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Market Engineering

Market Study of Global and China's Wireless Communication Module Industry

Date: October 14, 2025

For and on behalf of
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Title: Consulting Director

Overall Assumptions and Methodology

Methodology:

In preparing the report, Frost & Sullivan has relied on the statistics and information obtained through primary and secondary research.

•Primary research includes interviewing industry insiders, competitors, downstream customers and recognized third-party industry associations.

•Secondary research includes reviewing corporate annual reports, databases of relevant official authorities, as well as the exclusive database established by Frost & Sullivan over the past decades.

Assumptions:

The market size and forecasts were modeled by Frost & Sullivan based on the following assumptions.

•The social, economic and political conditions in wireless communication module market in China discussed will remain stable during the forecast period;

•The wireless communication module market in China will be driven by the factors which are stated in this report.

Research Scope

Market Study of Global and China's Wireless Communication Module Industry

Research Period
- Base year: 2024
- Historical: 2020 to 2024
- Forecasting: 2025E to 2029E

Service Market Scope
- Communication Module Market
  - Wireless Communication Module Market

Geographical Scope
- Global
- China

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1	Analysis of Macro Background and Key Downstream Demand
2	Analysis of Wireless Communication Module Market in the Global and China
3	Analysis of Competitive Landscape of Wireless Communication Module Market
4	Overview of the Company's Focus in the Field of Robotics

Analysis of Macro Background and Key Downstream Demand

Analysis of Macro Background and Key Downstream Demand
Macro Background Analysis of Wireless Communication Modules

- Driven by the wave of digitalization and intelligence, wireless communication modules have increasingly become a vital bridge connecting hardware and networks, data and services. Their emergence stems from the growing demand for mobile and real-time data transmission, evolving from basic voice calls and SMS to today's high-speed data connectivity and diversified application scenarios. As information technologies have advanced, communication modules have progressed from early 2G/3G/4G standards to the current 5G, enabling faster, more stable, and more secure wireless connections for application scenarios such as automotive electronics smart home, consumer electronics, and smart retail. Entering the era of intelligent connectivity, the demand for data transmission and processing has expanded further, prompting a shift from basic data transmission modules to smart modules with built-in computing capabilities. These smart modules not only support higher bandwidth and lower latency networks, integrating CPUs, operating systems, and development environments, but also enable terminal devices to perform real-time data processing and multimedia functions.

- With the rapid evolution and widespread application of artificial intelligence, the industry is moving toward cloud-edge-device collaboration to support deeper AI integration. As a result, AI modules have emerged — embedding powerful algorithms and computing capabilities into wireless communication modules. These modules can perform tasks such as machine learning inference, image recognition, or voice interaction directly on the device side, relieving cloud pressure and improving response speed. In this transformation, the wireless communication module market has grown substantially alongside the shift from intelligent connectivity to the AI era, unlocking new growth opportunities and innovation potential across a wide range of application scenarios.

Source: Frost & Sullivan

Analysis of Macro Background and Key Downstream Demand
Analysis of Development of Wireless Communication, Artificial Intelligence and Edge AI (1/2)
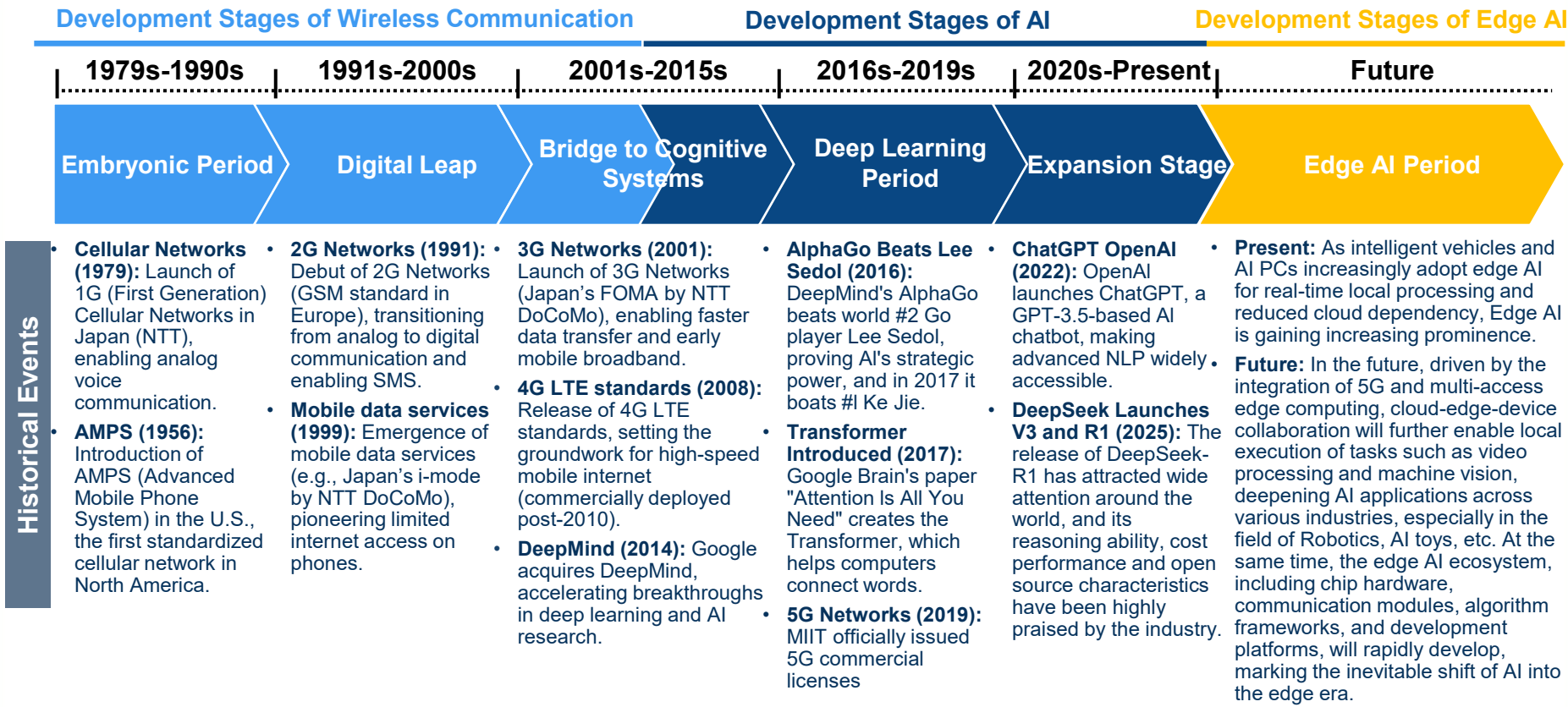
- Since the late 20th century, the widespread adoption of cellular networks (2G/3G) has driven the rapid development of mobile internet, resulting in a surge in device connectivity demands. Data transmission modules emerged to provide standardized wireless access, mainly supporting basic data communication in Machine-to-Machine scenarios. With the maturation of 4G/5G and the explosive growth of IoT, terminals began requiring stronger local processing and control capabilities, driving the rise of smart modules. These modules combine cellular connectivity with high-performance processors and OS, enabling complex algorithm execution and multi-protocol support, and are widely used in automotive electronics, smart home, consumer electronics, smart retail, etc.

- As entering the AI era, demands for low-latency and efficient on-device inference surged, leading to the emergence of the "cloud-edge-device" architecture. AI modules, the next evolution of smart modules, integrate NPUs and advanced computing units to deliver powerful heterogeneous computing for local AI inference in industrial, urban, and home scenarios. Combining communication and AI processing, AI modules are ideal enablers of Edge AI, with broad potential across AIoT applications — such as real-time image recognition in smart homes or ADAS in vehicles. Their high integration and adaptability position them as a cornerstone of future Edge AI.

Source: Frost & Sullivan

The Development of Wireless Communication, Artificial Intelligence and Edge AI Historical

Development Stages of Wireless Communication | **Development Stages of AI** | **Development Stages of Edge AI**

1979s-1990s	1991s-2000s	2001s-2015s	2016s-2019s	2020s-Present	Future
Embryonic Period	Digital Leap	Bridge to Cognitive Systems	Deep Learning Period	Expansion Stage	Edge AI Period

Historical Events

- **Cellular Networks (1979):** Launch of 1G (First Generation) Cellular Networks in Japan (NTT), enabling analog voice communication.
- **AMPS (1956):** Introduction of AMPS (Advanced Mobile Phone System) in the U.S., the first standardized cellular network in North America.

- **2G Networks (1991):** Debut of 2G Networks (GSM standard in Europe), transitioning from analog to digital communication and enabling SMS.
- **Mobile data services (1999):** Emergence of mobile data services (e.g., Japan's i-mode by NTT DoCoMo), pioneering limited internet access on phones.

- **3G Networks (2001):** Launch of 3G Networks (Japan's FOMA by NTT DoCoMo), enabling faster data transfer and early mobile broadband.
- **4G LTE standards (2008):** Release of 4G LTE standards, setting the groundwork for high-speed mobile internet (commercially deployed post-2010).
- **DeepMind (2014):** Google acquires DeepMind, accelerating breakthroughs in deep learning and AI research.

- **AlphaGo Beats Lee Sedol (2016):** DeepMind's AlphaGo beats world #2 Go player Lee Sedol, proving AI's strategic power, and in 2017 it boats #I Ke Jie.
- **Transformer Introduced (2017):** Google Brain's paper "Attention Is All You Need" creates the Transformer, which helps computers connect words.
- **5G Networks (2019):** MIIT officially issued 5G commercial licenses

- **ChatGPT OpenAI (2022):** OpenAI launches ChatGPT, a GPT-3.5-based AI chatbot, making advanced NLP widely accessible.
- **DeepSeek Launches V3 and R1 (2025):** The release of DeepSeek-R1 has attracted wide attention around the world, and its reasoning ability, cost performance and open source characteristics have been highly praised by the industry.

- **Present:** As intelligent vehicles and AI PCs increasingly adopt edge AI for real-time local processing and reduced cloud dependency, Edge AI is gaining increasing prominence.
- **Future:** In the future, driven by the integration of 5G and multi-access edge computing, cloud-edge-device collaboration will further enable local execution of tasks such as video processing and machine vision, deepening AI applications across various industries, especially in the field of Robotics, AI toys, etc. At the same time, the edge AI ecosystem, including chip hardware, communication modules, algorithm frameworks, and development platforms, will rapidly develop, marking the inevitable shift of AI into the edge era.

Source: Frost & Sullivan

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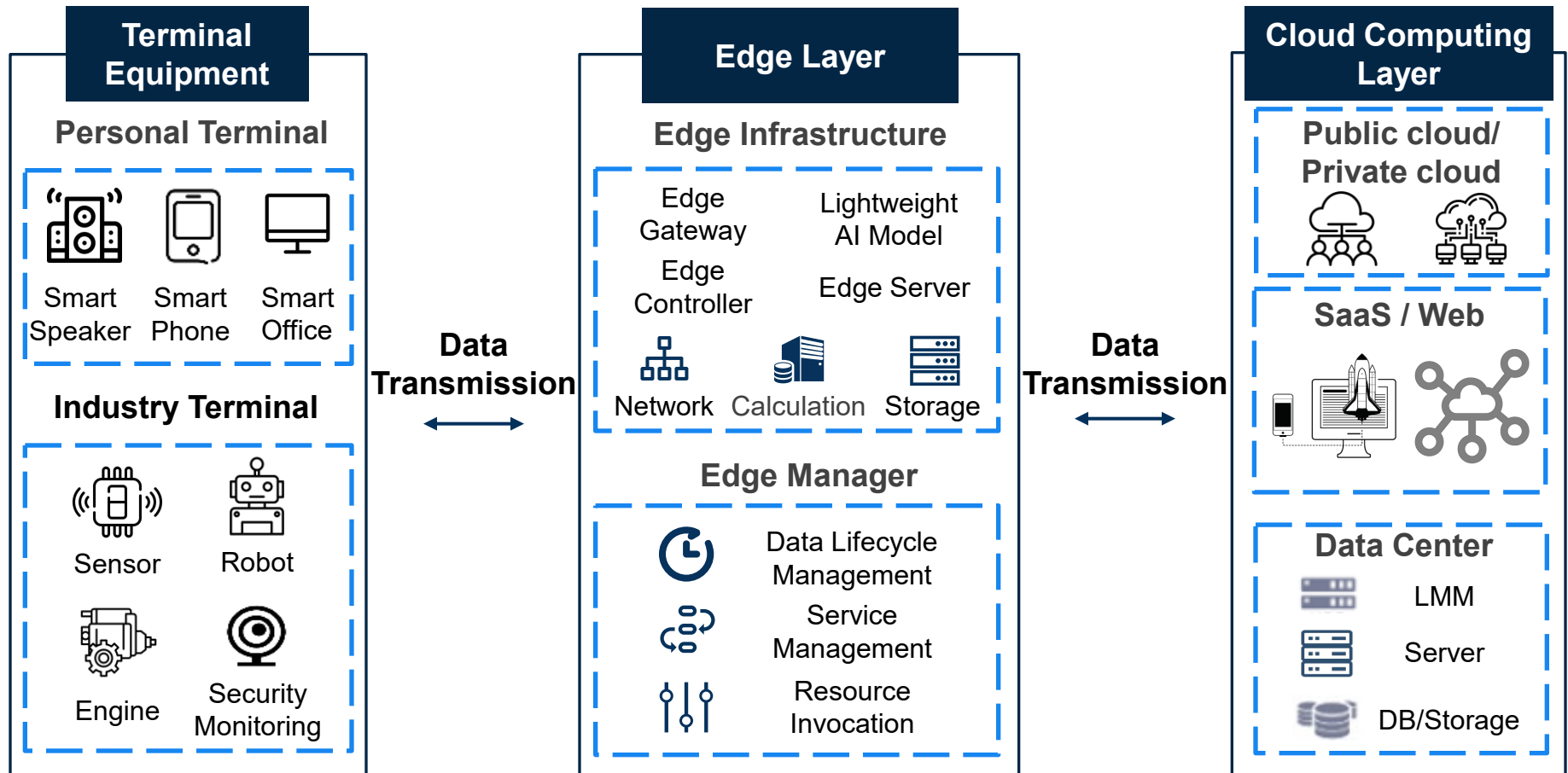
Analysis of Macro Background and Key Downstream Demand
Introduction to Cloud-Edge-Device Framework (1/2)

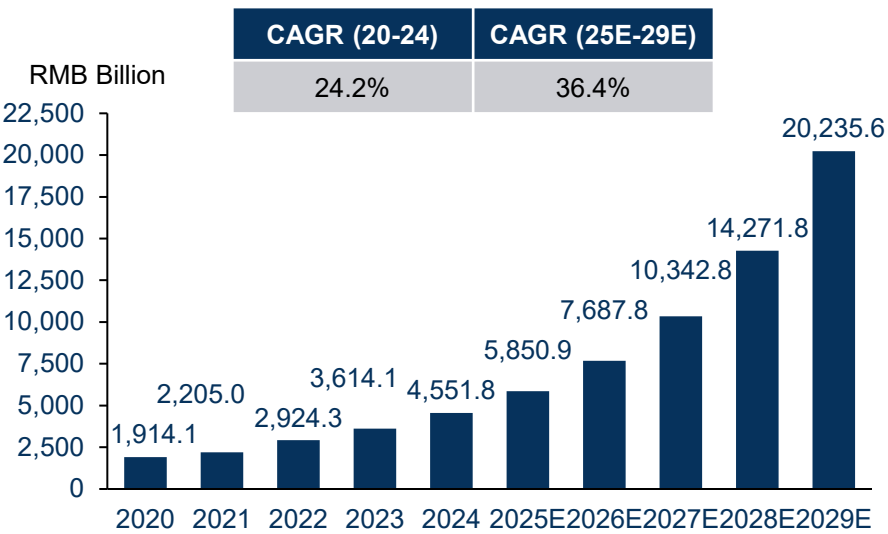- The cloud-edge-end architecture is a distributed model that integrates cloud computing, edge computing, and end devices. The cloud side is responsible for handling complex computations and big data storage (such as AI model training), and the edge layer completes real-time analysis locally (such as industrial quality inspection and autonomous driving decision-making). The end layer is further subdivided into personal end products (such as speakers, phones, and office equipment) and industry end devices (such as industrial sensors, robots, and medical equipment).

