Translated Excerpt

The following document is an excerpted translation of Shanghai's five-year plan for S&T development. This is one of many detailed provincial-level economic development plans likely to follow in the wake of China's national 14th Five-Year Plan, which was released in March 2021. Shanghai's plan identifies a raft of emerging technologies that the city government aims to boost, and proposes a major expansion and refinement of the city's tech transfer apparatus. This lengthy translated excerpt covers the following sections of Shanghai's plan: part I (overview), part III (basic research and innovation), part IV (key and core technologies), part VI (talent), and part X (innovation environment).

Title
Shanghai Municipal "14th Five-Year" Plan for Building a Science and Technology Innovation Center with Global Influence
上海市建设具有全球影响力的科技创新中心“十四五”规划

Source
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I. Development Basis, Situation, Mission, and Long-Term Goals

(i) Major progress in the construction of a science and technology (S&T) innovation center with global influence during the 13th Five-Year Plan period

Since the 13th Five-Year Plan [2016-2020], the Shanghai Municipal Party Committee and Municipal Government have thoroughly implemented the spirit of the major instructions of General Secretary Xi Jinping on the establishment of an S&T innovation center with global influence in Shanghai, have resolutely followed the path of innovation-driven development, and have adhered to the “Two-Wheel Drive” of technological innovation and structure and mechanism (体制机制) innovation. We have comprehensively improved the concentration of innovation resources, the influence of S&T achievements, the leadership of emerging industries, the attractiveness of the innovation environment, and the driving force of our radiating regional influence (区域辐射带动力). We have accelerated the formation of a basic framework system for the S&T innovation center, laying a solid foundation to allow S&T innovation center establishment during the 14th Five-Year Plan [2021-2025] to reach a new level.

- Predetermined goals for the core indicators of the Thirteenth Five-Year Plan have fundamentally been achieved. In 2020, Shanghai's total societal research and development (R&D) expenditures were equivalent to about 4.1% of the city's gross domestic product (GDP). The number of invention patents per 10,000 people reached 60.2, the number of Patent Cooperation Treaty (PCT) international patent applications reached 3,558, exceeding expectations, and there were 417,900 newly established enterprises. Moreover, the transaction value of technology export contracts at home and abroad was 126.87 billion yuan Renminbi (RMB), helping to nurture a new momentum.

- The concentration and visibility of Zhangjiang Comprehensive National Science Center has continued to improve. The establishment of national laboratories has been accelerated, with 14 major national S&T infrastructures having been built or under construction, initially forming the world's largest, most comprehensive, and complete photonics major S&T infrastructure cluster. A number of high-level research institutes representing the cutting-edge development direction of world S&T, such as the Tsung-Dao Lee Institute, the Shanghai Center for Brain Science and Brain-Inspired Technology, and the International Innovation Center of Tsinghua University, Shanghai, have been newly built and brought together.

- Major original S&T achievements have continued to emerge. Facing the cutting edge of world S&T, a number of pioneering achievements have emerged, such as the world's first circadian rhythm disorder cloned monkey model, the world's first artificial single-chromosome eukaryotic cell, and the world's first 10-petawatt (PW) laser amplification output. Shanghai scientists have published 124 papers in the three major journals *Science*, *Nature*, and *Cell*, accounting for 32% of the nation's total published papers in those journals. Facing major national needs, a number of major national S&T tasks have been accelerated. Shanghai has participated in the completion of major projects, such as the Jiaolong Manned Submersible, Xuelong Polar Observation Vessel, Tiangong Space Station, BeiDou Navigation Satellite System, Five-hundred-meter Aperture Spherical radio Telescope (FAST), Quantum Experiments at Space Scale (QUESS), and large aircraft, and have reached major achievements such as 300-millimeter large silicon wafers to fill domestic shortcomings. Facing the main economic battlefield, major breakthroughs have been made on strategic products such as etching machines and photolithography machines, artificial intelligence (AI) cloud training and inference chips have been released, and the performance and energy efficiency ratios of specific fields have reached the world's leading level. Facing the people's livelihoods and health, the innovative drug GV-971 for the treatment of Alzheimer's pathogens, advanced molecular imaging equipment for panoramic positron emission tomography (PET)/ computerized tomography (CT), the first domestically produced cardiac pacemaker, blood flow steering devices, and other major original biomedical products have been approved for listing.

- Our attractiveness to high-level talents has continued to grow. There are 178 academicians in Shanghai who belong to the Chinese Academy of Sciences (ranking the city second in the country). The city also has 1,617 leading talents in the "Local Team" ("地方队") training program, a total of 1,027 Oriental Scholars (东方学者), 1,338

Shuguang scholars (曙光学者), 1,157 members in the super postdoctoral incentive program, and 3,065 participants in the Youth Rising Star Program (青年启明星计划). The number of foreigners working in Shanghai is 215,000 (23.7% of the country's total), and about 50,000 work permits for high-end foreign talents have been issued. The number and quality of foreign talents introduced ranks first in the country, and for 8 consecutive years, Shanghai has been ranked "the most attractive Chinese city in the eyes of foreign talents," becoming the Chinese city of choice for the career development of global scientists.

- Our ability to serve the real economy has steadily increased. New and old conversion of industry has accelerated (产业新旧动能加快转换), as have breakthroughs in key and core technologies in key areas such as integrated circuits, biotechnology and pharmaceuticals, and AI. In 2019, the scale of our integrated circuit industry accounted for more than 20% of the national total, innovative drugs in the biotech and pharma industry have been approved for listing, accounting for about one-third of the country's total, and the local AI industry has gathered about one-third of the country's relevant talent. The energy levels (能级) of various innovative entities have continued to improve, the number of high-tech enterprises has exceeded 17,000, and a number of "hidden champions" in niche domains have accelerated. There are nearly 20 functional platforms for R&D and transformation, driving the industry output value of tens of billions of RMB. There are 14 national university science parks, more than 500 makerspaces, and nearly 30,000 small- and medium-sized technology companies and teams being incubated and served. A total of 771 regional headquarters of multinational companies and 481 foreign R&D centers have been introduced, ranking the city first in the country in terms of numbers. The construction of a multi-level capital market has been accelerated, and the STAR Market[1] has established and piloted a registration system. As of the end of 2020, there have been 215 listed companies, with a total of more than RMB 300 billion in funds raised and a total market value of nearly RMB 3.5 trillion. Specifically, 37 Shanghai companies are listed on the STAR Market, ranking the city first in the country in terms of raised funds and market value.

- Regional radial impact has continuously improved. Zhangjiang, Lingang, Minhang, Yangpu, Xuhui, Jiading, Songjiang, and other S&T innovation center incubators each have their own characteristics. The formation of the core area of the Pudong S&T Innovation Center has accelerated. The establishment of the Yangtze River Delta S&T Innovation Community has been accelerated, and the universal exchange of innovation vouchers has been gradually realized. International S&T cooperation and exchanges have been intensified. The preparations for the "Whole-Brain Mesoscopic Neural Connection Map" ("全脑介观神经联接图谱") major scientific project are progressing smoothly, and participation in the International Ocean Discovery Program (IODP), Square Kilometer Array (SKA) radio telescope, and other major scientific programs (projects) has continued to deepen. Inter-governmental S&T cooperation agreements have been signed with more than 20 countries and regions

[1] Translator's note: The STAR Market (科创板) is also known as the Sci-Tech Innovation Board of the Shanghai Stock Exchange. It was launched in July 2019 and markets itself as China's equivalent of the NASDAQ exchange in the United States.

and more than 20 Belt and Road[2] international joint laboratories have been built. The international influence of events such as the World Artificial Intelligence Conference (WAIC), Pujiang Innovation Forum, World Laureates Forum, and International Innovation & Entrepreneurship Competition has continued to increase.

- Comprehensive innovation and reform experiments have advanced in an in-depth manner. Legal and policy systems that conform to the laws of S&T innovation are continuing to be built, and the "22 S&T Innovations," "25 Scientific Reforms," the *Provisions of Shanghai Municipality on Promoting the Conversion of Science and Technology Achievements into Practical Applications*, the *Provisions of Shanghai Municipality on Promoting the Construction of Science and Technology Innovation Centers*, and other policies and regulations have been promulgated and implemented. The comprehensive innovation and reform experiment has achieved remarkable results. With a focus on the conversion of S&T achievements into practical applications (科技成果转化), S&T finance, and other fields, more than 70 local supporting policies and more than 170 reform measures have been introduced. At present, the 10 major reform measures that the State Council has authorized Shanghai to take the lead on have been fully implemented, and among the three batches of 56 replicable promotion measures approved by the State Council, 12 are based on Shanghai's experience.

(ii) New situation and new missions faced during the establishment of the S&T innovation center with global influence during the 14th Five-Year Plan period

During the 14th Five-Year Plan period, the world will undergo profound changes not seen in a century, and China has entered a critical period of approaching the front rank of the world's innovation-oriented countries. The establishment of the Shanghai S&T Innovation Center is at a critical stage between forming a basic framework system to achieving a comprehensive upgrade in functionality. Compared with the 13th Five-Year Plan period, Shanghai is facing a situation where internal and external risks and challenges and development needs are intertwined, creating a development situation where "crisis" and "opportunity" coexist in innovative development. This is mainly reflected as follows:

"One Major Trend:" The innovation opportunities and fierce competition brought about by the new round of S&T revolution are unprecedented. Scientific exploration continues to expand to both the macro level and also the micro level. Interdisciplinary and applied basic research are expected to produce major breakthroughs and give birth to new major scientific ideas and scientific theories. The pace of global technological change is accelerating, and the cross-integration and rapid iteration of cutting-edge technologies are reshaping the industrial system and spawning "tipping points," creating richer future scenarios and greater innovative value. The empowerment of new technologies and the integration of new industries have brought about new opportunities, making it ever more urgent for Shanghai to bolster the sources of S&T innovation. Shanghai must urgently benchmark the new requirements of the "Four

[2] Translator's note: The "Belt and Road" ("一带一路") refers to the Silk Road Economic Belt (丝绸之路经济带) and the 21st Century Maritime Silk Road (21世纪海上丝绸之路).

News,"[3] "Four Firsts,"[4] and "Two Batches"[5] proposed by General Secretary Xi Jinping. The city must seize the commanding heights of global S&T and firmly grasp the initiative in future development by cultivating new opportunities and making new advances.

