civil explosive industry.

V Construction contents

To strengthen overall planning and coordination. To give full play to the role of the National Intelligent Manufacturing Standardization Coordination and Promotion Group, General Group and Expert Group, and carry out the construction and planning of the intelligent manufacturing standards system under the joint guidance of the Ministry of Industry and Information Technology and the Standardization Administration of China.

To speed up standard research and development. To make full use of schemes such as multi-department coordination and multi-standardization technical organization cooperation to coordinate the efforts of enterprises, universities, research institutes and users, strengthen the testing and verification of key technical standards, speed up the development of key and urgently needed standards, and promote the effective implementation of standards systems.

To strengthen dissemination and training on implementation. To give full play to the role of local competent departments, industry associations, standardization technical organizations and professional institutions, strengthen publicity and training of standards, and guide enterprises to meet standards in research and development, production, and management.

To conduct dynamic adjustment. In line with the needs of intelligent manufacturing technology and industrial development, to timely revise the *National Intelligent Manufacturing Standards System Construction Guide* to effectively and orderly guide the formulation and implementation of intelligent manufacturing standards.

To strengthen international exchanges and cooperation. To regularly hold international forums on intelligent manufacturing standardization, actively participate in international standardization activities in ISO, IEC and ITU, and deepen international standard cooperation in intelligent manufacturing.

Introduction of SESEC Project

The Seconded European Standardization Expert in China (SESEC) is a visibility project co-financed by the European Commission (EC), the European Free Trade Association (EFTA) secretariat and the three European Standardization Organizations (CEN, CENELEC and ETSI). Since 2006, there has been three SESEC projects in China, SESEC I (2006-2009). SESEC II (2009- 2012) and SESEC III (2014-2017). In April 2018, SESEC IV was officially launched in Beijing, China. Dr. Betty XU was nominated as the SESEC expert and will spend the next 36 months on promoting EU-China standardization information exchange and EU-China standardization cooperation.

The SESEC project supports the strategic objectives of the European Union, EFTA and the European Standardization Organizations (ESOs). The purpose of SESEC project is to:

- **Promote European and international standards in China;**
- **Improve contacts with different levels of the Chinese administration, industry and standardization bodies;**
- **Improve the visibility and understanding of the European Standardization System (ESS) in China;**
- **Gather regulatory and standardization intelligence.**

The following areas have been identified as sectorial project priorities by the SESEC project partners: Internet of Things (IoT) & Machine-to-Machine(M2M) communication, communication networks & services, cybersecurity & digital identity, Smart Cities (including transport, power grids & metering), electrical & electronic products, general product safety, medical devices, cosmetics, energy management & environmental protection (including eco-design & labelling, as well as environmental performance of buildings).