Source: Frost & Sullivan

Analysis of Macro Background and Key Downstream Demand
Introduction to Cloud-Edge-Device Framework (2/2)

Cloud-Edge-Device Architecture Analysis

Terminal Equipment

Personal Terminal

- Smart Speaker
- Smart Phone
- Smart Office

Industry Terminal

- Sensor
- Robot
- Engine
- Security Monitoring

Data Transmission

Edge Layer

Edge Infrastructure

- Edge Gateway
- Lightweight AI Model
- Edge Controller
- Edge Server
- Network
- Calculation
- Storage

Edge Manager

- Data Lifecycle Management
- Service Management
- Resource Invocation

Data Transmission

Cloud Computing Layer

Public cloud/ Private cloud

SaaS / Web

Data Center

- LMM
- Server
- DB/Storage

Source: Frost & Sullivan

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Analysis of Macro Background and Key Downstream Demand
Macro Background Analysis of AI market - Market Size of Artificial Intelligence

- AI technology is catalyzing transformative change and innovation across the global economy and society, driven by rapid technological advancements, surging investments, and the expanding application of AI across diverse industries. Globally, the AI market has grown exponentially, expanding from RMB 1,914.1 billion in 2020 to RMB 4,551.8 billion in 2024, reflecting a CAGR of 24.2%. This momentum is projected to accelerate further, with the global market expected to surge to RMB 20,235.6 billion by 2029, achieving a CAGR of 36.4% from 2025 to 2029.

- Within this dynamic landscape, China's AI market has emerged as a key driver of growth, demonstrating remarkable expansion from RMB 325.1 billion in 2020 to RMB 733.0 billion in 2024, achieving a CAGR of 22.5%. While slightly trailing the global growth rate in the early phase, China's market is poised for explosive acceleration in the forecast period, projected to reach RMB 3,359.9 billion by 2029 with a CAGR of 37.2% from 2025 to 2029. This growth not only underscores the pivotal role of AI in shaping future economic landscapes but also highlights China's strategic positioning as a global leader in AI innovation and adoption.

Market Size of AI Industry (by revenue), Global, 2020-2029E

RMB Billion

CAGR (20-24)	CAGR (25E-29E)
24.2%	36.4%

Year	Value
2020	1,914.1
2021	2,205.0
2022	2,924.3
2023	3,614.1
2024	4,551.8
2025E	5,850.9
2026E	7,687.8
2027E	10,342.8
2028E	14,271.8
2029E	20,235.6

Market Size of AI Industry (by revenue), China, 2020-2029E

RMB Billion

CAGR (20-24)	CAGR (25E-29E)
22.5%	37.2%

Year	Value
2020	325.1
2021	430.6
2022	508.0
2023	578.4
2024	733.0
2025E	948.1
2026E	1,253.4
2027E	1,696.6
2028E	2,355.4
2029E	3,359.9
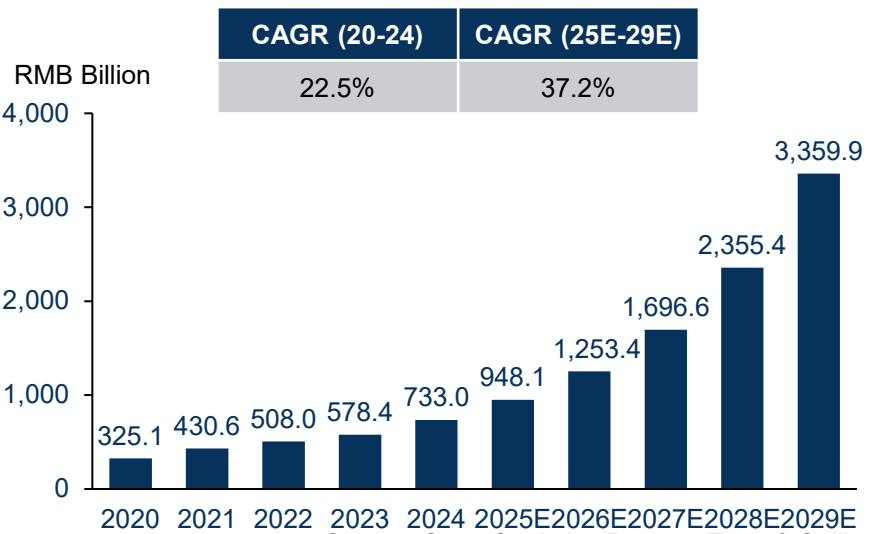
Source: State Statistics Bureau, Frost & Sullivan

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Analysis of Macro Background and Key Downstream Demand
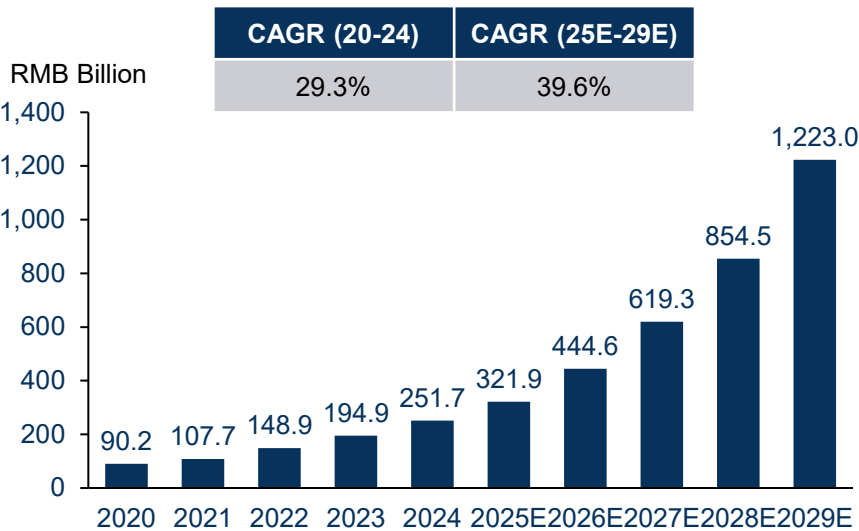# Macro Background Analysis of AI market - Definition of Edge AI

- Edge AI is a technology that deploys artificial intelligence capabilities on various end devices such as sensors and IoT terminals, enabling localized data processing and decision-making. It supports devices to execute AI tasks independently or coordinate in a hybrid manner with the cloud. It can process data at the source, thus reducing latency, enhancing privacy, optimizing bandwidth, and maintaining compatibility with the cloud architecture at the same time.

- The core differences between edge AI and traditional AI mainly lie in three aspects: First, in terms of deployment architecture, edge AI prioritizes local processing on terminal devices, often with cloud collaboration for model optimization, while traditional AI mainly relies on cloud servers for centralized processing. Second, in terms of data dimensions, edge AI can achieve the integrated application of local real-time sensor data and cloud historical data, whereas traditional AI mainly relies on data in cloud databases for processing. Finally, in terms of application scenarios, edge AI can enable local large model inference and autonomous decision-making, while traditional AI is better suited for handling large-scale data analysis tasks in the cloud. For example, edge AI applications include AI phone, AIPC, and embodied intelligent robot, while traditional AI includes customer behavior analysis in enterprise-level SaaS services and financial risk control modeling.

Analysis of Macro Background and Key Downstream Demand
Macro Background Analysis of AI market - Market Size of Edge AI

- The global Edge AI market has demonstrated explosive growth, expanding from RMB90.2 billion in 2020 to RMB251.7 billion in 2024, achieving a CAGR of 29.3%. This momentum is projected to accelerate further, with the market expected to surge from RMB321.9 billion in 2025 to RMB1,223.0 billion by 2029, reflecting an even higher CAGR of 39.6%. Meanwhile, China's Edge AI market has mirrored this upward trajectory, rising from RMB23.6 billion in 2020 to RMB61.4 billion in 2024. Looking ahead, China's market is forecast to outpace global growth, climbing from RMB80.2 billion in 2025 to RMB307.7 billion by 2029 at a remarkable CAGR of 39.9%. These figures underscore the rapid adoption of Edge AI technologies worldwide, driven by demand for real-time data processing, IoT integration, and decentralized computing solutions.

Market Size of Edge AI Industry (by revenue), Global, 2020-2029E

CAGR (20-24)	CAGR (25E-29E)
29.3%	39.6%

RMB Billion

Year	Value
2020	90.2
2021	107.7
2022	148.9
2023	194.9
2024	251.7
2025E	321.9
2026E	444.6
2027E	619.3
2028E	854.5
2029E	1,223.0

Market Size of Edge AI Industry (by revenue), China, 2020-2029E

CAGR (20-24)	CAGR (25E-29E)
27.1%	39.9%

RMB Billion

Year	Value
2020	23.6
2021	32.4
2022	41.7
2023	48.0
2024	61.4
2025E	80.2
2026E	108.2
2027E	149.4
2028E	207.4
2029E	307.7

Source: Frost & Sullivan
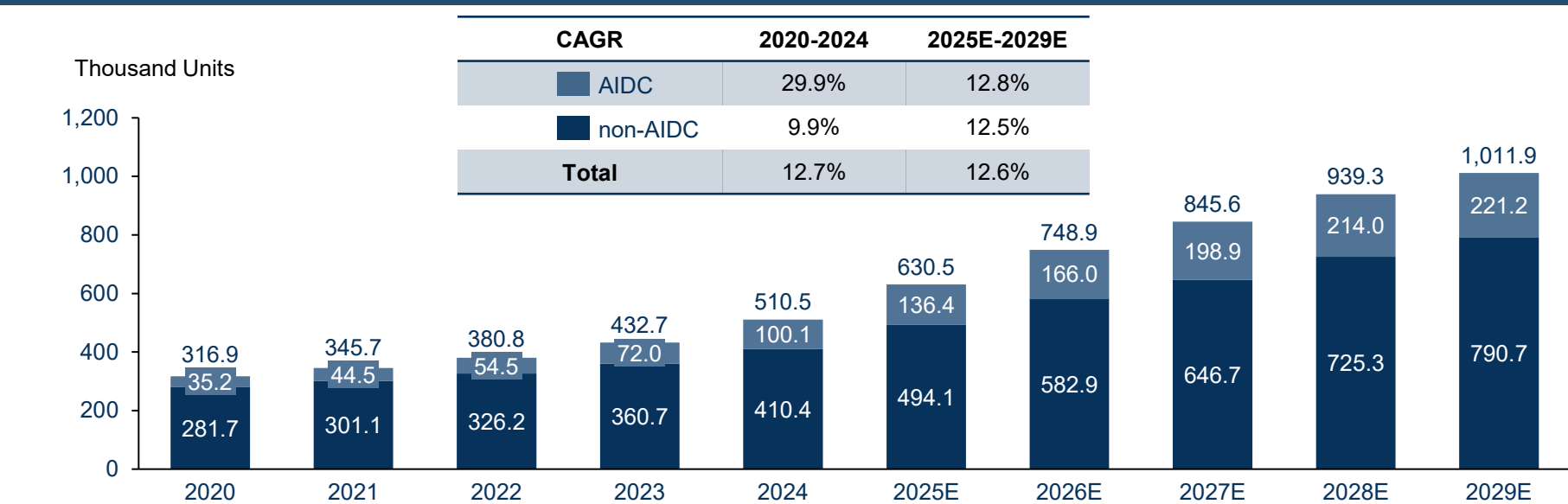
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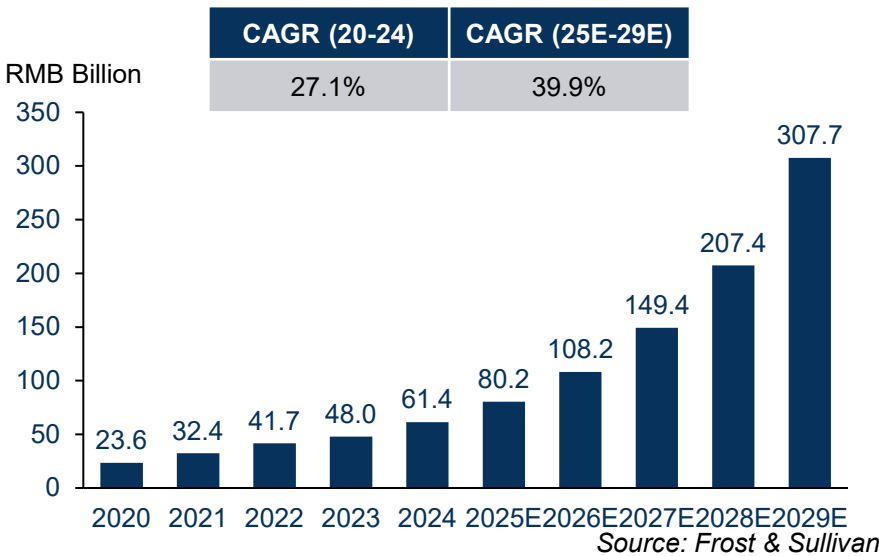
Analysis of Macro Background and Key Downstream Demand
Macro Background Analysis of AI market - The Large Language Model

Multimodal large language models are rapidly advancing in industry applications

Code understanding
coding
Code
3D scene description
3D
3D automatic modeling
Large model capability
image description
target detection
Image
image retrieval
Image generation
Video Q&A
Voice generation
Voice
False audio identification
Speech classification
speech recognition
speech synthesis
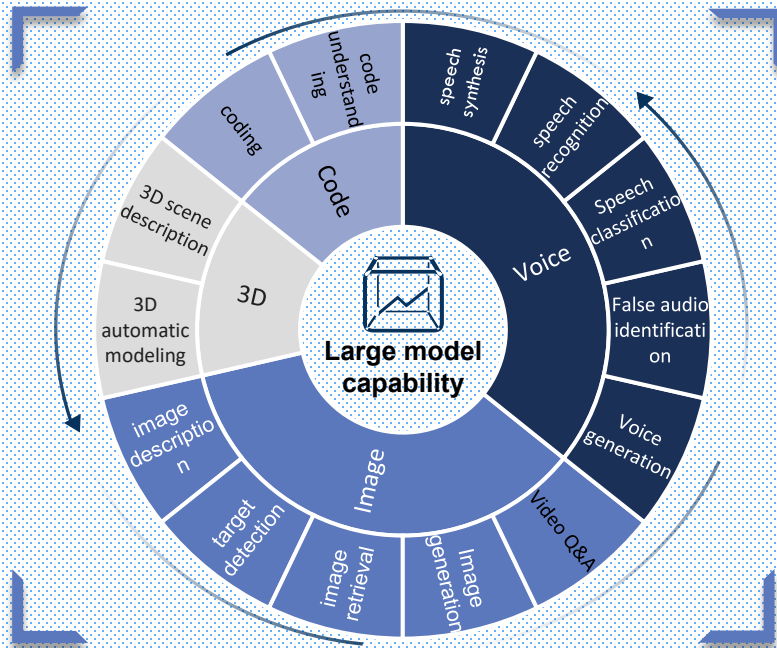
Characteristics of Large Language Model

① **Massive Parameter Scale:** Billions of parameters enable complex pattern recognition and contextual understanding
② **Multimodal Integration:** Processes text, images, and audio simultaneously for unified AI task execution
③ **Adaptive Learning:** Dynamically updates knowledge through continuous training and real-time feedback loops

□ ***The United States and China are the dominant forces in the research and development of AI large language models.*** *Leveraging its robust scientific research capabilities, technological innovation, and substantial resource investments, the United States has achieved a world-leading position in the quality, performance, and broad application of large language models, establishing a benchmark for global AI technology advancement. Meanwhile, China has emerged as a close contender. In recent years, the Chinese government has prioritized the research and application of artificial intelligence technology, driving the rapid development of AI large language models and related industries through comprehensive measures, including policy guidance, financial support, and talent cultivation.*

Global Trends in the Development of Artificial Intelligence Industry

Multimodal interaction deepens

Significant improvement in language modeling ability

Increased ethical and safety concerns

New testing challenges are gradually emerging

Continuous improvement in technical details
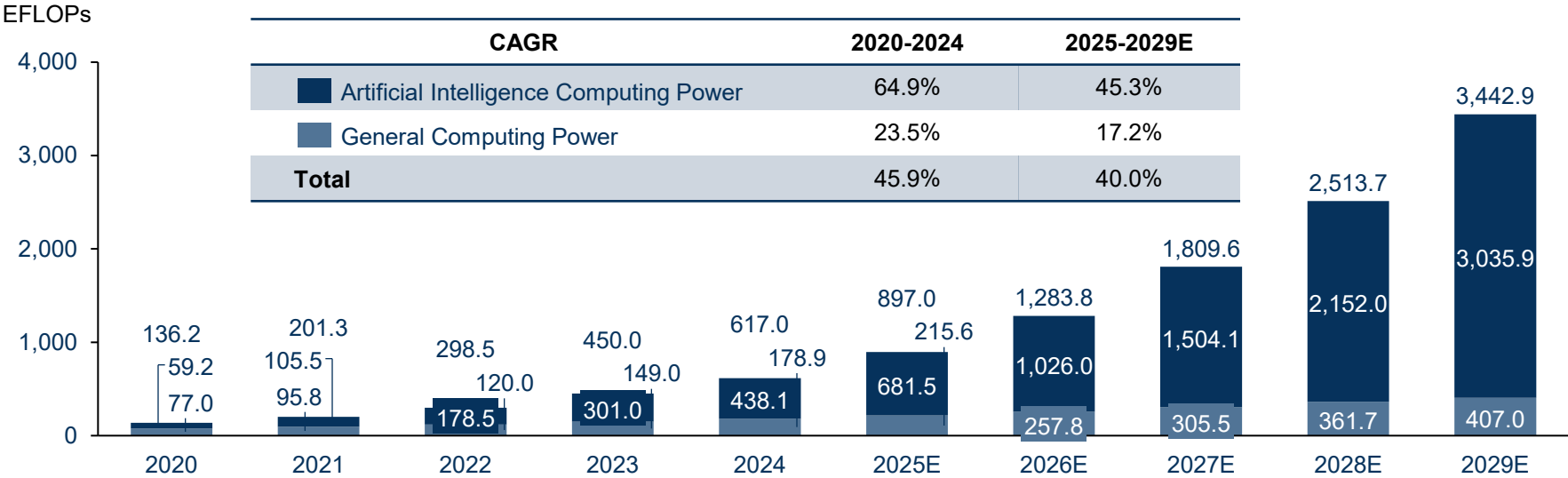
Cross domain exploration continues to deepen

Source: Frost & Sullivan

Analysis of Macro Background and Key Downstream Demand
Macro Background Analysis of AI market - The Number of Newly Built Cabinets

- The total number of newly built cabinets in the IDC industry in China increased from 316.9 thousand units in 2020 to 510.5 thousand units in 2024, representing a CAGR of 12.7%, reflecting a robust expansion as AI technologies and AI-driven businesses continue to gain traction. It is expected to reach 1,011.9 thousand units by 2029, representing a CAGR of 12.6% from 2025 to 2029.