"Two Major Risks:" The two major risks— the game being played between the great powers (**大国博弈**) and the impact of the global pandemic—have brought about unprecedented and grave challenges. Technological innovation has become a key force in reshaping the international landscape, and mastering key and core technologies, emerging technologies, and underlying technologies (**底层技术**) has become a key factor in the game being played between the great powers. At the same time, the global COVID-19 pandemic has brought about greater uncertainty, uncontrollability, and non-traditional external risk factors, which may affect the security and stability of the production chain and supply chain. Faced with these two major risks, to build an S&T innovation center with global influence, it is urgent that we rely on S&T to become self-reliant and thus achieve higher-quality development. There is an urgent need to create a central node for domestic great circulation with a strategic link with domestic and international dual circulation[6] under more open conditions. There must be a greater focus on key areas and a strengthening of strategically oriented technological breakthroughs. We must accelerate the exploration of a new nationwide system for key and core technology research, effectively respond to various risks and challenges, and maintain national strategic security.

"Three Major Innovation Needs:" With the regional integration of the Yangtze River Delta, improvements to urban energy levels, and the people's pursuit of the good life, the urgent need for high-level innovation has never been seen before. For the high-quality integrated development of the Yangtze River Delta region, there is an

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[3] Translator's note: The "four news" (“四个新”) are concepts from Xi Jinping's *Report* to the 19th Party Congress in 2017. They are: (1) The new era (新时代); this refers to the new era of socialism with Chinese characteristics. (2) The new mission (新使命); this refers to the historical mission of the Chinese Communist Party in the new era. (3) The new thought (新思想); this refers to Xi Jinping Thought on Socialism with Chinese Characteristics for a New Era. (4) The new journey (新征程); this refers to Chinese modernization led by socialism with Chinese characteristics.

[4] Translator's note: The "four firsts" (“四个第一”) refer to Xi Jinping's "four comprehensivelys" (四个全面) formulation, which (1) for the first time made establishing a well-off society in an all-round way (全面建成小康社会) into a key step in realizing the Chinese dream of the great rejuvenation of the Chinese nation (中华民族伟大复兴中国梦); (2) for the first time characterized the overall objective (总目标), to comprehensively deepen reform (全面深化改革), as perfecting and developing the system of socialism with Chinese characteristics (中国特色社会主义制度) and advancing the modernization of the national governance structure and governance capacity; (3) for the first time put comprehensively ruling the country according to law (全面依法治国) on par with comprehensively deepening reform; and (4) for the first time demarcated a path for comprehensively running the Party strictly (全面从严治党).

[5] Translator's note: Party theorists have named multiple formulations associated with Xi Jinping as the "two batches" (“两个一批”). It is unclear which one applies here.

[6] Translator's note: "Domestic great circulation" (国内大循环) and "domestic and international dual circulation" (国内国际双循环) are the two components of the "new development pattern" (新发展格局) that Xi Jinping introduced in 2020. The new economic pattern is to consist of domestic great circulation, a.k.a. a domestic consumption-led economy, in a mutually reinforcing relationship with "domestic and international dual circulation."

urgent need to accelerate the construction of the Yangtze River Delta S&T Innovation Community, give full play to the radiating and leading role of the S&T Innovation Center, and take the lead in forming the new development pattern. The energy level of Shanghai has improved, and there is an urgent need to rely on technological innovation to accelerate the reshaping of new competitive advantages, comprehensively promote the digital transformation of the city, promote the development of an innovative economy, and accelerate the continuous new and old conversion of industry. To build a people's city in the new era, there is an urgent need for S&T innovation to support the modern governance, sustainable development, and high-quality public service supply of megacities, provide more innovation and entrepreneurship opportunities for all to achieve success, and to satisfy the people's desire for the good life with better S&T innovations.

Facing the new situation and new mission, Shanghai still faces several problems and shortcomings in building an S&T innovation center with global influence, such as our weak capability to provide high-level innovation, persistent shortcomings in basic science, key and core technologies, basic technology, and software, and a lack of stamina in the city's drive for high-quality development. The traction of industrial demand for S&T innovation has not yet been formed, and the main body of industrial innovation has insufficient capacity and motivation in terms of innovation strength, resource allocation, and innovation demand. The integration of the innovation chain with the production chain must be improved. The openness advantages of global cooperation have yet to be formed, and the breadth and depth of open innovation must be expanded. The new mechanisms and models of collaborative innovation must be improved with urgency, and an environment that encourages innovation and tolerates failure must be further optimized.

(iii) By 2035, the functions of the S&T innovation center with global influence will be fully upgraded

The next 15 years will serve as a critical leap period for the comprehensive upgrading of the functions of a S&T innovation center with global influence. The development of S&T in this period will allow Shanghai to fundamentally become both a socialist modern international metropolis with a global influence and a people's city that fully reflects the characteristics of China, the era, and Shanghai by 2035. This will provide a strong support for Shanghai to become the core leading city of the Yangtze River Delta's globally influential world-class city cluster. The establishment of S&T innovation centers in the future demands a firm affirmation of the core position of innovation in the overall drive toward modernization. For self-reliance and self-improvement in S&T, we must strengthen the functions of S&T innovation policy sources, anchor the key areas and key links of S&T development, and carry out a forward-looking and systematic layout in an all-round way. Looking forward to 2035, the S&T innovation center with global influence will be fully upgraded, with the strength of S&T having risen sharply. More key and core technologies will be independently controllable (自主可控), and major original achievements and a supply of high-level S&T will have continued to emerge. The accelerating formation of an innovation ecosystem and governance system that strongly attracts and draws

together global innovation resources will provide a strong source of power for China to advance to the forefront of innovation-oriented countries.

[Part II, "Overall requirements," omitted from translation.]

III. Accelerate Original Breakthroughs in Basic Research, Enhance Original Innovation Capabilities

Accelerate the establishment of the Zhangjiang Comprehensive National Science Center. Create a group of strategic S&T forces with a forward-looking layout for a number of strategic and basic cutting-edge projects. Support institutions of higher education, research institutes, and enterprises in independently deploying basic research. Accelerate the formation of a batch of original achievements in basic research and applied basic research. Achieve “Zero to One” original breakthroughs and strive to become “first discoverers of scientific laws.”

(i) Accelerate improvements to the concentration and visibility of the Zhangjiang Comprehensive National Science Center

Based on the country’s major strategic needs, organize our strengths to focus on the establishment of the Zhangjiang Comprehensive National Science Center and continue to launch breakthroughs in the layout for major original innovations. Give full play to the key supporting role of major S&T infrastructure with the output of original S&T achievements in mind and accelerate the formation of a new bastion of scientific discovery.

1. Accelerate the establishment of the Zhangjiang Comprehensive National Science Center

Promote the establishment of Zhangjiang Comprehensive National Science Center with a global perspective and international standards. Form strategic, forward-looking, transformative, fundamental, and systematic major innovations in several key areas with a reliance on strategic S&T forces such as national laboratories and major S&T infrastructure clusters. Make efforts to form core basic original capabilities in key areas.

Key direction: **(1) Build a national strategic S&T force led by national laboratories:** Facing the frontiers of S&T around the world, the main economic battlefields, major national needs, and people’s lives and health, focus on advantageous fields, strengthen top-level design and overall coordination, promote the establishment and development of national laboratories, and promote the optimization and reorganization of state key laboratories. **(2) Promote the deep integration of national laboratories, facility construction, and cross-cutting cutting-edge research:** Under the leadership of national laboratories and world-class major S&T infrastructure clusters, form a high-level S&T innovation base with complete functions and interconnections and fully stimulate the spillover effects of original innovation, scientific research, talent gathering, and international collaboration. **(3) Build an interdisciplinary and cross-field collaborative innovation network:** Strengthen joint development with comprehensive national science centers such as Huairou [District] in Beijing, the [Guangdong-Hong Kong-Macau] Greater Bay Area, and Hefei. Accelerate

the gathering of high-level innovation entities such as institutions of higher education, scientific research institutes, new research institutes, and enterprises. Gather and cultivate the world's top research institutes and first-class research teams. **(4) Establish a multidisciplinary and cross-cutting cutting-edge research management system in line with the laws of science:** Accelerate the establishment of a free and open scientific research and technological innovation system environment, explore the establishment of an organizational structure and operating mechanism based on science and reason, and focus on cultivating a cadre of high-level scientists with sentimental attachments to the homeland.

2. Build a world-class major S&T infrastructure cluster

Continue to lay out and build major technological infrastructures and explore the establishment of a local system to support the construction of major national S&T infrastructure. Accelerate the establishment of a collaborative innovation network in which multiple entities participate in its establishment and use. Continue to enhance the supporting and leading role of major S&T infrastructure in basic research, technological research, and economic and social development.

Key direction: **(1) Form an overall pattern of "a group in use, a group under construction, a group in research, and a group in planning:"** Accelerate the construction of equipment for hard X-rays, the second phase of Shanghai Synchrotron Radiation Facility, the submarine scientific observation network, and high-efficiency and low-carbon gas turbines. Promote the implementation of major S&T infrastructure such as Shanghai's thorium-based molten salt reactor research facility. Basically establish the world's largest photonics major technology infrastructure cluster with the most complete varieties and strongest comprehensive capabilities. Steadily build a facility cluster in the field of life sciences and plan for the future in the energy, marine, and aerospace fields. Accelerate the planning of a new batch of major S&T infrastructures around areas that are urgently required by China's S&T development, offer comparative advantages, and serve as precursors to technological breakthroughs. **(2) Strengthen system construction and improve facility operating efficiency:** Improve whole life cycle system arrangements for planning argumentation and justification, organization building, and operations management for participation in major national S&T infrastructure. Strengthen the planning and layout of major S&T infrastructures that are forward-looking, pertinent, and can serve as a reserve (储备性). Properly arrange for talents, technology, and engineering reserves and increase the intensity of project management, technical research, and supporting conditions for projects under construction. **(3) Promote open sharing:** Support R&D on key technology for facilities and experimental technology and devices, as well as the opening and sharing of facilities, and build a diversified collaborative innovation network involving institutions of higher education, scientific research institutes, enterprises, and other entities.

(ii) Accelerate the building of high-level basic research forces

With a focus on basic scientific research and key and core technologies, supported by foundational S&T innovation systems, marked by world-class scientific research

institutes, and guaranteed by the basic conditions of scientific research, form a systematic layout for basic research forces with clear strategic objectives, efficient operating mechanisms, and strong resource integration.

1. Improve the system of bases for scientific research

Facing scientific and engineering research, technological innovation and the conversion of achievements into practical applications, and basic support and conditional guarantees, actively strive for the establishment of a national scientific research base platform in Shanghai, improve the city's system for scientific research base platforms, and optimize the city's layout direction and management system scientific research base platforms.