- With the emergence and development of generative AI, downstream demand for AIDC rapidly increased from 2020 to 2024. The total number of newly built cabinets applied for AIDCs increased from 35.2 thousand units in 2020 to 100.1 thousand units in 2024, representing a CAGR of 29.9%, which is much higher than that for non-AIDC. By 2029, the total number of newly built cabinets in AIDCs is expected to reach 221.2 thousand units due to the large market space and increasing number of market players, representing a CAGR of 12.8% from 2025 to 2029.

Total Number of Newly Built Cabinets in IDC Industry, China, 2020-2029E

CAGR	2020-2024	2025E-2029E
AIDC	29.9%	12.8%
non-AIDC	9.9%	12.5%
Total	12.7%	12.6%

Thousand Units

Year	non-AIDC	AIDC	Total
2020	281.7	35.2	316.9
2021	301.1	44.5	345.7
2022	326.2	54.5	380.8
2023	360.7	72.0	432.7
2024	410.4	100.1	510.5
2025E	494.1	136.4	630.5
2026E	582.9	166.0	748.9
2027E	646.7	198.9	845.6
2028E	725.3	214.0	939.3
2029E	790.7	221.2	1,011.9

Source: Frost & Sullivan

Analysis of Macro Background and Key Downstream Demand
Macro Background Analysis of AI market - The Scale of Computing Power of IDC

- With the continuous investment of the IDC industry in China, the total size of computing power in China has continued to expand. The rapid development of computing power is supported by the Action Plan for High-quality Development of Computing Infrastructure (《算力基础设施高质量发展行动计划》) as well, which was announced by Ministry of Industry and Information Technology and other government departments. According to the Plan, key tasks will be set concerning improving the comprehensive supply system of computing power, improving computing power efficient carrying capacity, and enhancing the application of computing power empowerment, etc.

- Measured by computing power level, there are two types of computing power with notable commercial importance: (i) general computing power and (ii) AI computing power. General computing power refers to the general capability of a computing system to perform computations, process data, and execute instructions. AI computing power refers to the computer system capability that supports artificial intelligence algorithm model training and the operation of AI models and applications. For example, home and office computers or laptops represent general computing power, while cloud-based AI platforms provide AI-specific computing power.

- In 2024, the total size of computing power in China increased to 617.0 EFLOPs from 136.2 EFLOPs in 2020, and it is expected to increase to 3,442.9 EFLOPs in 2029, representing a CAGR of 40.0% from 2025 to 2029. The increase was primarily driven by the increase in AI computing power, which accounts for the highest percentage among the overall computing power demands in China.

The Scale of Computing Power of IDC Industry, China, 2020-2029E

CAGR	2020-2024	2025-2029E
Artificial Intelligence Computing Power	64.9%	45.3%
General Computing Power	23.5%	17.2%
Total	45.9%	40.0%

EFLOPs

Year	Total	AI Computing Power	General Computing Power
2020	136.2	59.2	77.0
2021	201.3	105.5	95.8
2022	298.5	120.0	178.5
2023	450.0	149.0	301.0
2024	617.0	178.9	438.1
2025E	897.0	215.6	681.5
2026E	1,283.8	1,026.0	257.8
2027E	1,809.6	1,504.1	305.5
2028E	2,513.7	2,152.0	361.7
2029E	3,442.9	3,035.9	407.0

Source: Frost & Sullivan

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Analysis of Macro Background and Key Downstream Demand
Macro Background Analysis of AI market – Downstream Demand in the AI Field

Analysis of Downstream Applications of Communication Modules

- Driven by AI technology, wireless communication modules are upgrading from traditional "data transmission pipelines" to "edge computing nodes" with intelligent decision-making capabilities. AI empowers wireless communication modules mainly through four technical paths to achieve upgrades: edge computing power integration, intelligent resource management, multimodal data fusion, and security enhancement. The core application scenarios cover industrial quality inspection, autonomous driving, and smart home. Through the "cloud-edge-device" collaborative architecture, the transformation from a data transmission pipeline to an intelligent decision-making node is realized. With the development of 5G and lightweight large models, AI modules are becoming the core carriers of the intelligent interconnection of all things.

Analysis of the Demand for Communication Module in the AI Field

Data transmission module	Smart module	AI module
Requirement analysis:	**Requirement analysis:**	**Requirement analysis:**
• Channel state prediction for adaptive modulation/coding schemes • Beamforming optimization in mmWave 5G deployments • Intelligent packet prioritization based on content semantics	• AI enables predictive maintenance through vibration pattern analysis, reducing field failures in industrial IoT deployments. The growing need for autonomous decision-making at the edge drives demand for NPU-enhanced modules capable of running TinyML frameworks	• AI-specific communication modules are engineered with hardware-accelerated AI cores to address exploding computational demands. These modules require co-optimized hardware-software architectures supporting quantized neural networks and federated learning workflows
Product Function:	**Product Function:**	**Product Function:**
• Act as AI data arteries for time-sensitive model training pipelines • Implement AI-driven congestion control in dense IoT environments	• Execute localized AI inference for latency-sensitive tasks • Implement adaptive signal processing using reinforcement learning for optimal spectrum utilization	• Deploy on-device AI models for vision/audio processing in smart cameras/mics • Enable real-time sensor fusion through parallel AI pipelines

Source: Frost & Sullivan

Analysis of Macro Background and Key Downstream Demand
Demand Analysis of Communication Modules for AI Development

- Driven by AI technology, wireless communication modules are upgrading from traditional "data transmission pipelines" to "edge computing nodes" with intelligent decision-making capabilities. AI empowers wireless communication modules mainly through four technical paths to achieve upgrades: edge computing power integration, intelligent resource management, multimodal data fusion, and security enhancement. The core application scenarios cover industrial quality inspection, autonomous driving, and smart home. Through the "cloud-edge-device" collaborative architecture, the transformation from a data transmission pipeline to an intelligent decision-making node is realized. With the development of 5G and lightweight large models, AI modules are becoming the core carriers of the intelligent interconnection of all things.

- Wireless communication modules have emerged as foundational enablers across industries, bridging physical devices with digital intelligence through seamless connectivity. Their versatility spans automotive electronics, smart home, consumer electronics and smart retail serving as the nervous system of our increasingly interconnected world. In edge AI domains, these modules play a critical role in enabling robotic systems with autonomous decision-making capabilities, powering AI PCs, driving collaborative robotics with real-time environmental awareness. Beyond core AI applications, their influence extends to traditional sectors: enhancing conventional automotive electronics with predictive maintenance capabilities, optimizing legacy PC architectures through intelligent resource allocation, and modernizing consumer electronics with localized AI processing. The modules' evolving architecture integrates AI chips and positions them as cross-industry enablers, transforming basic connectivity into adaptive cognitive networks that respond to operational demands. As industries merge physical and digital workflows, wireless communication modules evolve from passive data conduits into intelligent nodes capable of localized analytics, protocol-independent optimization, and edge-to-cloud coordination — effectively serving as the foundational "smart terminal" empowering intelligent automotive systems, AI-ready PCs, autonomous robotics, smart home networks, and next-generation retail infrastructure.

Source: Frost & Sullivan

Analysis of Macro Background and Key Downstream Demand
Analysis of Downstream Application – Overview of Downstream Demand (2/2)

Overview of Downstream Application Scenarios for Wireless Communication Modules

Traditional Fields		Edge AI Fields

① Automotive Electronics
- Telematics
- Predictive diagnostics
- …

Intelligent Vehicle
- ✓ Vehicle networking
- ✓ Remote monitoring
- ✓ Autonomous driving
- ✓ …

② Consumer Electronics
- Wireless networking
- Remote access
- Data synchronization
- Entertainment enhancement
- …

AIPC
- ✓ Smart control
- ✓ Environmental perception
- ✓ Remote monitoring
- ✓ …

④ Smart Home
- Network aggregation
- Protocol conversion
- Smart home control
- …

AI Home
- ✓ Entertainment companion
- ✓ Smart Gateway
- ✓ …

③ Smart Retail
- Payment processing
- Data transmission
- Customer service
- Security monitoring
- …

Unmanned retail
- ✓ Automatic settlement
- ✓ Intelligent monitoring
- ✓ Remote management
- ✓ …

Source: Frost & Sullivan

Analysis of Macro Background and Key Downstream Demand
Analysis of Development Trends of the Edge AI Market (1/2)

- The Edge AI market is experiencing explosive growth by combining miniaturized computing, advanced neural networks, and ubiquitous connectivity. It enables real-time decisions through NLP-enhanced interfaces and computer vision for autonomous systems, while reducing cloud dependence. Deployed in vehicles, robotics and computing architectures, Edge AI delivers localized intelligence that optimizes responsiveness and privacy. Emerging hybrid architectures balance accuracy and latency using vision transformers and CNNs, while reinforcement learning improves wireless communication module operations. Key trends include vertical-specific AI chips, federated learning frameworks, and self-evolving models. With 5G-Advanced and Wi-Fi 7, Edge AI leverages wireless communication modules' split computing capabilities to dynamically allocate tasks between local and cloud resources.

- The following figure shows the market size of key downstream industries for Communication Modules in the field of edge AI:

Source: Frost & Sullivan
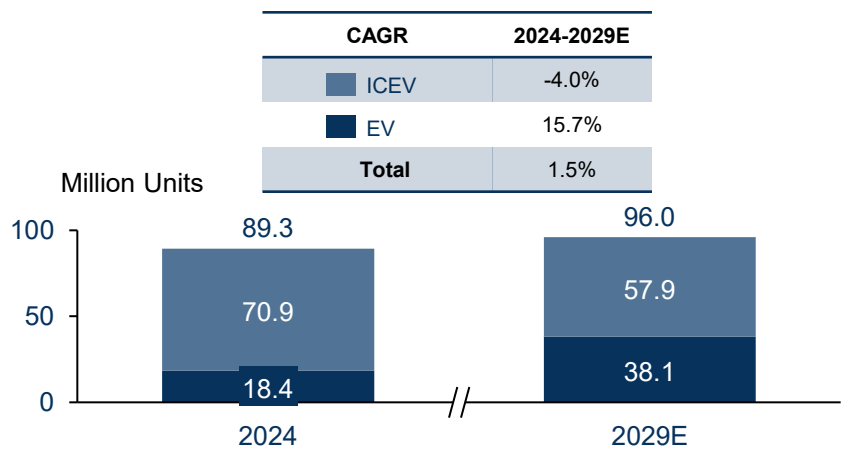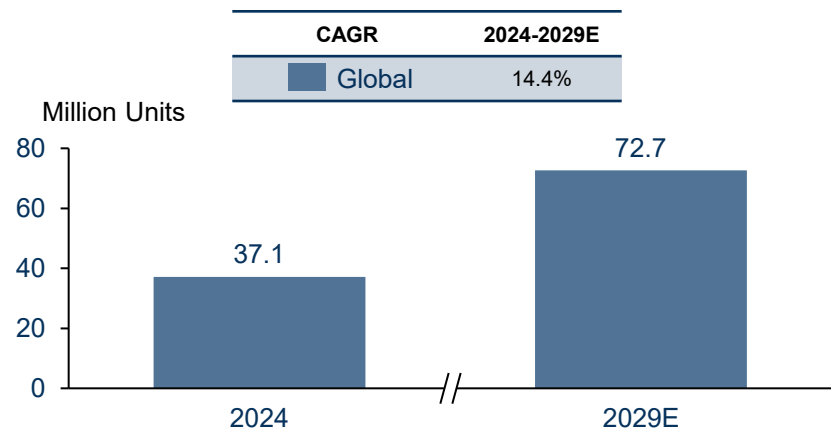
Analysis of Macro Background and Key Downstream Demand
Analysis of Development Trends of the Edge AI Market (2/2)

The Market Size of Key Downstream Industries for Communication Modules in the Field of Edge AI

Market Size of Service Robot Industry (by revenue), China & ROW, 2024&2029E

RMB Billion

China / ROW

- 2024: 223.3 (China 73.1, ROW 150.2)
- 2029E: 604.7 (China 183.7, ROW 421.0)

AI PC Shipments, China & ROW , 2024&2029E

Million Units

China / ROW

- 2024: 48.0 (China 14.5, ROW 33.5)
- 2029E: 215.2 (China 54.5, ROW 160.7)
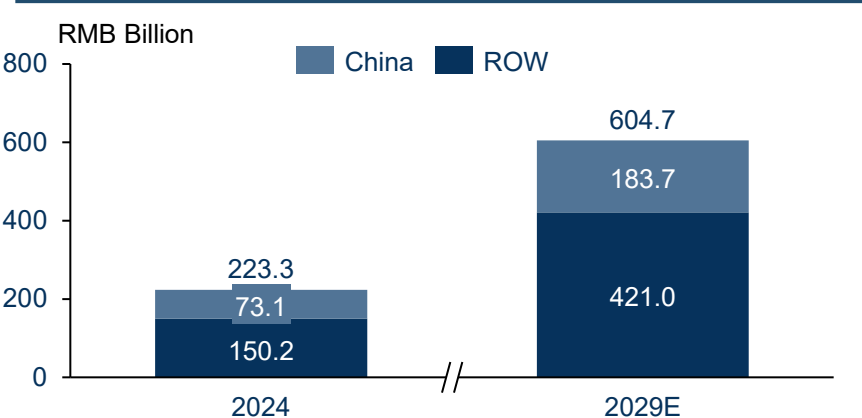
Intelligent Vehicle Shipments, China & ROW, 2024&2029E

Million Units

China / ROW

- 2024: 51.5 (China 16.7, ROW 34.8)
- 2029E: 88.6 (China 30.2, ROW 58.4)
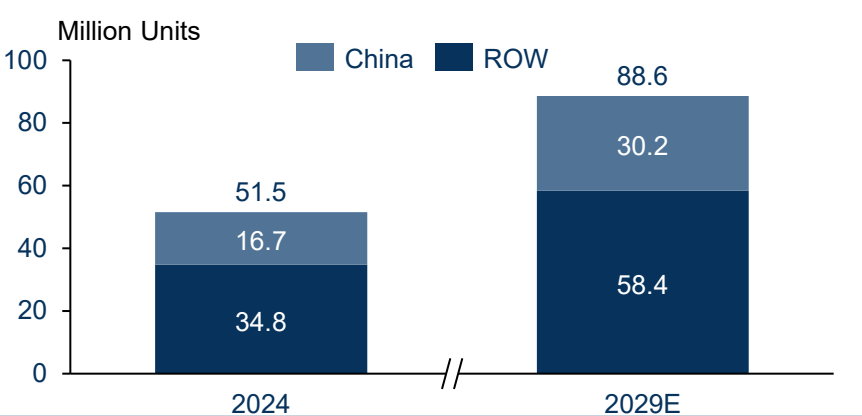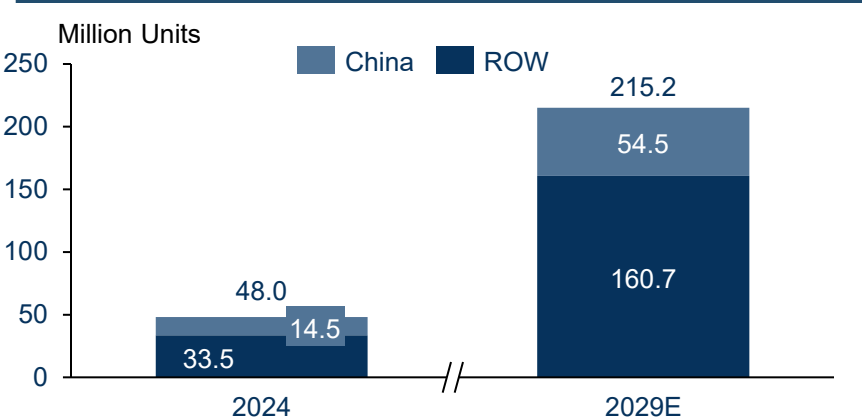
Market Size of AI Toys (by revenue), China & ROW, 2024&2029E
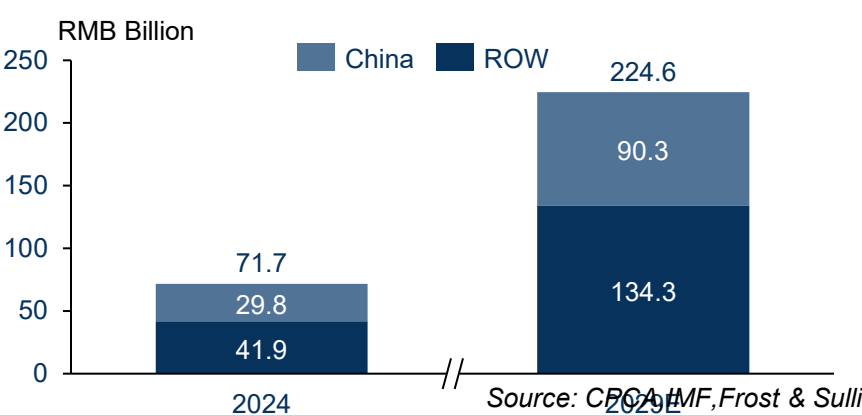
RMB Billion

China / ROW

- 2024: 71.7 (China 29.8, ROW 41.9)
- 2029E: 224.6 (China 90.3, ROW 134.3)

Source: CPCA,IMF,Frost & Sullivan

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Analysis of Macro Background and Key Downstream Demand
Analysis of Market Demand in Other Downstream Markets for Wireless Communication Modules (1/2)

- AI-powered wireless communication modules revolutionize industries by embedding intelligent connectivity. They enable real-time V2X traffic analysis in autos, support AR/VR with bandwidth allocation, provide industrial IoT noise filtering and POS fraud detection, and optimize drone networks with AI signal prediction. 5G CPE equipped with high-performance wireless communication modules can convert 5G signals into local networks for homes and businesses. Delivering 30% maintenance savings and city efficiency, these modules process critical data at source through context-aware connectivity, becoming the essential interface between physical and digital worlds in the cognitive computing era.

- The following figure shows the market size of key downstream industries for Communication Modules in Other fields:

Source: Frost & Sullivan

Market Size of Other Downstream Markets for Wireless Communication Modules

Vehicle Shipments, by Car Type, Global, 2024&2029E

CAGR	2024-2029E
ICEV	-4.0%
EV	15.7%
Total	1.5%

Million Units

- 2024: Total 89.3 (ICEV 70.9, EV 18.4)
- 2029E: Total 96.0 (ICEV 57.9, EV 38.1)

5G CPE Shipments, Global, 2024&2029E

CAGR	2024-2029E
Global	14.4%

Million Units

- 2024: 37.1
- 2029E: 72.7

PC Shipments, China & ROW, 2024&2029E

Million Units

China / ROW

- 2024: Total 258.9 (China 225.5, ROW 33.4)
- 2029E: Total 287.6 (China 251.7, ROW 35.9)
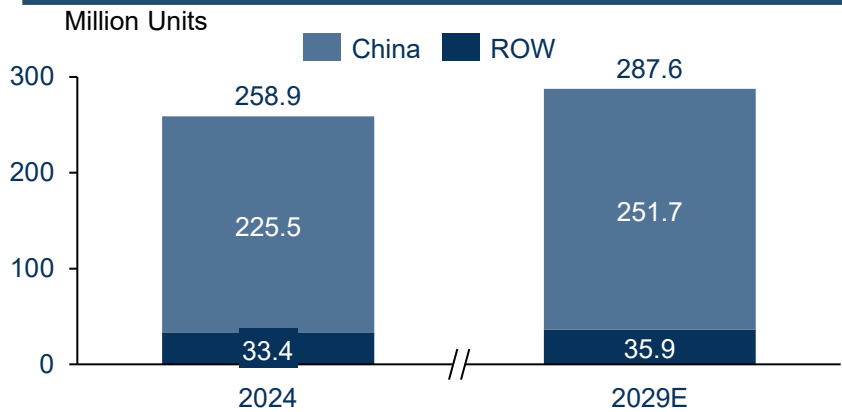
Smart POS Shipments, China & ROW, 2024&2029E
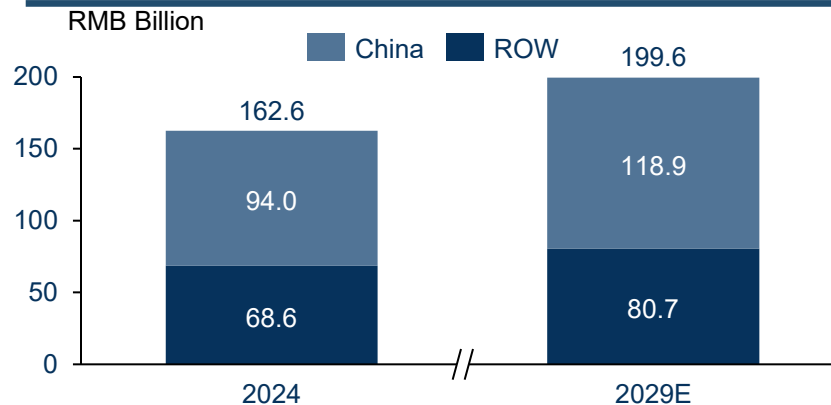
RMB Billion

China / ROW

- 2024: Total 162.6 (China 94.0, ROW 68.6)
- 2029E: Total 199.6 (China 118.9, ROW 80.7)

Source: CPCA,IMF,Frost & Sullivan

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Analysis of Wireless Communication Module Market in the Global and China

Analysis of Wireless Communication Module Market in the Global and China Definition and Classification of Wireless Communication Module

- Communication modules refer to an integrated hardware unit that packages baseband chip, radio frequency chip and related components to give end products ready-to-use cellular or short-range wireless connectivity. Communication modules include wireless communication module, wifi module, bluetooth module, etc. The wireless communication module refers to cellular wireless communication modules, excluding short-range wifi module, bluetooth module, etc. It combines core elements like radio frequency transceivers, baseband processors, antenna interfaces, and protocol stacks, supporting diverse scenarios. Through these standardized interfaces, it simplifies complex communication functions into plug-and-play solutions, accelerating device connectivity in IoT, smart systems, and industrial applications while bridging physical devices with digital ecosystems.

Classification of Wireless Communication Modules

Wireless Communication Module

Data Transmission Module

❑ Focused on secure, high-throughput data exchange, this module prioritizes reliable connectivity for streaming raw or preprocessed data between edge devices and centralized systems. It employs advanced error correction, QoS prioritization, and protocol optimization to maintain uninterrupted data pipelines critical for AI model training, system monitoring, and large-scale IoT deployments.

Smart Module

❑ Smart Module integrates embedded processing capabilities with wireless connectivity, enabling autonomous decision-making and localized task execution. It combines application-specific firmware, onboard memory, and multi-threaded processing to support complex operations like real-time diagnostics or adaptive control without cloud dependency, often deployed in IoT gateways or intelligent endpoints.

AI Module

❑ AI Module embeds dedicated neural processing units (NPUs) or AI accelerators to perform on-device machine learning inference. Optimized for low-power, high-efficiency execution of pre-trained models, it enables real-time analytics (e.g., image recognition, anomaly detection) directly at the edge, reducing latency and cloud reliance while preserving data privacy.

- Wireless communication modules are mainly divided into data transmission modules, smart modules, and AI modules. Data transmission modules focus on secure and high-throughput data exchange, giving priority to ensuring reliable connections for transmitting raw or preprocessed data between edge devices and centralized systems. They adopt advanced error correction, QoS prioritization, and protocol optimization to maintain uninterrupted data pipelines. Smart modules integrate embedded processing functions with wireless connections to achieve autonomous decision-making and local task execution. They combine application specific firmware, onboard memory, and multi-threaded processing to support complex operations such as real-time diagnosis or adaptive control without relying on the cloud, and are usually deployed in IoT gateways or intelligent endpoints. AI modules embed dedicated neural processing units (NPUs) or AI accelerators to perform machine learning inference on devices. They optimize pretrained models to achieve low-power consumption and high-efficiency execution, and can directly conduct real-time analysis at the edge (such as image recognition and anomaly detection), thereby reducing latency and dependence on the cloud while protecting data privacy.

Source: Frost & Sullivan

Analysis of Wireless Communication Module Market in the Global and China Analysis of Core Advantages of Data Transmission, Smart, and AI Module (2/2)

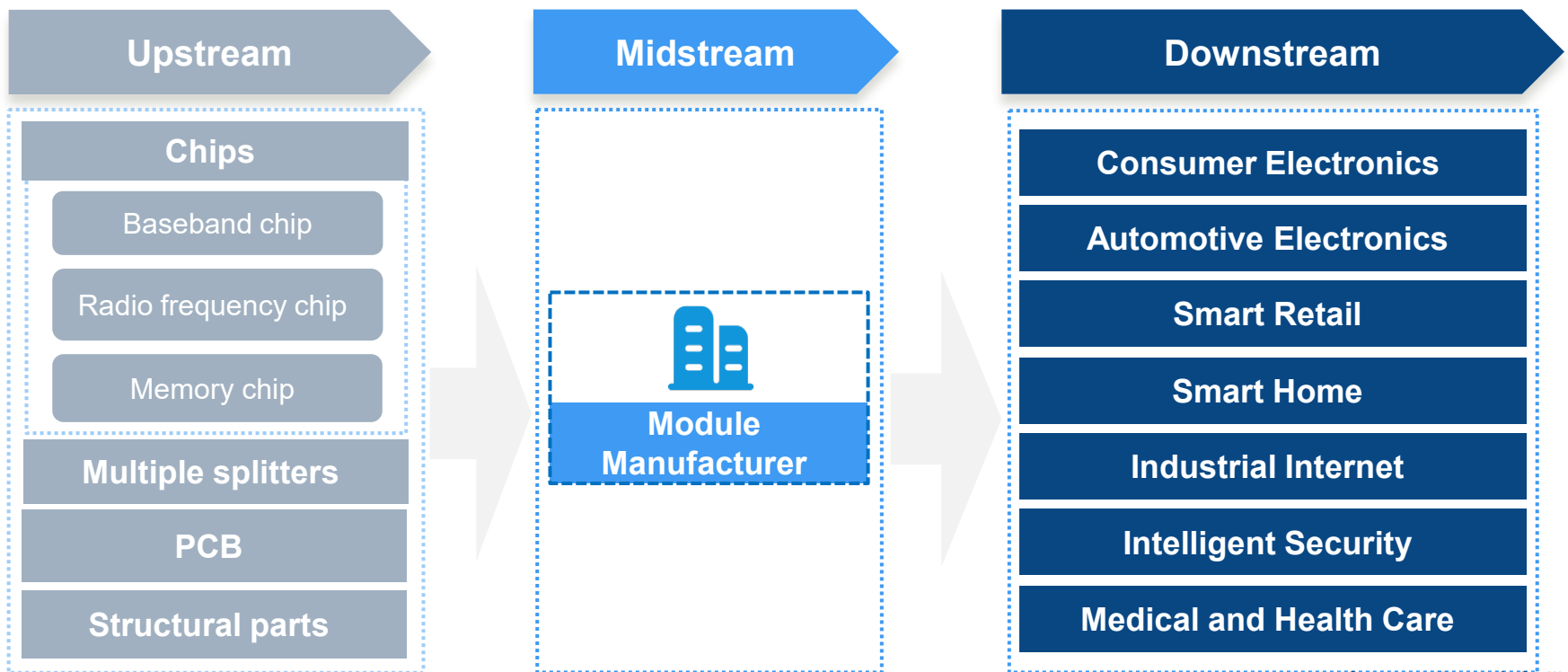|	Data Transmission Module	Smart Module	AI Module
Hardware Capabilities	• It integrates a baseband chip for cellular communication and MCU to manage basic connectivity protocols. The hardware focuses on low power consumption and reliable signal processing, lacking advanced computing components.	• Combines a baseband chip with a mid-to-high-tier SoC featuring multi-core CPUs. Includes peripherals for display interfaces, camera inputs, and audio processing.	• Employs high-performance SoC with dedicated AI accelerators and heterogeneous computing units (CPU+GPU+NPU). Supports LPDDR5/6 RAM and high-speed interfaces. May omit baseband chips to prioritize compute density.
System Capabilities	• It operates without a standalone OS, relying on firmware or lightweight real-time operating systems (RTOS) for protocol stack management. No application-level software support is provided.	• Fully compatible with Android OS, enabling app development via standard APIs (a set of rules or protocols that enables software applications to exchange data, features and functionality). Supports Linux-based systems for customization.	• OS-agnostic design compatible with Linux, Android, or real-time systems. Optimized drivers for AI frameworks (TensorFlow Lite, PyTorch) and containerized deployments.
AI Capabilities	• It handles encryption, bandwidth optimization, and real-time relay but contains no AI processing components. Its functionality is purely infrastructural, with no capacity for analytics, machine learning, or interaction with AI models.	• The Smart Module lacks native AI software frameworks or large language model integration. Its intelligence stems from predefined logic rather than adaptive learning or data-driven model training.	• The AI Module uniquely combines dedicated AI software stacks with support for large language models (LLMs) and neural network inferencing. It enables on-device training, real-time natural language processing, and dynamic model fine-tuning.

Source: Frost & Sullivan

Analysis of Wireless Communication Module Market in the Global and China Analysis of Wireless Communication Module Industry Chain

- The wireless communication module industry chain spans three segments: upstream focuses on core components including baseband chips and RF devices, relying on chip manufacturers and component suppliers; midstream is led by manufacturers integrating hardware and software to design standard and customized modules; downstream connects terminal application scenarios such as automotive electronics, consumer electronics, smart home, smart retail, etc., to drive large-scale IoT implementation. The entire chain collaborates to advance technological innovation and cost optimization, accelerating domestic substitution and global expansion through 5G and AIoT development.

The Industry Chain of the Wireless Communication Module

Upstream	Midstream	Downstream
Chips		**Consumer Electronics**
Baseband chip		**Automotive Electronics**
Radio frequency chip		**Smart Retail**
Memory chip	**Module Manufacturer**	**Smart Home**
Multiple splitters		**Industrial Internet**
PCB		**Intelligent Security**
Structural parts		**Medical and Health Care**

Source: Frost & Sullivan

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Analysis of Wireless Communication Module Market in the Global and China Comparative Analysis of Solutions for Communication Module Enterprises

	Comprehensive Vendor	Vertical Vendor	Generic Vendor
Module Portfolio	End-to-End Innovators offer full-stack solutions covering AI modules (equipped with NPUs/TPUs for edge computing), smart modules (Android/Linux-compatible with mid-tier SoCs), and data transmission modules (baseband-centric for IoT connectivity). These vendors prioritize heterogeneous integration, supporting diverse use cases like autonomous robotics, industrial automation, and smart cities	Focused on data transmission modules (e.g., 4G/5G, NB-IoT) and smart modules (with basic Android support), these vendors cater to cost-sensitive applications like asset tracking, telemetry, and consumer electronics. Their offerings lack dedicated AI acceleration but emphasize reliability and low-power performance	These vendors supply limited or generic modules, often focusing on single-category products like basic WiFi/BLE modules or legacy 2G/3G modules. Their portfolios lack differentiation in AI or smart capabilities, targeting low-complexity applications such as smart home gadgets or wearables
Solution Coverage	Beyond modules, they provide PCBA (Printed Circuit Board Assembly) services and develop end-to-end terminal products such as robots, smart gateways, and AIoT devices. Their vertical integration spans hardware design, firmware optimization, and cloud platform compatibility, enabling seamless deployment for enterprise clients. For example, vendors like Quectel and Fibocom integrate 5G modules with edge-AI capabilities into robotics systems, reducing dependency on third-party components	They rarely extend beyond module supply, occasionally offering customized firmware or protocol stack optimization for specific industries (e.g., smart meters, POS systems). Unlike comprehensive vendors, they avoid heavy investments in terminal product R&D, instead partnering with OEMs for downstream integration. For instance, Neoway and U-blox specialize in industrial IoT connectivity but rely on third-party hardware for end-device assembly	Solutions are minimal, typically restricted to standard module sales without software or hardware support. They operate as component distributors rather than solution architects, serving small-scale manufacturers needing off-the-shelf connectivity. Examples include niche players like BroadLink, which offers WiFi modules for smart appliances but lacks vertical integration