Key direction: **(1) Science and engineering research bases:** Strengthen top-level design and enhance national strategic S&T strength. By striving for the layout of basic research bases such as state key laboratories, basic science centers, mathematics centers, and municipal key laboratories, comprehensively consolidate the scientific research foundation in the fields of mathematics, chemistry, astronomy and space, earth sciences, environment, biology, medicine, public health, information, materials, manufacturing, engineering, energy, maritime, and integrated interdisciplinary fields. Encourage diversified entities such as private enterprises (民营企业) and new research institutes to participate in their establishment and promote the extension of enterprise technological innovation to the foundational frontiers. Improve the collaborative innovation and emergency response capabilities of key laboratories and promote regional collaboration on basic research and major emergency prevention and control. **(2) Technological innovation and achievement conversion bases (技术创新与成果转化类基地):** Establish a number of strategically positioned high-end R&D and conversion functional platforms and innovation platforms, such as technology innovation centers, engineering technology research centers, clinical medicine research centers, and professional technical service platforms that gather innovative resources under diversified governance structures with independently controllable technology, a strong ability to convert S&T achievements into practical applications, and efficient technical innovation services. Implement the integrated promotion from key technological breakthroughs to engineering (工程化) and industrialization and form a large-scale platform pattern of collaborative and networked technological innovation. Optimize operation and management mechanisms for S&T achievement conversion bases, enhance the degree of marketization and professional operations, and strengthen links and system integration with incubators, industrial parks, and capital. **(3) Basic support and conditional guarantee bases:** Aiming at independent controllability and efficient use as the goal and focusing on the needs of basic research, applied research, and product development (试验发展), strengthen basic prerequisites for S&T such as scientific research instruments and reagents, scientific data, biological germplasm and experimental materials, field observation stations, technical standards, metrics and testing, as well as the establishment of related base platforms. Fundamentally form the basic conditions for S&T resources covering and meeting the key areas of the city to improve the integration of S&T resources, shared service capabilities, and utilization

efficiency.

2. Building high-level research institutes

Focus on key areas, explore and optimize organizational models, management systems, and operating mechanisms, and accelerate the creation of a number of high-level research institutes.

Key directions: (1) Focus on basic cutting-edge fields such as physics, astronomy, and quantum, as well as key fields such as integrated circuits, biotech and pharma, AI, aerospace, and ship and marine engineering. Continue to promote the Tsung-Dao Lee Institute, Shanghai Quantum Science Research Center, the Shanghai Center for Brain Science and Brain-Inspired Technology, Shanghai International Innovation Center of Tsinghua University, Shanghai Artificial Intelligence Innovation Center, Shanghai Qi Zhi Institute (上海期智研究院), Shanghai Tree-Graph Blockchain Research Institute, Zhejiang University Shanghai Institute for Advanced Study, and other new high-level research institutes. Promote major basic cutting-edge scientific research, breakthroughs in key and core technologies, and system integration innovations, and establish a new legal person system for public scientific research institutes so as to improve the differentiated and categorized management mechanisms of mission-oriented scientific research institutes. (2) Focus on basic cutting-edge science, cutting-edge leading technology, modern engineering technology, and disruptive technologies, draw together international and domestic innovation resources, and deploy and build a number of high-level research institutes such as the Shanghai Applied Mathematics Research Center. (3) Support international first-class scientific research institutes and world-class universities that build new research institutes in Shanghai and support central government agencies in Shanghai that offer in-depth participation in the establishment of the S&T innovation center through collaborations between ministries and municipalities, between institutions and local governments, and between the central and local governments.

3. Strengthen the supporting force of basic conditions for scientific research

With the goal of independent controllability and efficient utilization, focus on key scientific research instruments, basic scientific research software, scientific databases, and international academic journals to accelerate deployment.

Key direction: (1) Accelerate the independent research and development of key scientific research instruments and the establishment of standards: Focus on R&D on high-end general purpose scientific instruments and equipment and key and core technologies as well as domestically produced components for major scientific instruments and equipment. Enhance independent R&D and the dedicated supply of large-scale scientific research instruments and scientific research equipment. Support innovative breakthroughs in scientific instrument principles, new technologies, new designs, new processes, and new applications to accelerate the formation of independent intellectual property (IP) rights. Encourage industry-academia-research institute collaborations to independently formulate, revise, and improve the technical standards of the instrument industry and strengthen the application and

demonstration of domestically produced scientific research instruments. (2) Improve basic scientific research software and scientific databases: Strengthen R&D on scientific computing, modeling and simulation, scientific experimentation, and other such software to gradually realize the independent R&D of functional modules for scientific research software. Promote the establishment of a scientific data center (library), accelerate the open sharing of scientific data in the context of big data, and become a gathering place for scientific data resources. (3) Create local international academic journals: Accelerate the establishment of competitive localized (本土化) international academic journals and enhance global academic influence in the field of basic scientific research.

Accelerate independent research and development of key scientific research instruments

Focus on original scientific research instruments, core components of major S&T infrastructure, core technologies, and key components of general purpose and professional scientific instruments and accelerate independent R&D.

Main tasks: (1) Support the development of high-end instruments and reagents in key directions such as medical testing, biotech and pharma, and public safety, and improve the energy level of engineering and industrialization. (2) Support research into high-safety and high-reliability technology such as terahertz technology, optical fiber sensing and detection technology, and key optical detection technology and focus on researching hybrid technology for fully automated scientific instruments, fully automated sample pre-processing equipment, and other types of scientific instruments. (3) Achieve breakthroughs in R&D, quality control (QC), and technical application integration for high-purity reagents, high-end reagents, and biochemical reagents. (4) Strengthen the promotion and application of instruments and equipment in the fields of food, environmental protection, public safety, and other aspects of people's livelihoods.

(iii) Deepen the establishment of innovation capabilities in institutions of higher education

Implement the establishment and deployment of the national "double world-class"[7] strategy. Taking "meeting the urgent needs of the country and striving for the world first-class" as a starting point, persist in key breakthroughs and promote work in all areas by drawing upon the experience gained at key points. Guide institutions of higher education towards combining the needs of both economic and social development so as to create curricula that can produce more original, forward-looking, and leading scientific ideas and scientific discoveries. Strive to become an important source for leading the international academic cutting edge, spurring technological changes in manufacturing, and accelerating innovation-driven

[7] Translator's note: Translator's note: The "world-class universities and world-class curricula" (世界一流大学和一流学科) initiative, abbreviated "double world-class" ("双一流"), was launched by the PRC government in 2017 with the aim of increasing the number of Chinese universities that rank among the world's best.

development.

1. Optimize the layout and construction of disciplines

Strengthen basic research, focus on original innovation, optimize the layout of disciplines, promote cross-disciplinary integration, improve the supply system of general purpose basic technology, focus on improving the original innovation and high-level talent training capabilities of institutions of higher education, and comprehensively enhance the overall strength of higher education in Shanghai.

Key direction: **(1) Strengthen the layout and construction of basic discipline systems:** Promote a comprehensive and systematic layout of basic disciplines and encourage institutions of higher education to explore original breakthroughs. Bravely open up new fields, propose new theories, and develop new methods, promote the development of basic research and applied basic research, and jointly create environments conducive to scientific research. **(2) Support the improvement of the basic research capabilities of applied disciplines:** Strengthen support for applied disciplines and enhance the basic research capabilities of applied disciplines. Promote interdisciplinary integration and encourage institutions of higher education to go beyond existing discipline boundaries. Create new models for the organization of curricula and promote the industrialization and conversion of innovation achievements into practical applications. Lay an important foundation for breakthroughs in key general purpose technologies for industry. **(3) Actively integrate into the global innovation network:** Strengthen international S&T innovation collaboration in all aspects, gather global innovation resources, and promote international S&T exchanges and collaborations. Lead or offer in-depth participation in major international and regional scientific programs and scientific projects. Establish a world-leading international joint collaboration laboratory and actively participate in the formulation of international standards and regulations. Implement higher education talent pooling activities to recruit international-class high-level talents and outstanding young talents.

Promote the establishment of peak and plateau disciplines (高峰高原学科)

Encourage and support institutions of higher education that fully focus on their own advantages and characteristics as they climb to new heights. Form a pattern of breakthroughs in multiple fields centered around breakthroughs in fields of research so as to promote the establishment of world-class curricula and comprehensively enhance the curriculum strength of institutions of higher education in Shanghai.

Main tasks: **(1) Continue to promote the establishment of peak disciplines:** Place greater emphasis on the layout of basic disciplines and improvements to the basic research capabilities of disciplines. Emphasize greater support for what is in demand, greater support for what is special, greater support for what is outstanding, and greater support for what is new. Place greater emphasis on serving the urgent needs of national strategies and accelerate the ascent of peak disciplines to new heights to ensure that Shanghai strives to advance to the forefront with world-class

universities and world-class curricula. **(2) Continue to promote the establishment of plateau disciplines:** Strive to guide local institutions of higher education towards independently identifying the key points of discipline development, strengthen the unique advantages of disciplines in the development of service areas, and improve the quality of talent training and innovation capabilities.

2. Promote high-quality collaborative innovation

Encourage institutions of higher education to carry out high-quality collaborative innovation around major scientific issues in economic and social development and breakthroughs in key and core technologies in key industries so as to enhance their contributions to the sources of industrial technological innovation.

Key direction: **(1) Promote the establishment of systems for collaborative innovation across institutions of higher education:** Focusing on the country's and on Shanghai's major strategies and industrial development needs, promote the in-depth integration of industry, academia, and research institutes, lay out and build a high-level collaborative innovation center, and gather all kinds of innovation resources and factors of production (要素) to carry out joint research. **(2) Deepen the reform of collaborative innovation systems and mechanisms:** Be demand-oriented, encourage the exploration of effective mechanisms and paths for collaborative innovation, implement the spirit of education evaluation reform, establish an evaluation system based on sound science and reason, and implement personnel incentive policies.

Major platform: **Build an innovation center for collaboration between institutions of higher education.** Support institutions of higher education that carry out and organize scientific research around the core links of the production chain. Support institutions of higher education that cultivate and build a number of innovation platforms. Promote accurate links between the innovation chain and the production chain as well as the conversion of the major original innovations and key technological breakthroughs of institutions of higher education into advanced productive forces (先进生产力).

3. Cultivate top-notch innovative talents

Support institutions of higher education that cultivate high-level talents with both political caliber and ability (德才兼备), improve dynamic adjustment mechanisms for disciplines and specialties, and cultivate a group of innovative basic research talents and high-quality applied talents.