Analysis of Wireless Communication Module Market in the Global and China Analysis of Core Performance Metrics of Wireless Communication Module

- The wireless communication module category includes three types: Data Transmission Modules focus on transmission speed, LPWAN coverage, and ultra-low power for IoT connectivity; Intelligent Modules integrate multi-core processors, OS compatibility, and edge processing for local task execution; AI Modules emphasize NPU computing power (TOPS), real-time vision/speech inference speed, and algorithm optimization to balance efficiency and on-device privacy in dynamic scenarios.
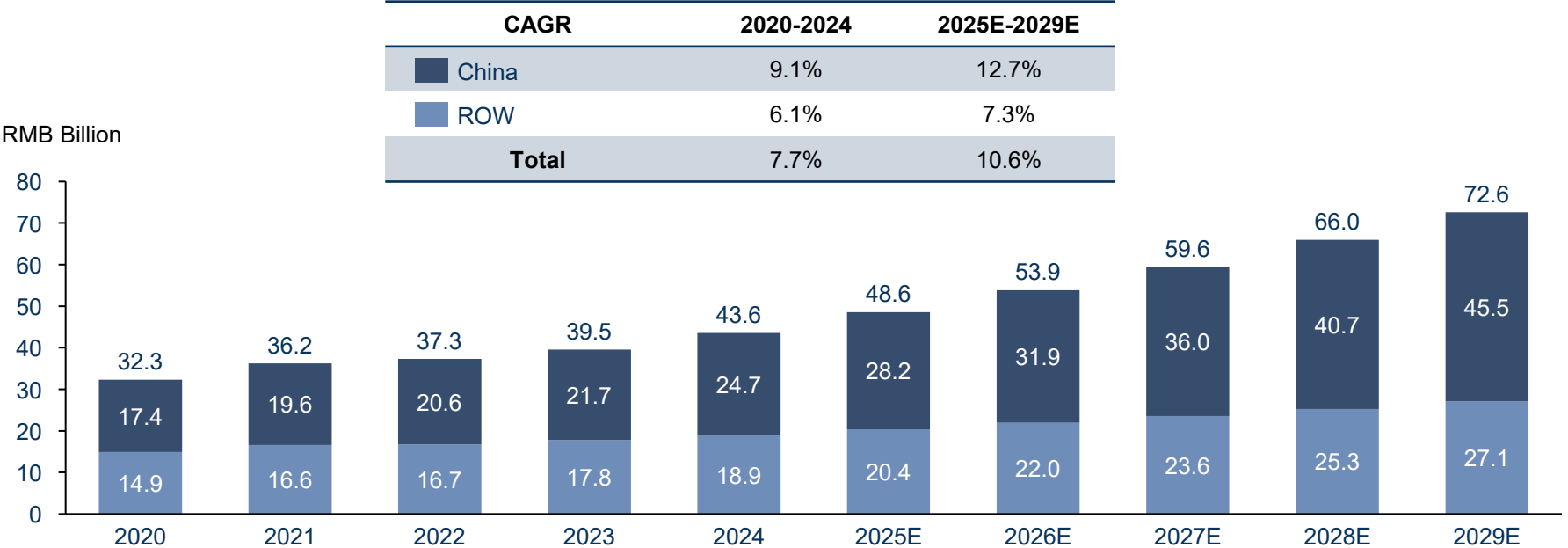
Core Performance Indicators Comparison

Category	Data Transmission Module	Smart Module	AI Module
Core functions	Focusing on data communication, it supports high rate and low latency transmission	Integrate machine learning and sensing technology to support basic decision-making and interaction	Integrated AI computing power, support large model reasoning and complex task processing
Computing power	No special computing power (depends on the basic functions of the communication chip)	No special computing power	1 - 50 TOPS
Standard of communication	4G, 5G RedCap, NB-IoT, LTE-M	4G, 5G, LTE Cat.1, Wi-Fi	5G, Wi-Fi 6, BLE 5.4
Rate of transmission	10 Mbps - 100+ Mbps	100 Mbps - 1 Gbps	100 Mbps - 1 Gbps
Time delay	20 - 50 ms	30 - 100 ms	< 50 ms
Power consumption	Low (lightweight design)	Medium (requires local computing support)	High
Main application scenarios	IoT, POS, Smart Home and Consumer Electronics…	Automative Electronics, IoT, Public Safety, Intelligent retail…	AI glasses, Edge Servers, Embodied Intelligent Robots…
Additional Features	High reliability and long battery life	Multi-sensor fusion, lightweight AI algorithm	Multimodal interaction (voice/image), large model adaptation

- Amid a surge in AI-driven applications and ongoing digital transformation, the global wireless communication module market has experienced robust growth, rising from RMB32.3 billion in 2020 to RMB43.6 billion in 2024, with a compound annual growth rate (CAGR) of 7.7%. Regionally, China's market has outpaced other regions worldwide, expanding from RMB17.4 billion in 2020 to RMB24.7 billion in 2024 and achieving a CAGR of 9.1% during this period. With 5G technology becoming mainstream and AI applications proliferating, the global market is poised to accelerate further. From 2025 to 2029, it is expected to grow at a CAGR of 10.6% and reach RMB72.6 billion by 2029, surpassing its historical growth rate. Meanwhile, as a leading electronics manufacturing powerhouse, China is projected to register a CAGR of 12.7% in the same timeframe — outstripping other regions — and expand its market size to RMB45.5 billion by 2029.

Market Size of Wireless Communication Module Market (by Revenue), Breakdown by types, Global, 2020-2029E

CAGR	2020-2024	2025E-2029E
China	9.1%	12.7%
ROW	6.1%	7.3%
Total	**7.7%**	**10.6%**

RMB Billion

Year	ROW	China	Total
2020	14.9	17.4	32.3
2021	16.6	19.6	36.2
2022	16.7	20.6	37.3
2023	17.8	21.7	39.5
2024	18.9	24.7	43.6
2025E	20.4	28.2	48.6
2026E	22.0	31.9	53.9
2027E	23.6	36.0	59.6
2028E	25.3	40.7	66.0
2029E	27.1	45.5	72.6

Source: IMF, Frost & Sullivan

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- From a downstream standpoint, the automotive sector — covering both front-fit and after-fit markets — continues to serve as a prime growth engine. In the front-fit market of the automotive electronics field, wireless communication modules are mainly applied to in-vehicle infotainment systems (IVI) to solve the problem of multi-screen interaction latency. They also support advanced driver assistance systems (ADAS) to meet the demand for real-time transmission of environmental perception data. Meanwhile, these modules primarily serve the in-vehicle telematics control unit (Tbox) to address the issue of stable interaction between vehicle status data and cloud platforms. In the aftermarket, wireless communication modules support Cellular Vehicle-to-Everything (C-V2X), enabling safety-critical information interaction between vehicles and roadside units (RSU).

- This segment is anticipated to grow from RMB7.8 billion in 2020 to RMB11.7 billion in 2024, before gaining additional momentum at a 12.6% CAGR from 2025 to 2029, eventually hitting RMB21.2 billion by 2029. Among them, the global market for wireless communication modules used in new energy vehicles' front-fit grew from RMB560 million in 2020 to RMB3.5 billion in 2024, reflecting a CAGR of 58.4% during that period. It is projected to reach RMB11.6 billion by 2029, with a CAGR of 26.5% from 2025 to 2029. Key drivers include the rise of vehicle electrification, the advancement of in-vehicle intelligence, and the increased adoption of ADAS features. In contrast, the robotics domain, propelled by ongoing breakthroughs in AI, is poised for rapid development in AI modules. Its market size is forecasted to climb to RMB5.6 billion by 2029, representing a notable 48.9% CAGR throughout the forecast period. The smart home sector has experienced rapid growth in recent years, driven by the swift rise in 5G CPE shipments. The overall smart home market size expanded from RMB4.4 billion in 2020 to RMB6.6 billion in 2024, and it is expected to further increase to RMB11.4 billion by 2029, with a CAGR of 11.2% from 2025 to 2029. 5G FWA is a fixed broadband access technology that primarily replaces traditional fiber/copper cables with wireless means to provide high-speed broadband services for households and enterprises. Among them, the market size of the 5G FWA sector is projected to increased from RMB4.7 billion in 2024 to RMB10.9 billion in 2029, with a CAGR of 18.2%. Meanwhile, more mature sectors such as smart retail should see steady growth fueled by upgrades in digital payment infrastructure; from 2025 to 2029, the market size are projected to expand at a CAGR of 8.5%, reaching RMB14.2 billion by 2029. The consumer electronics sector is expected to maintain a steady trajectory, with a 3.4% CAGR from 2025 to 2029, ultimately achieving RMB2.7 billion by 2029. Elsewhere, Other sectors are predicted to advance at a 5.4% CAGR during the same period, reaching RMB17.5 billion by 2029. Overall, the broad-based expansion across multiple sectors underscores the market's capacity to support a diverse range of intelligent, interconnected applications worldwide.

Source: Frost & Sullivan

**Market Size of Wireless Communication Module Market (by Revenue),
Breakdown by Downstream Sectors, Global, 2020-2029E**
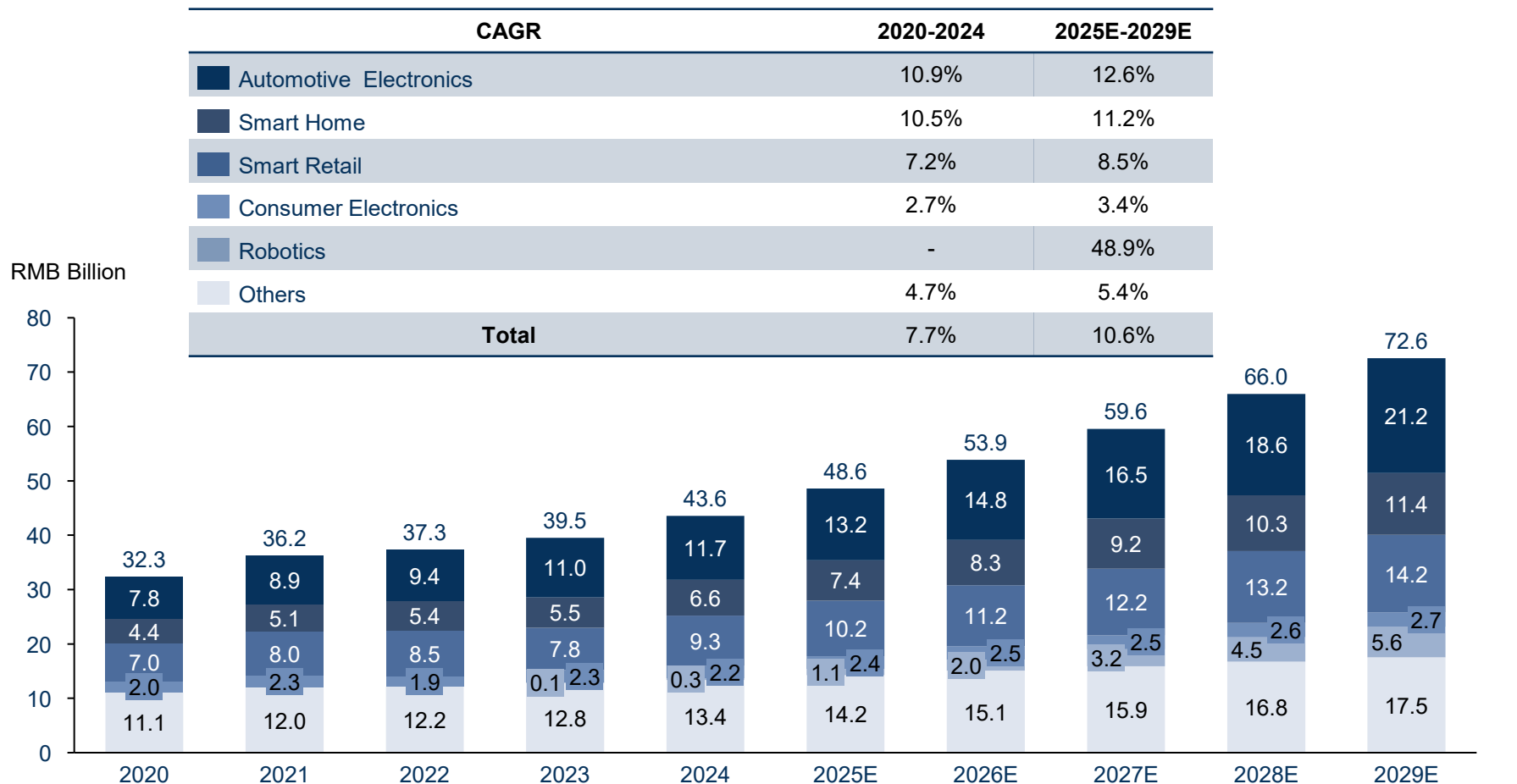
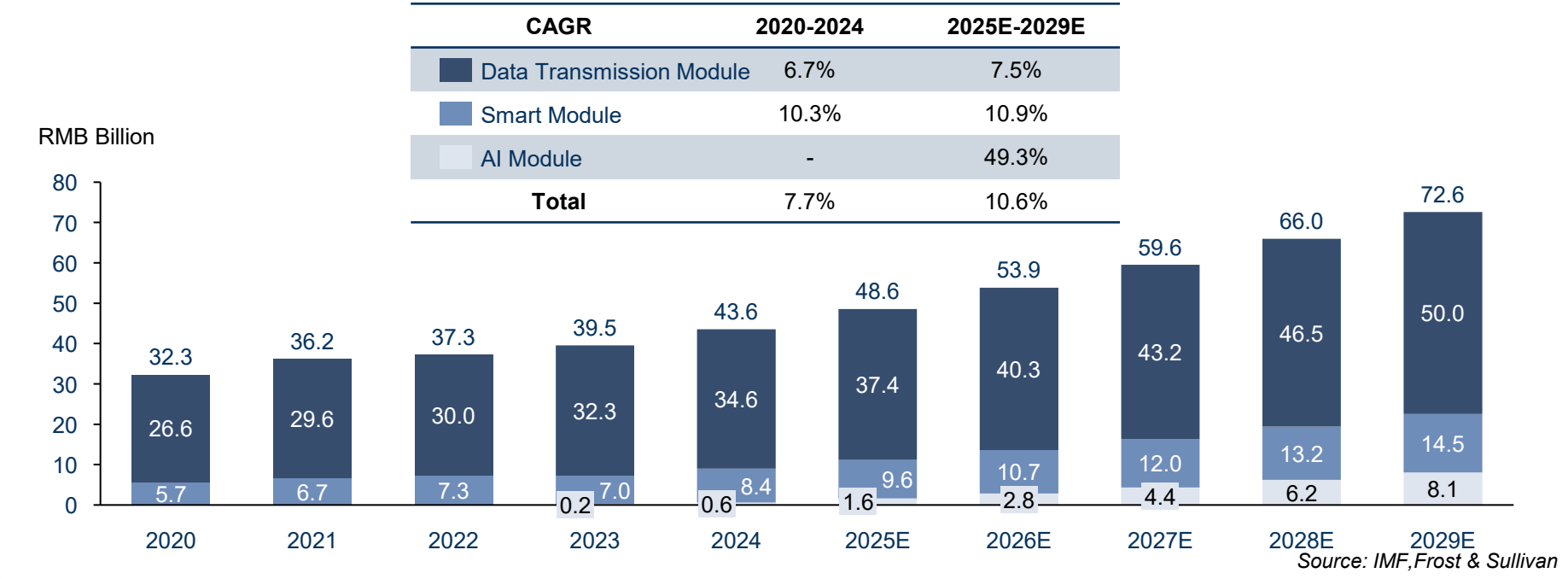| CAGR	2020-2024	2025E-2029E
■ Automotive Electronics	10.9%	12.6%
■ Smart Home	10.5%	11.2%
■ Smart Retail	7.2%	8.5%
■ Consumer Electronics	2.7%	3.4%
■ Robotics	-	48.9%
■ Others	4.7%	5.4%
Total	7.7%	10.6%

RMB Billion

Source: CPCA,IMF,Frost & Sullivan

Analysis of Wireless Communication Module Market in the Global and China Market Size of Global and China's Communication Module Market (4/4)

- From the perspective of different module products, data transfer modules dominate the market as the largest subsegment, growing from RMB26.6 billion in 2020 to RMB34.6 billion in 2024 at a CAGR of 6.7%. As the cornerstone of wireless communication module development, demand for these modules is expected to maintain stable growth, with the market projected to expand to RMB50.0 billion by 2029, achieving a CAGR of 7.5% from 2025 to 2029. The global smart module segment, driven by the rapid adoption of digital payments in North America and Europe, is anticipated to rise from RMB8.4 billion in 2024 to RMB14.5 billion by 2029, fueled by advancements in secure transaction technologies and IoT-enabled payment solutions. Meanwhile, AI modules, positioned as an emerging high-growth sector, are poised for explosive expansion amid accelerated AI technology commercialization. The market is expected to surge to RMB8.1 billion by 2029, delivering a staggering CAGR of 49.3% during 2025 — 2029, driven by AI-powered edge computing, intelligent automation, and industrial digitization applications.