Key direction: **(1) Implement a strong base (强基) incentive plan.** Focus on basic disciplines and cutting-edge interdisciplinary studies, build a group of bastions of strong base talent training, select a group of outstanding undergraduates and graduate students with ambition, interest, and potential in institutions of higher education at home and abroad, implement long-term, continuous training, and cultivate future scientists in basic disciplines. **(2) Strengthen the incubation of talents for the integration of science and education and the integration of production and education:** Deepen the training of talents integrating science with education, rely on important scientific research bases, and support the incubation of top-notch innovative

talents by carrying out major scientific research tasks. Link up to the establishment of Shanghai's industry-education integrated city (产教融合型城市), promote the reform of the industry-education training model for professional degree postgraduates, and carry out the training of high-level applied talents who are in short supply. **(3) Promote improvements to the quality of degree-granting locations (学位授权点):** Focusing on key fields and industries that are in short supply, strengthen the incubation and establishment of relevant degree-granting locations, and improve the quantity and quality of talent supply according to industry needs. Adjust and optimize the graduate training structure, continue to moderately expand the scale of professional degree programs, and further meet the talent needs of economic and social development.

(iv) Strengthen the forward-looking layout of basic research

Adhere to both free exploration and strategic demand traction, strengthen the top-level design and overall planning of basic research, and give full play to the key role of the Basic Research Strategic Advisory Committee as well as the supply and leading role of sources of basic research and applied basic research on S&T innovation. Aiming at the major scientific issues of global basic cutting-edge fields and key and core technologies, strengthen deployment in key areas and encourage interdisciplinary and cross-disciplinary research to form a first-mover advantage in key areas.

1. Brain science and brain-inspired AI

Maintain Shanghai's international leading edge in brain science and brain-inspired research, support the realization of disruptive brain-inspired AI technologies, and drive the industrial revolution of brain health and brain-inspired intelligence. Key directions: (1) Focusing on the principles of brain cognition, the mechanisms of brain diseases, and the key scientific issues of brain-inspired intelligence, promote major breakthroughs in research on cognitive neural circuit mechanisms, primate brain mapping, cognitive impairment-related brain disease mechanisms and interventions, brain-inspired computing, and brain-computer fusion. (2) Promote significant progress in the establishment of major municipal S&T projects in related fields and the Shanghai Center for Brain Science and Brain-Inspired Technology and initiate the implementation of major scientific programs.

2. Quantum technology

Focusing on the key scientific issues of the new principles and effects of quantum information, new approaches to quantum technology, and new enabling technology formed by quantum effects, strengthen cutting-edge exploration and achieve new breakthroughs, promote huge progress in next-generation information technology, communication security, and computing technology to enter the ranks of global quantum information innovation pioneers. Key directions: (1) Guided by functional integration and practicality, actively promote research into ultra-fast strong field quantum control, quantum materials and device design, multi-degree-of-freedom quantum sensors, new pathways in quantum computing, opto-acoustic quantum devices, quantum topological photonics, interface superconductivity, and programmable optical lattice quantum simulation. (2) Focus on breakthroughs in new

mechanisms and methods of quantum technology and research and development of core quantum devices.

3. Nanoscience and transformative materials (变革性材料)

Fully meet the development needs of strategic emerging industries, vigorously develop the scientific research system of nanometer and new materials, solve the key technical problems of high-performance materials in several key areas, and accelerate the development of new materials. Key directions: (1) Promote the specific synthesis and precise customization of nanofunctional units, the active structure and bionic collaboration of smart soft materials, the design and regulation of multiple functions of smart fibers, and the cutting-edge basic research of transformative materials such as the soft condensed matter functional materials. (2) Research and develop new advanced materials for new energy, information, biological and medical applications, and other important fields. (3) Achieve breakthroughs in major scientific issues around the technological basis for intelligent preparation of advanced materials such as additive manufacturing, material thermal manufacturing processing, material organization evolution, and digital twins of key components throughout the material life cycle. (4) Explore the establishment of new theoretical systems such as flexible and smart materials, develop a batch of transformative new materials that meet the needs of advanced manufacturing and lead the development of the industry, break through the ultra-high-performance limits of structural materials, and realize the controllable equipment, device construction, and intelligent integration of advanced functional materials.

4. Synthetic science and life creation (生命创制)

Break through the major scientific issues and key general purpose technical and scientific issues of the artificial biosynthetic system, form an innovation ecosystem of biofabrication science, technology, and strategic emerging industries, and significantly enhance the international competitiveness of synthetic biology. Key directions: (1) Promote the integration of multiple disciplines, achieve breakthroughs in artificial biological design, artificial biosynthesis of drugs, high-efficiency creation of artificial organisms of new structures and new functional drugs, and environmental ecosystem bioremediation to establish new theories and new methods. (2) Research and develop original core technologies in gene editing, DNA assembly, and directed evolution and build a variety of high-efficiency artificial biofabrication systems. (3) Explore new directions such as semiconductor synthetic biology and functional microbial robots.

5. Stem cells and regenerative medicine

Promote breakthroughs in major scientific issues and key technologies at the cutting edge of stem cells and regenerative medicine and build a stem cell regenerative medicine center and related emerging technology industrial clusters. Key directions: (1) Taking the demand for treatment of degenerative diseases, metabolic diseases, tumors and other major diseases as the traction, promote research on pluripotent stem cells, tissue stem cells, stem cell directional differentiation and cell transdifferentiation, stem cell-based tissue and organ functional repair and micro-organ construction, stem cell

therapy, and stem cell-based drug discovery. (2) Explore the new directions of AI-empowered life fabrication, neural fabrication, and brain life renewal engineering and promote the integrated development of the innovation chain and production chain for stem cells and regenerative medicine.

6. Core algorithms and future computing

Focus on cutting-edge and cross-cutting research in computing science, promote the innovative development and application of future computing technology, and enhance the ability to support research in cutting-edge science and key areas. Key directions: (1) Promote the application of modern algorithms, develop new algorithms, and make breakthroughs in algorithmic issues such as AI, modern cryptography, high-performance computing, quantum computing, and physical devices and computing. (2) Enhance the practicability of AI algorithms and the high performance and security of new computing systems.

7. Regulation and design of life processes

Accelerate the resolution of major scientific issues in complex life systems and promote life science research to enter a world-class level. Key directions: (1) Focus on tumor fate mechanism and process regulation by promoting tumor fate hologram drawing and its transformation applications, a tumor multi-dimensional temporal and spatial change law and fate maintenance mechanism, and research on different nutrition and metabolism reprogramming rules. Clarify the causative factors and pathogenesis and discover new targets and new pathways for tumor metabolism therapy. (2) Focus on major physiological processes such as cell cycles and metabolism, gene replication, transcription, and epigenetics, protein synthesis and degradation, and organ development and homeostasis as well as common chronic diseases, neurological diseases, infections and immunity, and other important disease pathological processes. Establish new data platforms for epigenetic analysis and mass spectroscopy and make new discoveries in the research directions of related nucleic acid and protein modification, gene expression regulation, and developmental regulation mechanisms. (3) Develop new methods for early diagnosis based on new molecular typing methods, new standards for imaging diagnosis, and new targets for biomarkers, and explore new medical strategies and models such as precision medicine and AI medicine. (4) Focusing on major scientific issues of genetic evolution and metabolic biology of agricultural organisms, carry out research on the development and evolutionary process mechanism and epigenetic regulation of plants and animals, establish a new genetic screening system, and deeply understand and reveal the metabolic mechanism of model animals and plants and the complex regulation network of life and the environment.

8. Physical sciences

Break through major scientific issues such as the physical properties of materials, the creation and transformation of new materials, and the material mechanisms of materials and blaze new paths for the advancement of scientific frontiers and original innovations in major fields. Key directions: (1) Relying on the fundamental and

supporting role of major S&T infrastructure on the cutting-edge development of physical sciences, promote state control and catalysis as well as the frontiers of physics and chemistry and their interdisciplinary research. Obtain new theories, new discoveries, and new methods in many-body theory, strongly correlated systems, soft condensed matter and effects, efficient and selective synthesis and assembly methodologies, eco-friendly new chemical systems, formation and transformation processes for matter at different time and space scales, and the relationships between substances, human health, and the system functions of the environment. (2) Strengthen interdisciplinarity, promote the birth of major new technological principles, provide a new knowledge base for new materials and devices, and promote a deep understanding of life phenomena.

9. Mathematical sciences

Optimize the environment for mathematics research, enhance the scientific research level of the Shanghai Applied Mathematics Center, promote the integration of mathematics and engineering applications and industrialization, and enhance international influence and innovation support. Key directions: (1) Support the free exploration and applied research of basic mathematics research, promote the coordinated and sustainable development of mathematics curriculum systems, and consolidate the foundation of mathematics research. (2) Strengthen applied mathematics and applied research on mathematics, promote scientific and engineering calculations, mathematical theories and methods of big data and AI, complex system optimization and control, and achieve major original achievements in research on key mathematical issues in key directions such as computational mathematics and information technology, energy and the environment, maritime, biotechnology and pharmaceuticals, and economic and financial security.

10. Space science

Focusing on the strategic tasks of national space S&T development, significantly enhance Shanghai's space science exploration capabilities and space technology competitiveness and improve Shanghai's space S&T support capabilities to respond to major challenges in social and economic development. Key directions: (1) Promote new discoveries in the fields of space astronomy and space physics, solar system exploration, microgravity science, and space life science. (2) Promote new breakthroughs in scientific issues in key areas such as ultra-quiet, ultra-precision, and ultra-stable space science satellite platforms, inertial sensors, ultra-high-sensitivity infrared detection, and ultra-precision laser interferometry. (3) Support space science research to make breakthroughs in response to global climate change, ecological degradation, major natural disasters, and energy and resource shortages.

(v) Organize the implementation of major strategic projects for basic and cutting-edge research

Adhere to national strategic needs to seek major breakthroughs in major national strategic projects, major municipal S&T projects, and major scientific programs and projects. Systematically lay out major strategic projects at the forefront of the

“World-Country-Shanghai” cascade of succession to strengthen Shanghai’s global voice in basic and cutting-edge fields.

1. Major national strategic projects

Connect to the implementation of national strategic deployments and strengthen coordination between central and local governments when exploring and implementing new mechanisms for the joint support of the central and local governments to jointly organize major national basic research tasks. Promote the establishment of effective paths for the establishment of a new nationwide system in which Shanghai is deeply involved in breakthroughs on major scientific issues. Key directions: (1) Promote the implementation of "S&T Innovation 2030—Major Projects" such as brain science and brain-inspired research, new generation AI, quantum teleportation, and quantum computing. (2) Strengthen support, services, and comprehensive guarantees for major national strategic tasks.

2. Major municipal S&T projects

In key areas where the country has demand and Shanghai has a foundation, organize the implementation of a batch of major S&T projects for which the city has a major leading role, a large amount of capital investment, an outstanding synergistic effect, and a significant supporting role. Key directions: **(1) Accelerate the launch of a new batch of major municipal S&T projects.** Facing key areas such as integrated circuits, biotech and pharma, and AI, concentrate superior resources and accelerate a forward-looking layout. **(2) Improve management mechanisms for major municipal S&T projects.** Strengthen the connections and overall planning of financial investments in S&T and optimize the organization and management.

3. Big science programs and big science projects

Accelerate the promotion of Shanghai’s participation in and initiation of large-scale scientific programs and large-scale scientific projects internationally, build an innovative and open collaboration platform, and enhance international influence in strategic cutting-edge fields. Key directions: (1) **Take the lead in the Whole-Brain Mesoscopic Neural Connection Map big scientific program.** Accelerate the preparation of a new batch of major scientific projects such as the International Human Phenotype Group and accelerate the advancement of major scientific projects such as the Square Kilometer Array Radio Telescope (SKA). Continue to support participation in the International Ocean Discovery Project (IODP) and the International Astronomical Digital Film Research Project. (2) **Implement international S&T partnership projects.** Cultivate and improve the ability of qualified scientific research units to participate in or initiate large-scale scientific projects and large-scale scientific works.

"Whole-Brain Mesoscopic Neural Connection Map" Big Science Project

Led by Shanghai scientists, mobilize and gather the world’s top scientists and teams to shape the global leadership of Shanghai brain sciences and attain a leading position in the fields of global brain science and brain-inspired intelligence.

Key tasks: **(1) Construct a whole-brain gene expression and cell classification map:** Establish a new method for high-throughput and high-precision analysis of gene expression and cell classification in the whole brain, construct a spatiotemporal information map of the expression of genes related to brain function in the whole brain, and clarify the distribution of important molecules in the synaptic transmission of various neurons in the whole brain. **(2) Analyze the structure and function of mesoscopic neural connections in the whole brain:** Draft various types of neuron output and input neural connection maps, establish automated, standardized, and high-throughput 3D neural connection reconstruction technology and analysis methods, and analyze the function and cognitive behavioral significance of different types of neuron connections. **(3) Observe and regulate the activity of mesoscopic neurons in the whole brain:** Develop new types of electrode arrays to simultaneously observe the electrical activity of thousands of neurons in multiple brain areas. Develop a new generation of fluorescent molecules or nanoparticle probes that are sensitive to changes in cell membrane potential, have a high signal-to-noise ratio, and can distinguish individual nerve impulses. Develop a new wireless miniature fluorescent microscope endoscope to observe the electrical activity of neuronal clusters in deep brain regions. **(4) Establish a big data processing and sharing platform for the whole-brain mesoscopic neural connection map:** Establish a unified data platform involving multiple countries and featuring major functions such as automatic data collection, processing, storage, and display in order to coordinate mission progress and data integration and sharing.

IV. Enhance the competitiveness of key and core technologies and create new drivers of high-quality industrial development

Intensify S&T research, accelerate breakthroughs in a number of key and core technologies, provide supplies for high-level technological innovation, support and lead the high-quality development of industry, and strive to become the “first creator of technological inventions” and “first pioneer of innovative industries.”

(i) Accelerate core technology research breakthroughs in three key areas

Focus on the three key areas of integrated circuits, biotech and pharma, and AI, gather elite forces, improve the new national system for deep participation in key and core technology research, and encourage the three major areas to accelerate progress toward the high-end of the global innovation chains, production chains, and value chains.

1. Integrated circuits (ICs)

Focus on the development of complete sets of processes, key equipment, materials, design tools, and core chips, make breakthroughs in the key and core technologies of integrated circuits, accelerate the formation of advanced complete process capabilities, promote the formation of first-class key products, improve the level of the integrated circuit production chain, and ensure the security and stability of the production chain and supply chain. Aiming at the frontiers of world S&T, strengthen the research layout of disruptive technologies, form a batch of original achievements in

new structures, new devices, and new methods for integrated circuits, and comprehensively improve original innovation capabilities in the field of integrated circuits.

Key directions: (1) Chip research and development (2) Electronic design automation (EDA) (3) Equipment and materials (4) Complete processes

Major platforms: Accelerate the construction of the National IC R&D Center, Integrated Circuit Equipment Material Innovation Center, Integrated Circuit Innovation Center, National Intelligent Sensor Innovation Center, and Shanghai Institute of IC Materials to serve as a system of innovation platforms for the promotion of major key technology research and the industrialization of integrated circuits.

2. Biotech and pharma

Benchmark to the highest international standards and best levels, focus on the cutting edge of biotech and pharma, and create a bastion of innovation for the biotech and pharma industry around key platform construction, core technology breakthroughs, clinical verification and transformation, and new product applications.

Key directions: **(1) In the field of innovative drugs and vaccine research and development,** achieve breakthroughs in cell therapy, gene therapy, drug target discovery and confirmation, new antibody drug development, carbohydrate drug development, targeted preparations, nucleic acid interference drug development, and the development of other key technologies, and promote applications in regenerative medicine, the treatment of major chronic diseases, tumor immunotherapy, and the prevention and treatment of infectious diseases. Construct major disease models that align closely with clinical characteristics, accelerate the research and application of original and innovative drug discovery based on new and general purpose biomarkers and new technologies for drug and vaccine design, and promote the application of new technologies, new materials, and new dosage forms in the development and production of new drugs and vaccines. **(2) In the field of high-end medical equipment,** research and develop digital diagnosis and treatment equipment, biological material processing equipment, high-end pharmaceutical production equipment and flexible manufacturing, interventional medical devices, traditional Chinese medicine (TCM) medical equipment and TCM production equipment, artificial heart-lung machines (extracorporeal membrane oxygenation; ECMO), leadless pacemakers, artificial organs, fully degradable stents, 3D bioprinting, and other products and key material technology and core components. **(3) In the field of medical digitalization and intelligence,** carry out R&D on internet medical blockchain and telemedicine technology and AI medical products and application scenarios. **(4) In the field of TCM,** strengthen in-depth cross integration of cutting-edge technologies such as systems biology, big data, and AI with TCM research, develop meridian specificity and acupuncture treatment mechanisms, medicinal property theories for TCM, compatibility theories for prescriptions, and an effective material basis and action mechanisms for TCM compound prescriptions. Establish methods and techniques for evaluating the efficacy of TCM to be recognized by academic circles at home and abroad. **(5) In the agricultural field,** establish a phenotypic and genomics database

based on the security needs of the seed industry and mine for important functional genes. Integrate genome editing and conventional breeding technologies to establish a theory and technical system for precise crop design. Focus on the research of new germplasms of rice and green leafy vegetables with high yield, high quality, multiple resistance, high efficiency, and wide adaptability. Establish plant growth models based on phenotypic research and carry out research on plant factory hardware facilities and control software.

Major platforms: **1. Interdisciplinary science facilities for drug target discovery and confirmation:** Lay out source innovations for new drug creation, build a complete molecular, cell, and animal multi-dimensional drug target library, and form an intensive, informatized (信息化), automated, and intelligentized (智能化) comprehensive technology system for drug target research. **2. High-level biosafety laboratories:** Integrate multidisciplinary forces such as life sciences, biotechnology, medicine and health, big data, and AI, accelerate breakthroughs in key technologies in the field of biosafety, and build a high-level platform for biosafety experimentation. **3. Carbohydrate Drug R&D Technology Innovation Center:** Support the establishment of a carbohydrate drug research and development technology innovation center, overcome scientific issues and key technologies such as carbohydrate structure analysis, sample preparation, and drug discovery, and build a world-class carbohydrate drug resource library. **4. National Research Center for Clinical Medicine:** Continue to promote the construction of national clinical medical research centers for metabolic diseases, digestive system diseases, radiation and treatment (interventional therapy), eye diseases, senile diseases, and oral diseases. Support the creation of a national clinical medicine research center for birth defects and rare diseases, pathological diagnosis, infectious diseases (AIDS), and other municipal clinical medicine research centers.

Tackling key and core technologies in the field of biomedicine

1. Cell therapy and gene therapy: Establish a key technology system for cell therapy and gene therapy from the laboratory to the clinical stage, covering core technologies such as carrier research and development, production technology, quality control, and clinical transformation to meet the growing demand for the industrialization of cell and gene therapy in the domestic and international markets and to promote the technological innovation and industrialization of cell therapy and gene therapy products.

2. Major medical equipment and core components: In response to the major needs of healthcare and the key technical issues that restrict the development of the industry, focus on medical imaging equipment and in vitro diagnostic equipment, strengthen R&D on common technologies for digital diagnosis and treatment equipment, develop universal core components, digital analysis systems, and biomedical materials with independent intellectual property rights, promote the upgrading of traditional diagnosis and treatment equipment, establish a technical standards system for digital diagnosis and treatment equipment, and accelerate the

development and industrialization of digital diagnosis and treatment equipment.

3. Artificial intelligence

Carry out research on the basic theory of AI, organize research on key general purpose AI technologies, establish an internationally leading AI theory and technology system, and create a benchmark innovation ecosystem and experimental zone.

Key directions: **(1) Basic theory:** Carry out basic theoretical research on cognitive and fusion intelligence, autonomous and general intelligence, collaborative and evolutionary intelligence, and robust and trustworthy intelligence and break through the bottleneck of basic intelligence theory. Carry out continuous learning, causal inference, game optimization, and other new learning theories to improve the cognitive level of learning theories. Carry out research on new collaborative theories such as the boundaries of human-machine behavior, interaction and cooperation mechanisms, and human-in-the-loop and optimize the collaborative development theory for humans and machines. Carry out cross-theoretical research across AI and brain science, psychology, sociology, and quantum science to promote the formation of new and original AI theories. **(2) General purpose technology:** Achieve breakthroughs in key general use technologies such as knowledge computing engines, cross-media analysis, inference, and decision-making, hybrid enhanced intelligence, and deep natural language understanding. Build a tool set and algorithm evaluation platform that meets industry needs and improve empowerment applications and capabilities of AI in scenarios such as transportation, smart communities, health, smart finance, smart manufacturing, smart education, and public event management and decision-making. **(3) Social governance:** Carry out long-term, cross-domain AI social experiments, research and develop ethical AI systems, and build AI technology standards and testing and evaluation platforms in key areas.

Major platforms: the unmanned systems multi-body coordination facility (the Shanghai Research Institute for Intelligent Autonomous Systems), Shanghai Artificial Intelligence Innovation Center, Shanghai Qi Zhi Institute, Shanghai Tree-Graph Blockchain Research Institute, the visual computing national new generation AI open innovation platform, the intelligent marketing national new generation AI open innovation platform, the experimental teaching and testing national new generation AI open innovation platform, the cloud intelligence and robotics national new generation AI open innovation platform, the Shanghai new generation AI computing and empowerment platform, and the Shanghai Processor Technology Innovation Center.