Market Size of Wireless Communication Module Market (by Revenue), Breakdown by types, Global, 2020-2029E

CAGR	2020-2024	2025E-2029E
Data Transmission Module	6.7%	7.5%
Smart Module	10.3%	10.9%
AI Module	-	49.3%
Total	**7.7%**	**10.6%**

RMB Billion

Year	Total	Data Transmission Module	Smart Module	AI Module
2020	32.3	26.6	5.7	
2021	36.2	29.6	6.7	
2022	37.3	30.0	7.3	
2023	39.5	32.3	7.0	0.2
2024	43.6	34.6	8.4	0.6
2025E	48.6	37.4	9.6	1.6
2026E	53.9	40.3	10.7	2.8
2027E	59.6	43.2	12.0	4.4
2028E	66.0	46.5	13.2	6.2
2029E	72.6	50.0	14.5	8.1

Source: IMF,Frost & Sullivan

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- From the perspective of different module products, data transfer modules dominate the market as the largest subsegment, growing from RMB26.6 billion in 2020 to RMB34.6 billion in 2024 at a CAGR of 6.7%. As the cornerstone of wireless communication module development, demand for these modules is expected to maintain stable growth, with the market projected to expand to RMB50.0 billion by 2029, achieving a CAGR of 7.5% from 2025 to 2029. The global smart module segment, driven by the rapid adoption of digital payments in North America and Europe, is anticipated to rise from RMB8.4 billion in 2024 to RMB14.5 billion by 2029, fueled by advancements in secure transaction technologies and IoT-enabled payment solutions. Meanwhile, AI modules, positioned as an emerging high-growth sector, are poised for explosive expansion amid accelerated AI technology commercialization. The market demand for AI modules has surged as industries increasingly rely on intelligent decision-making at the edge, driven by advances in AI technology and the evolution of wireless communication modules. As the industry shifts from traditional data transmission pipelines to edge computing nodes, AI modules are playing a critical role in sectors such as industrial quality inspection, autonomous driving, and smart home applications. The global AI module market, positioned as an emerging high-growth sector, are poised for explosive expansion amid accelerated AI technology commercialization.The market is expected to surge to RMB8.1 billion by 2029, delivering a staggering CAGR of 49.3% during 2025 — 2029, driven by AI-powered edge computing, intelligent automation, and industrial digitization applications.

Market Size of Wireless Communication Module Market (by Revenue), Breakdown by types, Global, 2020-2029E
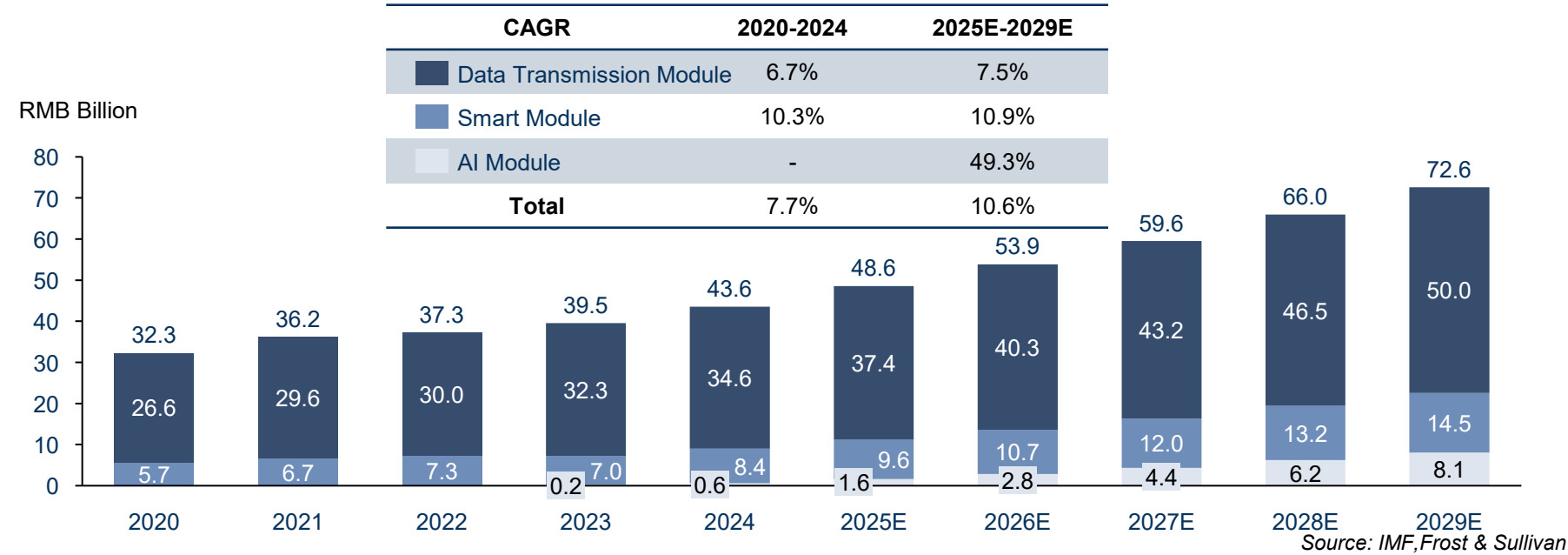
CAGR	2020-2024	2025E-2029E
Data Transmission Module	6.7%	7.5%
Smart Module	10.3%	10.9%
AI Module	-	49.3%
Total	7.7%	10.6%

RMB Billion

Year	Data Transmission Module	Smart Module	AI Module	Total
2020	26.6	5.7		32.3
2021	29.6	6.7		36.2
2022	30.0	7.3		37.3
2023	32.3	7.0	0.2	39.5
2024	34.6	8.4	0.6	43.6
2025E	37.4	9.6	1.6	48.6
2026E	40.3	10.7	2.8	53.9
2027E	43.2	12.0	4.4	59.6
2028E	46.5	13.2	6.2	66.0
2029E	50.0	14.5	8.1	72.6

Source: IMF,Frost & Sullivan

Analysis of Wireless Communication Module Market in the Global and China
The Driving Factors in the Wireless Communication Module Market

Key Drivers for Wireless Communication Module

Diversification of Downstream Applications Fueling Demand

- Wireless communication modules drive cross-industry innovation: enabling phone/AR connectivity, automotive networking, IoT tracking, smart home automation, and retail AI systems. This fuels demand for multi-standard, power-efficient, and rugged designs tailored to sector needs.

AI Convergence Reshaping Market Opportunities

- Edge AI transforms wireless communication modules into nodes, enabling autonomous vehicles, voice-controlled hubs, and retail vision systems. These AI-enhanced modules require accelerators, 5G/6G, and adaptive computing for localized inference, driving demand in manufacturing IoT and smart retail.

5G Commercialization

- 5G commercialization boosts wireless communication module demand with its highspeed, low-latency connectivity for industrial IoT, autonomous vehicles, and VR. This drives market growth and spurs development of 5G-compliant modules across industries.

Source: Frost & Sullivan

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Analysis of Wireless Communication Module Market in the Global and China Development Trends in the Wireless Communication Module Market

1 | **AI/ML and Edge Computing Integration**

- AI-powered wireless communication modules enable autonomous systems via edge computing. Embedded NPUs perform real-time analytics like predictive maintenance while reducing cloud dependency. 5G-AI modules optimize connectivity in crowded venues. Federated learning enhances privacy by training models locally, requiring efficient thermal/power designs for edge workloads.

2 | **Ultra-Low-Power Solutions**

- Ultra-low-power wireless communication modules optimize hardware, software, and protocols to cut energy use while maintaining performance. They extend battery life, lower costs, and reduce emissions in IoT, wearables, and smart homes. Advancing semiconductor and energy harvesting tech makes them essential for AI applications.

3 | **Modularization and Customization for Vertical Industries**

- Industry-specific wireless communication modules replace generic solutions. Automotive-grade (AEC-Q100) supports V2X, industrial IoT enables TSN synchronization, and healthcare modules ensure HIPAA compliance. SDR allows multi-protocol switching, while open SDKs enable custom firmware for agriculture/logistics applications.
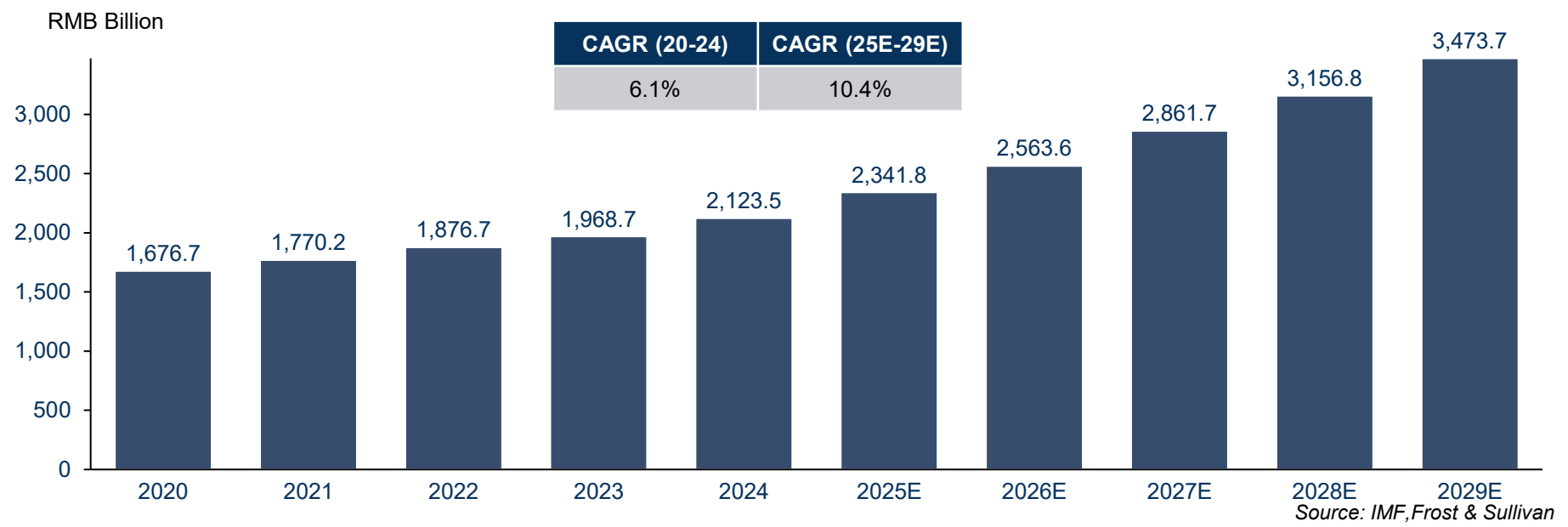
Source: Frost & Sullivan

Analysis of Wireless Communication Module Market in the Global and China Analysis of China's Electronics Manufacturing Services Market

- Electronics Manufacturing Services (EMS, Electronics Manufacturing Services) refers to a professional outsourcing model that provides electronic brand owners with full-value-chain services covering product design, engineering development, raw material procurement, manufacturing, testing, and after-sales service. As a major manufacturing power, China boasts a vast number of EMS providers, offering domestic wireless module manufacturers a wide range of manufacturing options — a dynamic force driving the growth of the wireless communication module market. In the future, with the deep application of Industry 4.0 technologies, the automation rate of production lines will be further improved; at the same time, leading enterprises will extend their business to core links such as chip packaging through vertical integration to strengthen economies of scale. Under this trend, more and more industries are turning to outsourcing services.

- China's EMS market has shown significant growth from 2020 to 2024. The total market size expanded from RMB1,676.7 billion in 2020 to RMB2,123.5 billion in 2024, with a CAGR of 6.1%. Looking ahead, the market is expected to continue expanding, reaching RMB3,473.7 billion by 2029. Asia's EMS market is projected to reach approximately RMB3 trillion in 2024, with a CAGR of 6.7% expected from 2025 to 2029.

Market Size of Electronics Manufacturing Services Market (by Revenue), China, 2020-2029E

RMB Billion

CAGR (20-24)	CAGR (25E-29E)
6.1%	10.4%

2020	2021	2022	2023	2024	2025E	2026E	2027E	2028E	2029E
1,676.7	1,770.2	1,876.7	1,968.7	2,123.5	2,341.8	2,563.6	2,861.7	3,156.8	3,473.7

Source: IMF,Frost & Sullivan

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Analysis of Wireless Communication Module Market in the Global and China
Impact of global chip supply crunch in 2022

- From late 2021 through 2022, the global semiconductor industry experienced supply shortages, driven by the ongoing COVID-19 pandemic, increased demand from the downstream sectors, and widespread supply chain disruptions. Specifically, the persistent COVID-19 pandemic severely disrupted semiconductor manufacturing, with major foundries worldwide experiencing periodic shutdowns, reduced workforce attendance, and logistics delays. In addition, explosive demand growth emerged downstream, fueled by trends including widespread remote work adoption, accelerated 5G infrastructure deployment, and the electric vehicle boom, which dramatically increased chip requirements for smart modules and communication equipment, worsening the supply-demand imbalance. Fractured global supply chains also triggered dramatic price surges for critical chip materials and extended lead times, creating a self-reinforcing cycle of "shortage-hoarding-worsening shortage" that ultimately escalated into an industry-wide systemic crisis. These factors contributed to a global chip shortage, impacting numerous industries, including the global communication module industry in which we operate.

Source: Frost & Sullivan

Analysis of Wireless Communication Module Market in the Global and China Analysis of Price Trends of Major Raw Materials

- As a critical raw material in wireless communication modules, DRAM exhibits extremely volatile price fluctuations. Taking DDR4 as an example, the contract price of an 8GB DDR4 memory chip was USD3.0 per piece in 2020, rose to USD3.7 per piece in 2021, fell back to USD3.0 per piece in 2022, continued to decline to USD1.5 per piece in 2023, and rebounded to USD1.8 per piece in 2024. The price of DDR4 memory chips is volatile and cyclical. The price increase in 2021 was mainly due to global chip capacity shortages and supply chain tensions caused by the pandemic. The price declines in 2022 and 2023 were mainly due to factors such as overcapacity, a weak consumer electronics market, and industry inventory correction cycles. The price rebound in 2024 was jointly driven by multiple factors, including explosive demand for AI servers, active production cuts by manufacturers, and the recovery of 5G communication equipment demand. Due to the comprehensive production phasedown leading to an enlarged supply gap, combined with rigid demand in industrial/automotive sectors, the price is projected to continue rising throughout 2025.

Source: Frost & Sullivan

Analysis of Competitive Landscape of Wireless Communication Module Market

Analysis of Competitive Landscape of Wireless Communication Module Market Ranking and Market Share Analysis (1/5)

- In 2024, the global wireless communication module market exhibits a relatively concentrated competitive landscape, with the top five companies collectively holding 76.1% of the market share. Among these players, the Company stands out as one of the two leading enterprises in the wireless communication module space, securing second place with an 15.4% market share and RMB6.7 billion in revenue. Notably, in the consumer electronics sector and the smart home sector, the Company ranks first with revenues of RMB1.7 billion, and RMB2.4 billion, respectively. In the automotive electronics sector, the Company ranks second with revenue of RMB1.7 billion,underscoring its strong competitiveness in the wireless communication module industry.

Ranking of Wireless Communication Module Companies (by Revenue), Global, 2024

Ranking	Company	Revenue (RMB Billion)	Market Share (%)
1	Company A	18.6	42.7%
2	**The Company**	**6.7**	**15.4%**
3	Company B	3.0	6.9%
4	Company C	2.8	6.3%
6	Company D	2.1	4.8%

Source: Frost & Sullivan

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Analysis of Competitive Landscape of Wireless Communication Module Market Ranking and Market Share Analysis (2/5)

Ranking of Wireless Communication Module Companies in Automotive Electronics Sector (by Revenue), Global, 2024

Ranking	Company	Revenue (RMB Billion)	Market Share (%)
1	Company A	2.8	23.8%
2	**The Company**	**1.7**	**14.4%**
3	Company B	1.2	10.0%
4	Company C	0.9	7.6%
5	Company E	0.5	4.6%

Source: Frost & Sullivan

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Analysis of Competitive Landscape of Wireless Communication Module Market Ranking and Market Share Analysis (3/5)

Ranking of Wireless Communication Module Companies in Consumer Electronics Sector (by Revenue), Global, 2024

Ranking	Company	Revenue (RMB Billion)	Market Share (%)
1	The Company	1.7	75.9%
	Others	0.5	24.1%

Source: Frost & Sullivan

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Analysis of Competitive Landscape of Wireless Communication Module Market Ranking and Market Share Analysis (4/5)

Ranking of Wireless Communication Module Companies in Smart Home Sector (by Revenue), Global, 2024

Ranking	Company	Revenue (RMB Billion)	Market Share (%)
1	**The Company**	2.4	36.6%
2	Company B	1.1	16.5%
3	Company A	0.9	13.2%

Source: Frost & Sullivan

FROST & SULLIVAN

Analysis of Competitive Landscape of Wireless Communication Module Market Ranking and Market Share Analysis (5/5)

Notes:

(1) Company A is a listed company, founded in 2010 and headquartered in Shanghai, China. It is a global supplier of cellular and GNSS modules, specializing in providing high-performance, high-quality wireless communication modules for various industries.