Tackling key and core technologies in the field of AI

1. Basic AI support systems: Research and develop foundation layer open source algorithms, frameworks, and chips. Focusing on key industries such as transportation, medical care, and manufacturing, support the development of cloud training and terminal execution-oriented development frameworks, basic operator libraries, and algorithm libraries to improve and optimize the open source software ecosystem. Build large-scale AI data, algorithms, knowledge, and other resource libraries. Research and develop high-performance, high-scalability, low-power cloud

smart chips and low-power, high-performance terminal smart chips for terminal applications that are suitable for machine learning calculations. Develop supporting tools such as programming environments.

2. Smart technology and systems for process manufacturing: Develop basic theories for the automation and intelligentization of the process industry and industrial software. Research and develop ubiquitous perception and intelligent cognition, multi-target autonomous coordinated control, human-machine-object fusion intelligent decision-making, and process safety and environmental intelligence monitoring and emergency decision-making for process manufacturing processes to form a man-machine inclusive process manufacturing intelligence system.

(ii) Support and lead the development of key industries

Focus on key industries and advantageous areas such as strategic emerging industries, make breakthroughs on a number of key and core technologies in materials, equipment, and advanced processes, build a number of bases and platforms for experimentation and industrialization, and develop a series of new advanced manufacturing and high-end equipment products that are technologically advanced and oriented toward industrialization to support and lead the rapid development of key industries.

1. New materials

Strengthen the role of material genome engineering technology in the construction of materials R&D systems, enhance our ability to make innovations in cutting-edge new materials and our ability to provide assurance for independence in key strategic materials, and support the development of information, equipment, energy, biology and other industries.

Key directions: **(1) Advanced basic materials:** Promote research on key technologies for material preparation such as advanced smelting, coagulation casting, and high-efficiency green synthesis and accelerate the upgrading of advanced basic materials such as advanced metal materials and new chemical materials. **(2) Key strategic materials:** Focus on key strategic materials such as advanced semiconductor materials, carbon fiber composite materials, superalloys, artificial crystals, and high-performance membrane materials and provide key material support for electronic information, high-end equipment, advanced energy, biotech and pharma, and other fields. **(3) Cutting-edge new materials:** Cultivate the development of superconducting materials, graphene, 3D printing materials, and smart materials and develop new research methods for transformative materials and new green manufacturing technologies.

Major platform: National Carbon Fiber Composite Material Technology Innovation Center.

Technical research in the field of new materials

1. Carbon fiber composite materials for large aircraft: Achieve breakthroughs in the preparation technology of key materials for large aircraft such as domestically

produced high-toughness thermosetting resins and prepregs, dry fiber tows and liquid molding resins, thermoplastic resins and prepregs and plates, and green resins, as well as automated tape laying (ATL) and automated fiber placement (AFP) equipment and technology. Build a materials database and, in combination with big data technology, form large-scale composite material structure design, analysis, verification, and manufacturing capabilities. Encourage model applications for plastic mandrels and other process accessories. Develop archetypical domestically produced carbon fiber parts such as fuselage cap-type co-cured reinforced wall panels, thermoplastic composite corner sheets, and dry fiber liquid-formed window frames to improve the maturity of domestic carbon fiber composite technology and make it initially suitable for model selection.

2. Superconducting technology and integrated application systems: Construct the first kilometer-level high-temperature superconducting power transmission cable demonstration project in China. Achieve breakthroughs in key technologies for high-temperature superconducting magnets with large sizes, high current density, and strong magnetic fields. Complete the design of high-temperature superconducting fusion neutron sources, manufacture key components, and carry out related system integration engineering technology research. Achieve breakthroughs in the key technologies of superconducting devices and their system integration, develop superconducting sensors and detectors, superconducting processors and parametric amplifiers, and other superconducting devices, and realize system application demonstrations in the fields of quantum technology, geomagnetic detection, and biological imaging.

2. New information infrastructure

Promote technological innovation in fields such as 5G, big data, and the industrial internet and provide technical support for the construction of infrastructure for urban digital transformations.

Key directions: **(1) 5G:** Research on key 5G evolution technologies such as non-orthogonal multiple access (NOMA), direct terminal connection, millimeter wave communications, and in-band full-duplex (IBFD). Develop standardized open wireless access network white box equipment that adapts to the development of mobile communication networks. Research and develop mobile 5G communication modules such as wearable devices and smart units. Build an industrial 5G private network with high reliability and large uplink bandwidth. Form open industry standards and promote application demonstrations. **(2) Data processing and circulation:** Facing key application areas such as headquarters economies, smart manufacturing, biotech and pharma, and smart connected cars, build a platform system that supports exabyte (EB)-level data circulation services, research and establish a safe and efficient cross-border data circulation mechanism that is in line with international regulations, and create an “international data port.” **(3) Industrial internet:** Research industrial internet unified modeling theoretical framework and digital twin modeling language tools that integrate sensing, control, communications, computing, data, and other elements to realize multi-disciplinary, multi-dimensional, and multi-environment

collaborative reasoning. Research “terminal-edge-cloud” collaborative optimization technology for the integration of information and materials and improve the level of collaborative decision-making and dynamic optimization in each manufacturing link to realize accurate real-time feedback closed-loop control across multiple network levels. Research and develop key equipment such as industrial intelligent gateways and industrial edge computing units that support the deep integration of operational technology (OT) and information technology (IT), build an integrated security protection system for the industrial internet, form an industrial brain based on data definitions (基于数据定义的工业大脑), and promote the digital transformation of industrial enterprises.

3. Basic software

Continue to promote research on key technologies of basic software such as operating systems, middleware, databases, and software development tools and support application demonstrations in areas such as smart manufacturing, government affairs, finance, and internet services.

Key directions: **(1) General purpose technologies and R&D tools for basic software:** Research low-code rapid development platforms and technical systems based on business blueprints and domain modeling technologies to provide professional tools for enterprise management software development. Promote R&D on application software in embedded operating systems, database systems, cloud operating systems, and related fields and improve the level of independent research and development of basic software and key application software. **(2) General purpose technologies and applications of industrial software:** Integrate the development of new information technologies such as the industrial internet, big data, AI, cloud computing, research platformization (平台化), componentization, and lightweight and service-oriented industrial software architectures and development technology to support the efficient and sustainable optimization of industrial software development. Research the core technologies of industrial software such as the modeling, standardization, and softwareization (软件化) of industrial data and technical knowledge to promote the transformation of industrial technology into industrial software. Research and develop industrial software applications such as product design, industrial control, operations and maintenance (O&M) services, production control, and other professional aspects of the industry and carry out industry demonstrations and promotions.

4. Smart networked vehicles and new energy vehicles

Carry out technological research around the intelligentization and networking of vehicles and promote the application and popularization of intelligent technology on mass-produced vehicle platforms. Promote the development and application of key technologies and core products for fuel cells.

Key directions: **(1) Smart networked vehicles:** Research and develop core technologies such as on-board perception, driving decision-making, active and passive interaction, collaborative control, and regional information fusion, develop “low-cost,

high-reliability, and easy-to-mass produce" on-board chips, modules, and systems and carry out L4 autonomous driving demonstrations in specific fields. Carry out research on key technologies for data security and endogenous security and safety of intelligent networked vehicles and promote application demonstrations and the construction of systems of standards. **(2) Hydrogen fuel cell vehicles:** Achieve breakthroughs in the mass manufacturing technology of core basic materials and core components, master the design, verifications and vehicle integration technology of long-life voltaic piles (电堆) and systems, and carry out application demonstrations.

Technological breakthroughs in the field of smart networked vehicles and new energy vehicles

1. Geofenced L4 autonomous driving: Carry out the independent research and development of on-board components such as infrared night vision, frequency-modulated continuous wave (FMCW) LiDAR, and low-cost inertial measurement units (IMUs). Develop a fusion sensing system incorporating millimeter wave radar, visible light vision, infrared night vision, and LiDAR. Develop an intelligent decision-making control system based on domestically produced domain controllers. Research key technologies and evaluation test methods for the endogenous safety and security of intelligent connected vehicles. Promote geofenced L4 autonomous driving demonstration applications.

2. High power density, long life fuel cell stacks and systems: Achieve breakthroughs in preparation technology for core basic materials such as catalysts, proton-exchange membranes (PEMs), and gas diffusion layers (GDLs). Develop new-generation high-performance components such as high-performance air compressors and hydrogen circulation systems. Study the internal mechanisms of fuel cell stacks, establish rapid evaluation methods and identification and diagnosis techniques for the life attenuation of materials and key components, and improve the reliability of high-power density voltaic piles in an on-board environment. Improve fuel cell dynamic control technology to achieve high-power, high-volume-and-density integration of power systems, high power system output, and long-life applications in commercial vehicles.

5. Smart manufacturing and robots

Serve the strategic goal of building China into a "manufacturing powerhouse,"[8] establish an internationally leading intelligent manufacturing technology product support system, and form an important base for world-leading robot R&D, manufacturing, and system integration.

Key directions: **(1) Core basic components and equipment for smart**

[8] Translator's note: This translation renders the Chinese word 强国 qiángguó—which literally means "strong nation"—in English in two different ways, depending on context. When qiángguó is used in the general geopolitical sense, it is translated "world power," as in the phrase "socialist modernized world power" (社会主义现代化强国). When the Chinese text refers to a specific flavor of qiángguó, it is translated "powerhouse," as in the phrase "S&T powerhouse" (科技强国). For a more thorough discussion in English of the Chinese word qiángguó, see: https://www.newamerica.org/cybersecurity-initiative/digichina/blog/lexicon-wangluo-qiangguo/

manufacturing: Research and develop new types of smart manufacturing core basic components and devices such as sensors, intelligent measurement, industrial controls, drive controls, and human-machine collaboration. Research and develop intelligent manufacturing processes and equipment based on new principles, new methods, new energy fields (新能场), and new materials, including new computer numerical control (CNC) machines, additive manufacturing equipment, and intelligent production lines, and carry out application demonstrations in collaboration with industry. **(2) Integrated smart manufacturing systems:** Achieve breakthroughs in core technologies and integrated systems such as smart factories, cyber-physical fusion, digital main lines (数字主线), digital twins, product life cycle management, and product management and control that integrates design, manufacturing, and O&M, and build smart factories and smart enterprises in key areas. **(3) Robotics:** Research and develop basic components such as high-end precision reducers, controllers, and servo motors. Achieve breakthroughs in general purpose key technologies such as the lightweight design of robots, the integration of multi-axis drives and controls, information perception and navigation, robot operating systems, human-computer interaction, and autonomous programming. Research and develop industrial robots with features such as fully autonomous programming, human-computer cooperation, and heavy-duty automated guided vehicles (AGVs), and specialty robots with features such as autonomous obstacle avoidance while walking and underwater detection in complex housings, and service robots for medical and health care, assistance for the elderly and for the disabled, public services, and smart education. Carry out application demonstrations in collaboration with industry.