(2) Company B is a private company, founded in 2005 and headquartered in Beijing China. It operates in the telecommunications sector, focusing on the development and provision of communication technologies and solutions.

(3) Company C is a listed company, founded in 2007 and headquartered in Shenzhen, China. It is a world-class provider of IoT terminals and wireless data solutions, offering standardized smart communication modules and IoT solutions for global customers.

(4) Company D is a listed company, founded in 1997 and headquartered in Beijing, China. It is one of the world's largest mobile network operator, providing mobile voice and multimedia services through its nationwide mobile telecommunications network across China.

(5) Company E is a listed company, founded in 1994 and headquartered in Shenzhen, China. It is a national high-tech enterprise focusing on intelligent connectivity, providing a comprehensive artificial intelligence IoT industry chain, including wireless communication modules, enterprise-level IoT cloud platforms, AIoT devices, and city-level large and medium-sized platforms.

(6) Ranking of wireless communication module companies in automotive electronics sector based on revenue from continuing operation and discontinuing operation.

(7) Ranking of wireless communication module companies, ranking of wireless communication module companies in consumer electronics sector and ranking of wireless communication module companies in smart home sector based on revenue from continuing operation.

Source: Frost & Sullivan

Analysis of Competitive Landscape of Wireless Communication Module Market Entry Barriers of the Wireless Communication Module Market

Key Entry Barriers for Wireless Communication Module

Technical Complexity and Certification Hurdles

➤ As a key component for realizing device interconnection, the efficient data transmission capability of wireless communication modules relies on advanced wireless communication technologies and intelligent data processing technologies. However, 5G communication modules facing the global market are subject to strict multiple certification requirements. They must not only comply with global communication standards such as 3GPP, but also pass regional certifications such as FCC, CE, and NCC, as well as network access tests of major carriers such as AT&T and Verizon. The process of obtaining all these certifications is extremely complex and time-consuming, during which a large amount of R&D resources need to be invested in repeated testing and optimization. For new entrants, they not only need to break through technical barriers but also bear high certification costs, which makes the market access threshold extremely high. At present, the number of enterprises worldwide that can obtain the above high-standard certifications accounts for only a very small proportion of all enterprises.

High Capital Intensity and R&D Investment

➤ The wireless communication market is characterized by rapid technological iterations and stringent standards. From module design to performance testing, it is necessary to continuously invest huge amounts of funds in building laboratories and purchasing precision equipment. At the same time, it is essential to form high-end R&D teams to tackle core technical challenges such as radio frequency and communication protocols. The substantial sunk costs and long return cycles make it difficult for enterprises with weak capital strength to enter this market.

Fragmented Supply Chain Risks

➤ The industry's reliance on a concentrated semiconductor supply chain creates vulnerabilities. Geopolitical tensions, such as US-China trade restrictions on advanced chips, force companies to diversify suppliers or stockpile inventory. Vertical integration is a common strategy—Quectel, for example, invests in in-house testing facilities and strategic alliances with foundries like TSMC—but requires substantial capital. Smaller players may struggle to secure long-term contracts with chipset vendors, leaving them exposed to price volatility and allocation shortages during demand spikes.

Market Consolidation and Ecosystem Lock-In

➤ The market is dominated by a handful of players that have entrenched relationships with cloud providers, chipset vendors, and telecom operators. These incumbents offer end-to-end solutions, such as pre-integrated modules with cloud management platforms, creating ecosystem lock-in. New entrants must differentiate through niche capabilities, for example, modules optimized for satellite IoT or others. Additionally, open-source initiatives are emerging to challenge proprietary ecosystems, but gaining traction requires significant community support and compatibility with legacy infrastructure.

Source: Frost & Sullivan

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Overview of the Company's Focus in the Field of Robotics

Overview of the Company's Focus in the Field of Robotics
Definition and Classification of the Lawn Mowing Robot

- The lawn mowing robot is an automated device used for mowing. With built-in sensors and a navigation system, it has functions such as autonomous movement, area recognition, timed operation, random walking, and obstacle avoidance, significantly improving the efficiency of lawn maintenance and leading to a continuous increase in market demand. Its core lies in advanced communication modules, which integrate AI navigation, multiple types of environmental sensors, and precise positioning technologies. The AI processes terrain data locally to optimize the mowing and obstacle avoidance strategies, and the wireless protocols enable secure cloud connections to support remote control and fleet management. Technical features such as low-latency transmission, edge computing, and multi-sensor synchronization are in line with the development trend of mobile robots, making the communication modules a key factor in ensuring the efficient and stable operation of lawn mowing robots.

Classification of the Mowing Robot

Manual mowing robot	- Users need manual control and operation, suitable for small lawn. The price is usually relatively affordable and easy to maintain, suitable for gardening enthusiasts who like to do it themselves or on a limited budget.
Automatic mowing robot	- Autonomous operation, using sensors and navigation systems, suitable for medium and large lawns. Some high-end models support virtual boundary setting and rainy day sensing.
Intelligent lawn mowing robot	- With smart connection function, remote control and monitoring can be carried out through mobile phone application. Some models are equipped with real-time map generation and data statistics functions.
Solar mowing robot	- Powered by solar energy, it is environmentally friendly and suitable for sunny areas. Its energy independence is particularly suitable for remote courtyard use, and long-term use can significantly reduce electricity bills.
Multi-functional lawn mowing robot	- Besides mowing, it offers functions like leaf blowing and cleaning. Its all-in-one design suits year-round yard maintenance, saving storage and costs through multi-functionality.

Source: Frost & Sullivan

Overview of the Company's Focus in the Field of Robotics
The Market Size of the Lawn Mowing Robot

- The global lawn mowing robotic market is undergoing a high expansion phase and is expected to continuously grow at a CAGR of 13.4% from 2024 to 2029. The market size is expected to increase from USD2,494.9 million in 2024 to USD4,873.0 million in 2029. This growth trajectory is driven by multiple technological innovations, policy support and structural demand in the regional market, demonstrating strong long-term development potential.

Market Size of Lawn Mowing Robots, Global, 2020-2029E

CAGR (20-24)	CAGR (25-29E)
17.8%	13.4%

USD Million

Year	Value
2020	1,296.7
2021	1,480.0
2022	1,532.0
2023	1,910.0
2024	2,494.9
2025E	2,949.9
2026E	3,434.0
2027E	3,930.0
2028E	4,412.5
2029E	4,873.0
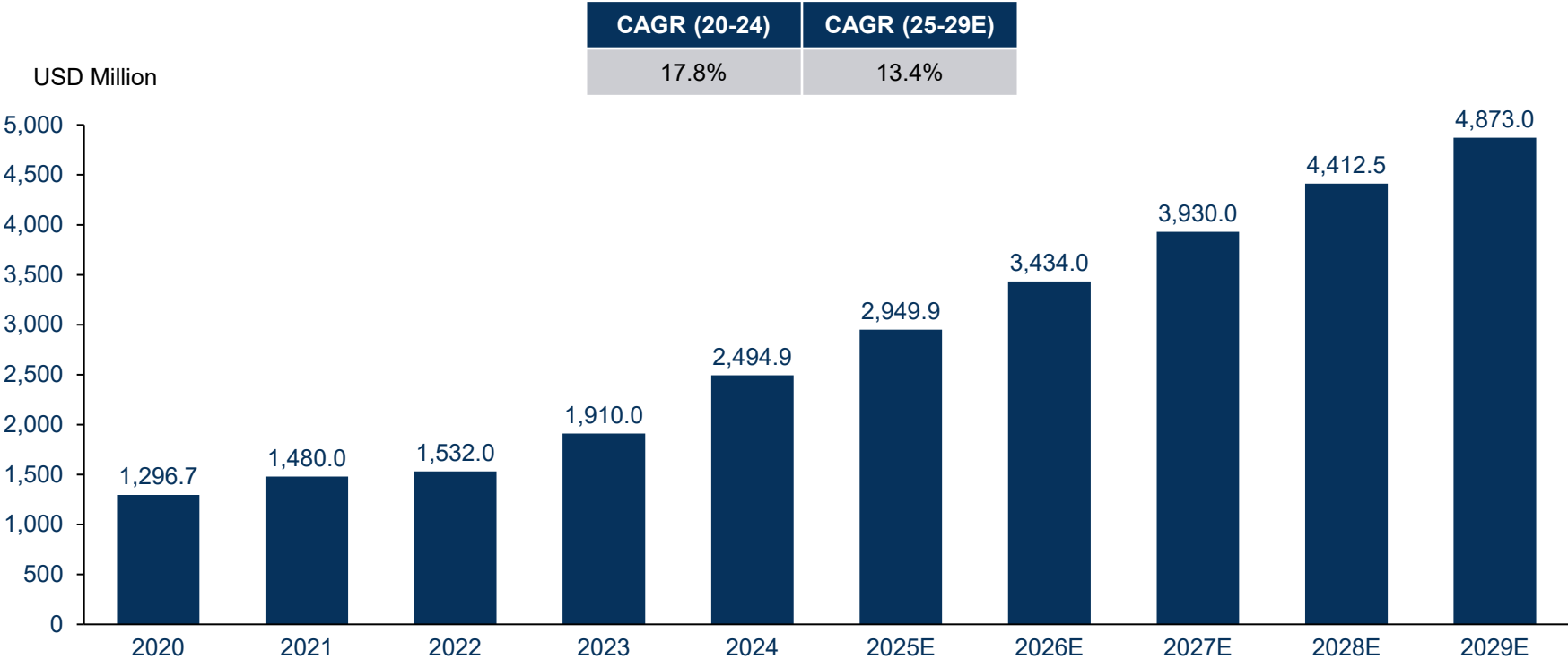
Source: NBA, Frost & Sullivan

FROST & SULLIVAN

Overview of the Company's Focus in the Field of Robotics
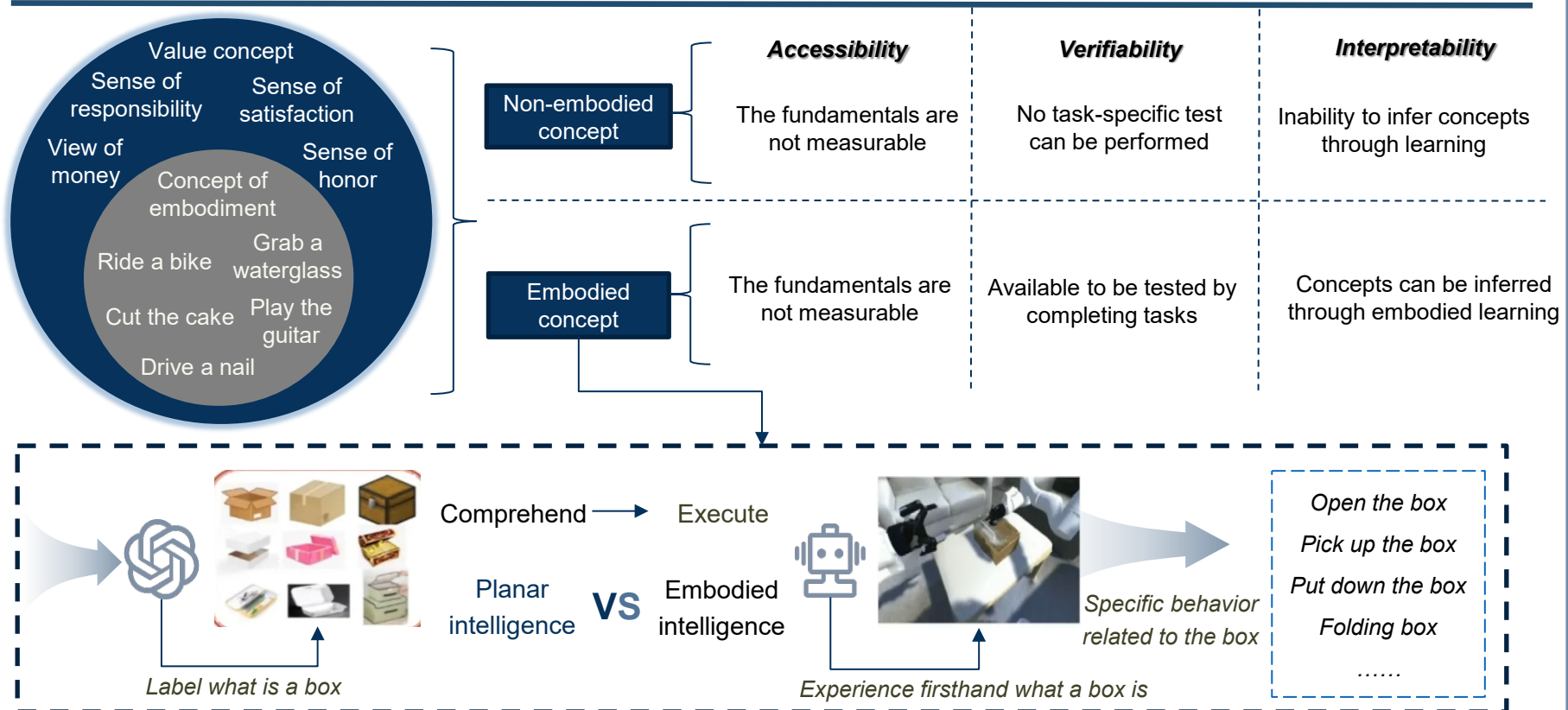# Definition of Embodied Intelligence (1/2)

- Embodied intelligence is an intelligent system that realizes the perception, cognition and behavioral control of the world through the dynamic interaction between the body and the environment. The scientific theory of embodied intelligence is that true understanding comes from behavioral practice, and through actual actions and interactions, machines or individuals can deeply understand and embody scenes and concepts. The global embodied intelligence market, valued at USD2.2 billion in 2024, is projected to reach USD16.1 billion by 2029, boasting a CAGR of over 48.9%.

- Embodied intelligence, whether humanoid robots or context-aware service machines, require communication modules that replicate neural-like coordination between perception, cognition, and action. These modules provide the backbone for real-time fusion of multi-modal sensory inputs (visual, auditory, tactile) and their translation into motion control signals. AI modules enable on-device processing of reinforcement learning algorithms for adaptive decision-making, while high-speed 5G/mm Wave or TSN protocols ensure sub-millisecond latency in dynamic human-robot interactions.

Source: Frost & Sullivan

Definition of Embodied Intelligence Architecture

Value concept

Sense of responsibility | Sense of satisfaction

View of money | Sense of honor

Concept of embodiment

Ride a bike | Grab a waterglass

Cut the cake | Play the guitar

Drive a nail

	Accessibility	*Verifiability*	*Interpretability*
Non-embodied concept	The fundamentals are not measurable	No task-specific test can be performed	Inability to infer concepts through learning
Embodied concept	The fundamentals are not measurable	Available to be tested by completing tasks	Concepts can be inferred through embodied learning

Comprehend → Execute

Planar intelligence **VS** Embodied intelligence

Specific behavior related to the box

Label what is a box

Experience firsthand what a box is

Open the box

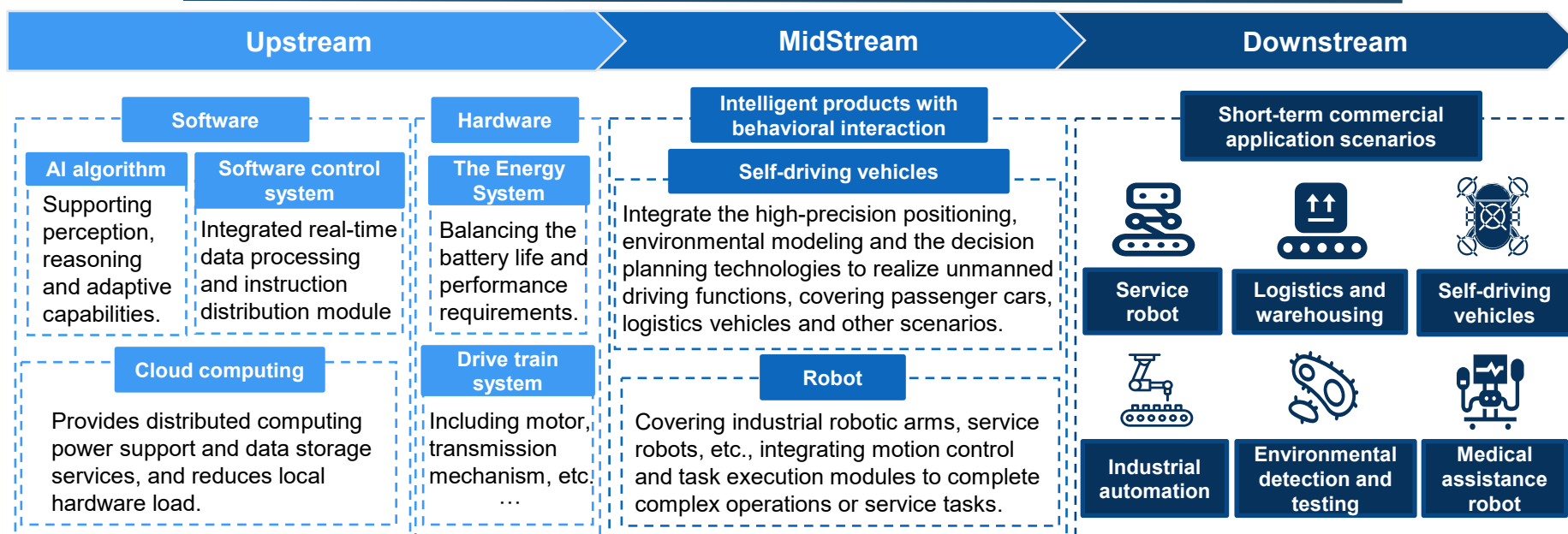*Pick up the box*

Put down the box

Folding box

......