Major platforms: National Technology Innovation Center for Process Intelligence and the National Technology Innovation Center for Medical Robots.

Technical research in the field of smart manufacturing and robotics

1. Human-computer inclusive intelligent collaboration robots: Research and develop ontology technology (本体技术) including innovative configuration designs for intelligent collaborative robots, ultra-high power density modular integrated drive and control units, high-precision, high-flexibility and high-response controls, and autonomous security protections. Research multimodal multi-sensor data processing and fusion technology, and human-robot-environment ternary interaction and optimization theory and realize the deep integration and co-fusion of human, robot, and the environment. Develop fault models, process models, and knowledge maps of intelligent collaborative robots, launch autonomous motion and operation planning for intelligent collaborative robots, cloud-edge-terminal system architecture, collaborative control technology research, and the study of autonomous decision-making theory based on AI algorithms such as reinforcement learning and deep learning. Develop intelligent collaborative robots and systems that integrate humans and machines for application scenarios such as precision assembly and fine operations for industrial production.

2. Smart factory lean management and control platforms: Develop multimodal, cross-scale, massive business data, and manufacturing resources and

knowledge integration models and integration standards for the production and operation processes of smart factories. Research the collaborative intelligent decision-making optimization methods of manufacturing process resources with domain knowledge transfer learning capabilities. Achieve breakthroughs in technologies including the collaborative deployment of multiple systems in the production processes for smart factories, multi-process dynamic operation optimization, whole process quality tracking and control, online process planning and intelligent perception, and complex system failure prediction and health management. Build a lean management and control platform for smart factories based on cyber-physical fusion to realize the optimal scheduling of the entire process of smart factories with horizontal integration and vertical coordination and integration as well as multi-objective, multi-task real-time optimized control and intelligent decision-making based on big data. Carry out application demonstrations in key areas and core enterprises to build a new generation of smart factories.

6. Aerospace

Focusing on core equipment such as whole-aircraft and on-board systems and engines, promote R&D on core components, systems, and aircraft production lines. Achieve breakthroughs on key technologies for satellite broadband communication system network controls and develop the next-generation BeiDou navigation system.

Key directions: **(1) Large commercial aircraft:** Initially realize the independent control of key and core technologies for large commercial aircraft R&D and manufacturing, develop a new generation of flexible aircraft production lines, achieve breakthroughs in the key equipment and technologies of intelligent production lines, and promote the achievement of domestic production of (国产化) aircraft manufacturing equipment to realize the development of the full lineage of (谱系化发展) commercial aircraft. **(2) Aircraft engines:** Focus on the key technologies of civilian turbofan aircraft engines with large bypass ratios, carry out research on key technologies of new configurations of aircraft engines such as geared turbofan (GTF) engines, establish prototypes for surface strengthening technology for key parts, master 3D printing fuel nozzle industrialization technology, and carry out research on the application of melt-controlled self-generating composite materials. **(3) Satellite internet:** Carry out research on the intelligent manufacturing technology of satellites and launch vehicles and provide technical support for the cost reduction and efficiency increase of satellite manufacturing and launches. Arrange R&D on key technology products and systems including low-orbit satellite broadband communication system network controls, laser inter-satellite links, integrated on-board integrated electronics systems, on-board remote sensing payload and intelligent data processing, ground smart terminals, and integration of communications, remote sensing, and navigation. Promote the networking of satellite Internet systems, and accelerate experiments and applications in greenhouse gas monitoring, environmental monitoring, and space experiments. **(4) BeiDou navigation:** Arrange research on key technologies for the new generation of BeiDou navigation. Based on the country's enhanced network construction, develop BeiDou's high-precision service capabilities for satellite-ground integration and cover the world. Achieve breakthroughs in the core components and

key software and hardware technologies of the integrated positioning, navigation, and timing (PNT) system for communication and navigation fusion and multi-sensor fusion, and promote large-scale application research for precise space-time interconnections.

Major platforms: **1. BeiDou Navigation Technology Innovation Center:** Focus on the sky, ground, sea and space-time interconnection system and create an internationally influential demonstration of intelligent interconnected high-precision BeiDou navigation technology. **2. Satellite internet technology and industrial innovation demonstration platform:** Focusing on satellite internet, promote the construction of related parks in the space information industry base, such as for smart manufacturing of multimedia satellites, key single machines (单机) and key components, application terminals, and operational services with the preliminary construction of the system technology innovation chain and industrial application demonstrations represented by a "satellite smart manufacturing center," "global satellite network operations center," "air navigation interconnection," "sea navigation interconnection," and "vehicle-linked applications." Promote resource integration and benign interaction between domestic and foreign production chains and improve the development level and international competitiveness of Shanghai's spatial information industrialization.

Technical breakthroughs in the field of aerospace

1. Research on key technologies, core components, and equipment for civil aircraft design and manufacturing: Facing the design and manufacturing requirements of the C919 large passenger aircraft, carry out research on advanced civil aircraft manufacturing technology characterized by "flexible controls," "process-like manufacturing," and "a high degree of intelligentization." Achieve breakthroughs in key technologies such as multi-robot collaboration and robot cabin entry to achieve the flexible automated linking of cargo transfer and the integrated testing of connected intelligent aircraft system functions.

2. Smart mass manufacturing of satellites and components of the global multimedia satellite network system: In response to the development needs of global multimedia satellite network systems and the rapid deployment of low-orbit satellites, carry out research on the mass production of satellites and components, achieve breakthroughs in key technologies such as 3D printing of components, digital 3D manufacturing assistance, automated intelligent testing, and real-time simulation and testing of space-ground integrated communications. Establish intelligent assembly and integration, automated testing, and testing assembly lines for low-earth-orbit (LEO) commercial satellites and promote the upgrading of satellite research and production models.

7. Energy equipment

Focus on the field of advanced energy equipment, promote the incubation and development of emerging energy industries, and provide technical support for continuously enhancing the competitiveness of energy high-end equipment manufacturing and technical services.

Key directions: **(1) Gas turbines:** Achieve breakthroughs in the key technologies of gas turbines such as advanced high-efficiency compressor design technology, low-emission and high-stability combustion technology, advanced cooling technology, new thermal barrier coatings, and high-temperature component material technology. Realize the development and demonstration application of 300-megawatt (MW) class F heavy-duty gas turbines, 5MW class small gas turbines, and a new generation of 100-kilowatt (kW) class micro gas turbines. **(2) Far offshore wind turbines:** Achieve breakthroughs in the integrated design technology of offshore floating large-scale wind turbines, towers, and foundations and develop core equipment such as large-scale offshore wind turbine bearings, large-scale direct-driven permanent magnet generators, and large-scale converters to complete the development of 5MW floating wind turbines and 12MW and above offshore wind turbines. **(3) New-generation advanced nuclear energy systems:** Achieve breakthroughs in key technologies such as small modular thorium-based molten salt reactors, thorium-based molten salt dry post-treatment, and material irradiation and post-irradiation inspections to build a 10MW-class small modular thorium-based molten salt research reactor. **(4) Ship engines:** Research and develop key technologies for smart low-emission marine engines, such as ammonia, hydrogen fuel, and methanol. Achieve breakthroughs in the key general purpose technologies of the ship engine industry such as large-scale controllable combustion, high-pressure fuel injection, low-vibration and low-noise design, and low-friction and high-efficiency lubrication to complete the independent research and development of 50MW-class marine low-speed engines, 10MW-class marine medium-speed engines, and 3MW-class marine high-speed engines to achieve the independent design of low-speed ship engines.

Major platforms: The small modular thorium-based molten salt reactor research facilities, national magnetic-inertial fusion energy research center, national gas turbine manufacturing innovation center, national ship engine manufacturing innovation center, and high-efficiency and low-carbon gas turbine test equipment.

Technical research in the field of energy equipment

1. Far offshore wind power: Develop large-scale floating wind turbines suitable for China's sea conditions to form a leading domestic far offshore large-scale generator group and independent R&D and manufacturing capabilities for key components. Master the complete set of technologies for the design, construction, and operation of the Shenyuanhai Wind Farm and provide technical support for demonstration applications.

2. Serialized products for small gas turbines: Develop serialized products of 5MW-class small gas turbines to form independent research, development, testing, and manufacturing capabilities for small gas turbines and carry out demonstration applications.

8. Marine technology and engineering equipment

Focusing on high-end ships, offshore equipment, and other fields, arrange and implement a number of major tasks, make breakthroughs in a number of future-oriented key technologies in advanced design and manufacturing processes, and enhance independent innovation (自主创新) capabilities.

Key directions: **(1) Smart and green marine equipment:** Carry out R&D on ship intelligent systems and key technologies for green ships, form intelligent and green marine equipment capabilities, and launch remotely operated vehicles (ROVs) capable of deep-sea operations (underwater exploration and mineral development), thin-film liquid natural gas (LNG) containment systems, intelligent ship engine rooms, large-scale marine engineering offshore installation and dismantling operations, high-power offshore wind turbine installation and maintenance operations, and ocean drilling. **(2) Development and utilization of deep-sea resources:** Achieve breakthroughs in key technologies such as deep-sea high-power heavy-duty operations, low-disturbance green development on the seabed, intelligent deep-sea operation environment perception and auxiliary decision-making, and seabed environmental disturbance monitoring and evaluation, develop core key products such as eco-friendly seabed mining, and achieve real-world at-sea test verification. **(3) Ocean exploration, observation, and comprehensive management:** Master the key technologies of marine comprehensive test fields, submarine observation network access detection technology, distributed autonomous ocean sensor networking technology, the key technologies for all-weather surfacing and far-offshore residential floating research facility platforms, and refined early warning and forecasting technology that couples wind, waves, and currents. Carry out R&D on super long-range autonomous unmanned monitoring technology. **(4) Development of marine biological resources:** Carry out research on the reliability design technology of ocean pastures under deep and distant sea conditions and on key technologies for deep and distant sea aquaculture equipment and supporting facilities. **(5) Polar S&T:** Launch polar environment and space observation, comprehensive polar geophysical exploration, deep ice sheet sampling, polar ecological health assessment and protection, polar waterways, biological and space resource utilization, and other technology and equipment R&D. Develop polar region navigation ships, ice sheet cargo conveyance tools, and ultra-low temperature materials, and build a polar region stereoscopic observation network. Improve China's independent R&D capabilities and environmental protection capabilities for polar observation and detection equipment and provide support for China's polar utilization strategy.