Source: Frost & Sullivan

Overview of the Company's Focus in the Field of Robotics Industry Chain of Embodied Intelligence

- The embodied intelligence industrial chain is composed of three collaborative levels. The upstream focuses on core enabling technologies, including advanced sensors, AI processors, adaptive algorithms, and computing platforms; the midstream integrates components into interactive products such as autonomous driving vehicles and collaborative robots; the downstream applications cover multiple fields such as logistics, healthcare, and urban management, and accelerate deployment through cross-domain factors such as the 5G-V2X network to form a closed-loop system and achieve the vertical integration of AI innovation and commercial applications.
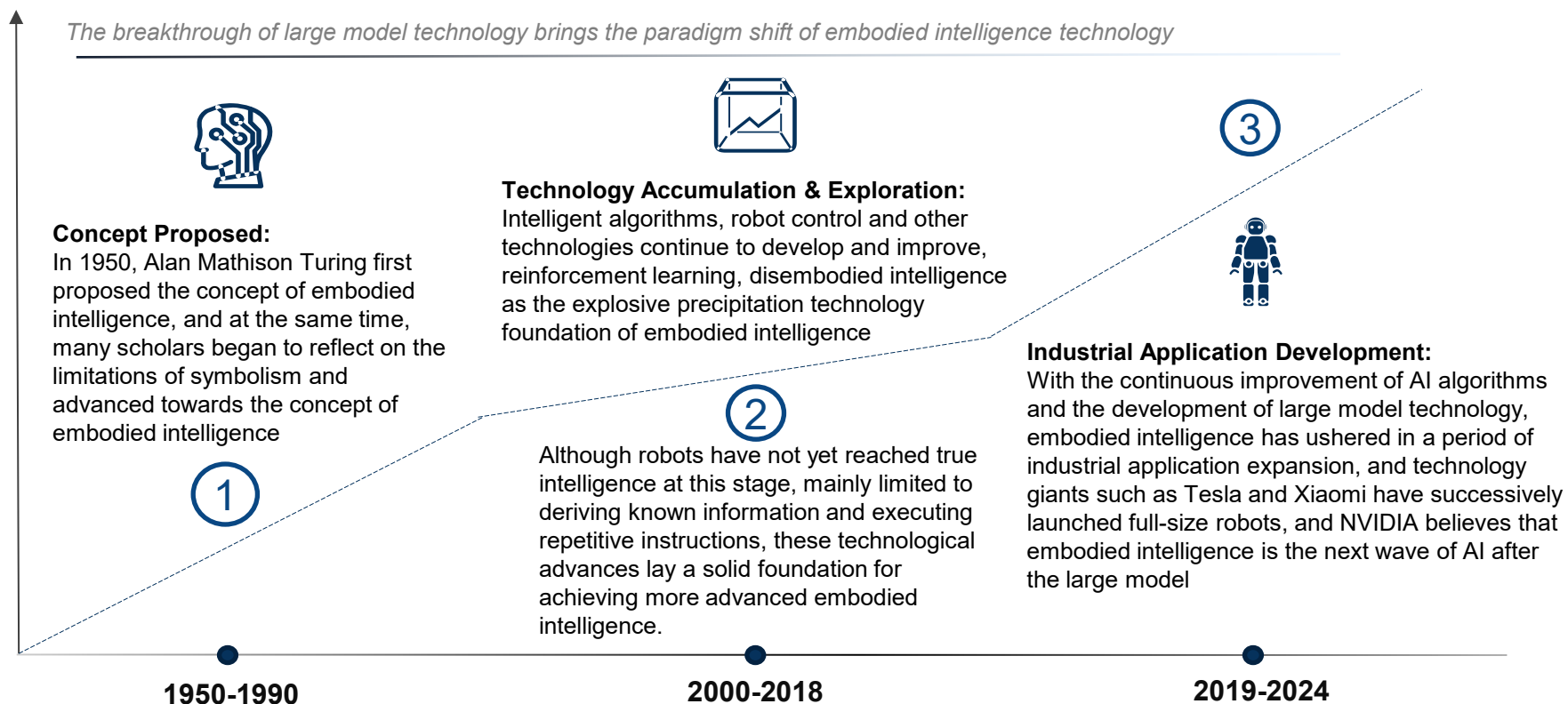
The Industry Chain of the Embodied Intelligence

Upstream	MidStream	Downstream

Upstream

Software

AI algorithm
Supporting perception, reasoning and adaptive capabilities.

Software control system
Integrated real-time data processing and instruction distribution module

Cloud computing
Provides distributed computing power support and data storage services, and reduces local hardware load.

Hardware

The Energy System
Balancing the battery life and performance requirements.

Drive train system
Including motor, transmission mechanism, etc. …

MidStream

Intelligent products with behavioral interaction

Self-driving vehicles
Integrate the high-precision positioning, environmental modeling and the decision planning technologies to realize unmanned driving functions, covering passenger cars, logistics vehicles and other scenarios.

Robot
Covering industrial robotic arms, service robots, etc., integrating motion control and task execution modules to complete complex operations or service tasks.

Downstream

Short-term commercial application scenarios

- Service robot
- Logistics and warehousing
- Self-driving vehicles
- Industrial automation
- Environmental detection and testing
- Medical assistance robot

Source: Frost & Sullivan

Overview of the Company's Focus in the Field of Robotics Development History of Embodied Intelligence

- The development of embodied intelligence has gone through three stages: the first stage is to propose the concept of embodied intelligence, the core of which is the thinking and discussion of philosophical concepts. The second stage is technology accumulation and laboratory exploration, mainly artificial intelligence and robot control technology accumulation. The third stage is the stage where the deepening of artificial intelligence technology leads embodied intelligence to technological breakthrough, and the large model introduces a new technological paradigm for embodied intelligence.

Development History of Embodied Intelligence Industry

The breakthrough of large model technology brings the paradigm shift of embodied intelligence technology

Concept Proposed:
In 1950, Alan Mathison Turing first proposed the concept of embodied intelligence, and at the same time, many scholars began to reflect on the limitations of symbolism and advanced towards the concept of embodied intelligence

Technology Accumulation & Exploration:
Intelligent algorithms, robot control and other technologies continue to develop and improve, reinforcement learning, disembodied intelligence as the explosive precipitation technology foundation of embodied intelligence

Although robots have not yet reached true intelligence at this stage, mainly limited to deriving known information and executing repetitive instructions, these technological advances lay a solid foundation for achieving more advanced embodied intelligence.

Industrial Application Development:
With the continuous improvement of AI algorithms and the development of large model technology, embodied intelligence has ushered in a period of industrial application expansion, and technology giants such as Tesla and Xiaomi have successively launched full-size robots, and NVIDIA believes that embodied intelligence is the next wave of AI after the large model

1950-1990 | **2000-2018** | **2019-2024**

Source: Frost & Sullivan

Verification Statements (1/3)

- The Company is the one of the world's 1st Launch of Edge AI solutions.
- The automotive electronics application scenario and the smart home application scenarios are the primary growth drivers for the wireless communication module market.
- Wireless communication module providers who are able to provide customers with bespoke solutions have advantages over their competitors. In particular, the market demand for robotic solutions that leverage advanced wireless communication modules for autonomous functions is especially significant.
- The Company is one of the first companies in the world to launch smart modules and AI modules. The Company has also extended our business vertically to provide Edge AI solutions and robotic solutions. The Company is one of the first few providers in the world to provide Edge AI solutions, and the Company possess the core technologies of robotic solutions, primarily including visual perception and low-speed motion control.
- Outsourcing the manufacturing of products aligns with the industry practices in wireless communication module industry in China, which allows module provider to allocate the necessary resource on R&D.
- The Companies' module products ranked the first among the major players in the wireless communication module industry in China in terms of average selling price in 2024.
- The Company was one of the first companies in China to launch proprietary branded 3G products. In the era of 4G and 5G, the Company has become a globally leading company in the wireless communication module industry.
- The Companies' customers and downstream companies cover multiple renowned automobile manufacturers. During the Track Record Period, the Company provided module products to eight of the top ten automobile manufacturers in China in terms of revenue in 2024.
- The Companies' customers primarily include globally recognized personal computer manufacturers, including Dell Inc. and Hewlett-Packard Development Company, L.P. ("HP"), and wearable device and motion camera manufacturers. The Company is supplier of the top three personal computer manufacturers globally in terms of revenue in 2024.
- The Companies' automotive-grade 5G data transmission modules support advanced baseband and radio frequency architecture. The Companies 5G data transmission modules can achieve a maximum download speed of 10.53 Gbps, surpassing the industry average download speed of approximately 5.0 Gbps in global wireless communication module industry.
- The Company is the first wireless communication module provider in the world to launch 5G data transmission module that support more than 20 5G new radio frequency bands while also being compatible with over 30 4G LTE frequency bands.
- The Companies' 4G data transmission modules support quick registration and connection to networks. The Company has reduced startup-to-connection time of modules to within three seconds, which is significantly below the industry average in global wireless communication module industry.
- The Companies' smart modules integrate high-performance GPUs and vector extension technology for image processing. The Companies' smart modules support (i) up to five cameras' inputs and (ii) dual screen displays with resolutions up to 1920 × 1080 and 60fps, significantly outperforming industry averages in the global wireless communication module industry.

Source: Frost & Sullivan

Verification Statements (2/3)

- The Companies' smart modules feature a highly integrated design, allowing end products to achieve a more compact size compared to the industry average.
- The Company design our Fibocom AI stack to support multiple operating systems and platforms, enabling diverse AI model deployment across different application scenarios. The Companies' Fibocom AI Stack also allows deployment of AI models under varying CPU capabilities tailored to specific market needs, offering broad compatibility compared to industry averages in global wireless communication module industry.
- High-performance modules, such as the 18 TOPS modules, support local execution of AI models with up to seven billion parameters, outperforming industry averages in global wireless communication module industry.
- The Companies' lightweight AI modules are designed for lightweight AI tasks, including object detection, human keypoint recognition, and facial recognition, achieving better energy efficiency than industry averages in global wireless communication module industry.
- The Company develop and optimize audio and visual algorithms as well as AI models, alongside self-developed application development, delivering faster algorithm performance than typical solutions.
- The Company have developed a unified scheduling and communication framework that enables dynamic task distribution and secure data transmission across different processing units, optimizing performance by achieving computing power up to 48 TOPS, significantly surpassing industry averages in global wireless communication module industry.
- The Companies' lawn mower robotic solutions offers customers a ready-to-use experience, with installation times shorter than the average in the global lawn mowing robotic industry.
- The Company leverage self-developed vision-based perception technology and low-speed motion control technology to provide precise navigation, real-time obstacle avoidance and responsive hazard detection up to centimeter-level positioning accuracy. These capabilities allow the Companies' lawn mowing robots to achieve position accuracy within one to three centimeters and within 60 milliseconds, surpassing industry averages in global lawn mowing robotic industry, ensuring fewer missed spots and safer operation.
- The Company offer both monocular ("2D") and binocular ("3D") vision configurations, achieving a field of view of up to 90 degrees in the Companies' 3D models, allowing the Companies' solutions to adapt to the majority of lawn complexities, outperforming the industry averages in global lawn mowing robotic industry performed by monocular systems.
- The Company is the first wireless communication module provider in wireless communication module industry in China successfully meet leading international standards including IEC 62443-4-1 and NIST.IR.8259 standards.
- It is a common commercial practice in China for customers to settle payments through third-party payors for various personal reasons, and Certain Relevant Customers are small- and medium-sized enterprises, and it is common for them to settle payments through personal bank accounts of their employees for convenience.
- The automotive electronics application scenario and the smart home scenario are the main growth drivers for the wireless communication module market.

Source: Frost & Sullivan

Verification Statements (3/3)

- The decrease in the gross profit margin of other solutions was primarily due to an increase in the proportion of PCBAs and end-products the Company delivered in 2024. PCBA and end-products generally have lower gross profit margin than R&D services, which was in line with the industry.
- The decrease in the gross profit margin of other solutions was primarily due to an increase in the proportion of the PCBA and end-products the Company delivered in 2023. PCBA and end-products generally have lower gross profit margin than R&D services, which was in line with the industry.
- The Companies' modules support 5G and Wi-Fi 6 wireless communication, offering greater flexibility in network access. The Companies' 5G smart modules are compatible with mainstream 5G frequency bands worldwide, meeting diverse terminal requirements for different 5G frequency bands and enabling customers to rapidly in global markets. Our smart modules also support 3GPP Release 16 standards, Wi-Fi 6/7, and dual-band GPS, achieving lower latency than industry averages in global wireless communication module industry. This ensure precise positioning and connectivity, making them particularly suitable for application scenarios such as consumer electronics.
- The Companies' embodied-AI robotic solutions includes two mechanical arms, capable of performing complex tasks with high accuracy. Compared to single-arm robots, the Companies' embodied-AI robotic solutions are able to complete more complex operations in a more precise manner within the same time frame.
- Data quality and diversity are critical constraints in AI model training. The companies' embodied-AI robotic solutions supports manual operation through a handheld controller, allowing customers to perform demonstrations without affecting odometry accuracy. This ensures precise movement tracking during manual operation, facilitating accurate trajectory recording and real-time data capture, which in turn allows robots to achieve higher efficiency in collecting end-to-end data compared to industry average in the global embodied intelligence industry.
- Based on our launch of 5G data transmission modules in 2019, launch of smart modules in 2017 and launch of AI modules in 2025, the Company is the one of the world's 1st launch of 5G data transmission modules, smart modules and AI modules.
- Through continuous evolution, wireless communication modules have integrated computing power, which enables them to meet the growing demand for Edge AI processing. This advancement allows edge devices to utilize AI models embedded within wireless communication modules or utilize cloud-based large models, effectively enabling AI-driven functionalities. The integration of wireless communication modules with AI has been an industry trend.
- The global embodied robotic solution market size is expected to grow from US$3.6 billion in 2025 to US$16.1 billion in 2029, representing a CAGR of 45.4%.
- In 2019, the Company collaborated with Intel to jointly launch one of the world's first 5G data transmission modules and launched the world's first 5G data transmission modules embedded with integrated blockchain technology. In 2020, the Company collaborated with China Unicom to jointly launch the world's first 5G+eSIM modules and China's the first 5G data transmission modules embedded with a domestic chip.
- Automotive electronics is one of the most demanding application scenarios due to the importance of safety, and therefore requires relatively higher quality standards for module products.
- During the Tracked Record Period, the Company sold module products to seven of the top ten companies in the smart retail application scenario globally in terms of revenue in 2024.

Source: Frost & Sullivan

FROST & SULLIVAN

Verification Statements (4/4)

- Data quality and diversity are critical constraints in AI model training. The Companies' embodied-AI robotic solutions supports manual operation through a handheld controller, allowing customers to perform demonstrations without affecting odometry accuracy. This ensures precise movement tracking during manual operation, facilitating accurate trajectory recording and real-time data capture, which in turn allows robots to achieve higher efficiency in collecting end-to-end data compared to industry averages in the global embodied intelligence industry.

- Global 4G/5G networks vary widely across telecom operators, each with unique frequency bands, standards, and testing requirements, complicating single-product compatibility. Typically, providers in the wireless communication module industry in China launch multiple stock-keeping units in different countries to address such challenge.

- To address rising bandwidth demands in automotive systems as automotive applications become complex, The Companies' in-car network communication technology uses Ethernet to build a local network within vehicles, enabling high-speed data transmission and real-time communication between vehicle systems. Such network supports up to 1000 Mbit/s data rates, optimizing video transmission and other high-bandwidth applications.

Source: Frost & Sullivan