Major platform: Marine comprehensive test fields.

(iii) Strengthen breakthroughs in strategic cutting-edge technology

Adapt to the trends of industrial change, deploy strategic cutting-edge technologies, accelerate forward-looking, pilot, and exploratory major technological breakthroughs, and provide support for the incubation and expansion of future industries.

1. Brain-computer interface (BCI)

Through the “brain-machine-environment-brain” feedback loop, communication and control channels are established between the brain and external devices to achieve breakthroughs in and applications of key underlying technologies.

Key directions: **(1) Neural interface:** Research and develop new high-throughput flexible skin electrodes, flexible deep electrodes, and silicon-based integrated micro-damage rigid electrodes. **(2) Microchips:** Develop high-throughput neural activity signal acquisition and control integrated chips. **(3) Algorithms:** Establish cognitive mechanism and calculation models for multimodal perceptual information collaboration and build new codec algorithms. **(4) Systems:** Develop a highly robust, highly secure, highly adaptable recording and control integrated software and hardware system. **(5) Animal verification and clinical research:** Establish animal model BCI behavior paradigms and clinical ethics and experimental systems, study non-invasive brain state regulation technology, and provide auxiliary treatment methods for patients with brain diseases.

2. Brain-inspired photonic chips

Drawing lessons from the structure and mechanisms of human brain nerves and using photons as the information carrier, carry out cutting-edge research on the core principles and key technologies of brain-inspired photonic chips, laying the foundation for the development of high-performance AI chips in the future.

Key directions: (1) Research on optical neural technologies with low power consumption and high computing power such as new neuromorphic computing architectures and neural network models. (2) Research on the theoretical models and theoretical devices of photonic memristors and the establishment of prototype brain-inspired photonic chips by imitating the basic units of neural networks. (3) Research on the materials and device preparation technology of laser, electron beam, and plasma beam nano-processing, and preparation of photonic chips based on carbon, silicon, lithium niobate, and other materials. (4) Research on nano-control technologies in photonic chips, including optical computing theories and technologies of new systems such as neural networks and quantum computing.

3. Autonomous smart unmanned systems

Build systems such as global precise perception, complex environment simulation, autonomous multi-body coordination, and digital twin control to achieve breakthroughs in the key and core technologies for algorithms, devices, and systems.

Key directions: **(1) Whole area perception:** Build a high-precision large-scale perception system to realize multi-scenario dynamic environment perception and multi-agent real-time perception. **(2) Environmental simulation:** Build a complex multi-scenario simulation system to support the testing and verification of land, sea, air, and sky unmanned systems. **(3) Multi-body coordination:** Build a multi-body collaboration and algorithm experimentation system to achieve multi-body collaboration between land, sea, air, and space. **(4) Twin control:** Build a digital twin control system and realize management, control, and prediction based on physical space and information space perception data and simulation data. **(5) Demonstration**

applications: Carry out demonstration applications of land, sea, air, and space autonomy and achieve breakthroughs in the key technologies and applications of thousands of heterogeneous multi-body autonomous collaborations.

4. Sixth-generation mobile communications (6G)

Carry out 6G network system architecture innovation and cutting-edge general purpose key technology research to lay a technical foundation for 6G standardization competitions and industrial development.

Key directions: **(1) Network and system architecture:** Explore new technologies and methods for addressing, routing, forwarding, transmission, security protection, and privacy protection of new types of network communications. Create an advanced network communication basic testing and verification platform around white-box hardware, open source software, and open interfaces. Support rapid verification and iterative innovation of new network architectures, protocol systems, and efficient algorithms to lead the development of international standards. **(2) Cutting-edge key general purpose technologies:** Carry out the development of key technologies including wireless coverage extensions, wireless air interface transmission, high-density radio frequency (RF) front-end technology, wireless network security architecture, spectrum sharing and coexistence, all-scene on-demand services, and the integration of air, space, and ground networks.

5. Blockchain technology

Promote research on the key underlying technologies for blockchain with high performance, security, and scalability, master basic technologies such as peer-to-peer network digital signatures and consensus algorithms, and build a batch of independent public chain and consortium chain new infrastructures and open source communities.

Key directions: (1) Research cutting-edge technologies in the blockchain field such as consensus protocols, encryption, digital signatures, smart contracts, and cross-chain protocols, as well as new basic platform technologies for public chains and consortium chains and build blockchain application development support platforms and open source communities to form a blockchain technology system and continuous innovation capabilities. (2) Research technologies such as security monitoring, privacy-preserving computation, and contract auditing and give play to the role of blockchain in data sharing, optimizing business processes, reducing operating costs, improving synergy efficiency, and building trustworthy systems to promote the realization of cross-departmental and cross-regional joint maintenance and utilization of government data.

6. Extended reality (ER)

Facing the interaction needs of people and the digital world in the age of intelligence, make progress in expanding the basic theories of reality, cutting-edge technology, and software and hardware, solve the core technical problems of perception, decision-making, and interaction, and realize the in-depth application of mainstream scenarios.

Key directions: **(1) Crossmodal perception technology:** Research real-world visual, auditory, and language perceptual computing, multimodal collaborative non-sensory interactive inputs, and other technologies. Research and develop key devices such as optical, acoustic, and mechanical sensors that move intelligent computing forward, achieve crossmodal and energy-efficient superhuman intelligent perception, and improve recognition accuracy. **(2) High-fidelity content generation technology:** Research technologies such as the intelligent understanding of complex and diverse unstructured content and the context-adaptive high-fidelity generation of content, develop an ER content production platform, and achieve seamless integration of the real world and virtual space. **(3) Deep immersion technology:** Research the holographic feedback of near-eye display optical waveguides and audio-visual-tactile fusion, research and develop core devices such as multi-focal distance and ultra-low latency display devices, and seamless brain-computer collaboration interfaces, and provide a deeply immersive and real sensory interactive experience. **(4) Key components:** For the application of ER systems, launch flexible touch display integration, zinc oxide array substrate, flexible micro-light-emitting diode (LED), and other panel technologies, non-polarizer high transmittance and under-screen camera display and other module technologies, and blue phosphorescent materials and devices, and other material technologies to improve user experience with ER and such.

7. Pushing manufacturing past its limits (超限制造)

Research and develop a new generation of ultrafast laser manufacturing technology, break through manufacturing limits in the fields of chemicals, pharmaceuticals, information, medical equipment, and aerospace.

Key directions: **(1) Scientific issues:** Explore the new mechanism of ultrafast laser precision manufacturing, and the new principle of the momentum transfer, heat transfer, qualitative transformation, and chemical reaction process (三传一反) for micro-nano fluid fine chemicals. **(2) Key general purpose technologies:** Research and develop general purpose core technologies such as large-size and high-precision transparent material three-dimensional internal engraving, metal material multi-function precision etching, and micro-nano chemical system design and evaluation, and establish related technology platforms. **(3) Key prototypes:** Develop key prototypes of micro-nano chemical reactions for the continuous manufacturing of fine chemicals and pharmaceuticals and develop domestically produced micro-nano reaction devices (反应装置) and precision interventional medical prototype devices. **(4) Application demonstration lines:** Build a multi-step continuous flow process application demonstration line based on pushing micro-chemical system manufacturing past its limits.

8. Fiber robots

Focusing on the precise diagnosis and treatment needs of major diseases such as tumors and cardiovascular diseases, research and develop millimeter and submillimeter micro-scale surgical robot systems with integrated and diversified functionality including photomechanical, acoustic, and electrical features.

Key directions: (1) Research kinematics, dynamics, and attitude control methods for micro-scale surgical robots, achieve breakthroughs in multi-body precise control and inclusive interaction technology based on multi-mode micro-sensing, and realize controllable robot shapes, controllable stiffness, and controllable interactivity. (2) Research and develop optical fiber-based micro-imaging systems, establish optical biopsy image databases, develop precise tracking algorithms for robots and lesions, and realize functions such as target recognition and redirection as well as real-time intraoperative planning. (3) Research and develop surgical robot systems such as image-guided orthopedic surgical robots and image-guided neurosurgery robots, develop high-precision multi-degree-of-freedom mechanical arms, high-precision sensors, and other core components, develop prototypes of micro-scale surgical robots, carry out verification, and promote clinical practice application demonstrations.

9. Smart bionics

Explore new functional materials for bioinformatic functions, achieve breakthroughs in new devices for information acquisition and processing, and develop intelligent bionic systems with integration around multiple bionic functions.

Key directions: **(1) Bionic mechanisms and materials:** Research and develop new bioinformatic functional materials (生物化信息功能材料) such as bionic perception, information processing, bionic energy, and environmental interaction. **(2) Bionic functional devices:** Develop high-sensitivity bionic chips for vision, hearing, smell, touch, and other functions, bionic positioning and navigation devices based on biomagnetic protein and magnetotactic bacteria, and energy conversion and storage devices based on bionic nano power-generating materials and bionic membrane materials. **(3) Smart bionic systems:** Research the key technologies of adaptive biological function fusion for environmental diversity, develop new multi-scale intelligent bionics, and realize the composite perception and fusion processing of multi-dimensional heterogeneous information.

10. Millimeter wave radar systems

Explore new technologies, new frequency bands, and new applications for millimeter-wave radar, develop miniaturized, high-resolution, and multi-functional vehicle-mounted millimeter-wave radar systems, and promote the development of automotive intelligentization.

Key directions: **(1) High frequency bands:** Research the key technologies of 120GHz high-frequency millimeter-wave radar, achieve breakthroughs in bottlenecks such as high-frequency RF front-end chips, high-resolution algorithms, and miniaturized antennas to meet the requirements of miniaturized on-board systems and high resolution. **(2) Anti-interference:** Research millimeter wave radar with orthogonal frequency division multiplexing (OFDM) technology and achieve breakthroughs in key technologies such as anti-interference radio frequency front-end chips, signal processing algorithms, antennas, and high-performance processors to improve spectrum utilization. **(3) New applications:** Research integrated radar for detection and communication, forming a collaborative application of singular and swarm intelligence.

11. Deep water exploration, communication, and deep-sea development technology

Research and develop a series of equipment for far-offshore development, concentrate the scientific research strength of Shanghai's shipbuilding and offshore engineering, integrate the comprehensive advantages of the Yangtze River Delta to carry out joint research, and achieve breakthroughs in key technologies and demonstration applications.

Key directions: **(1) Deep-water exploration technology:** Research and develop a new generation of high-precision, low-power, high-reliability marine three-dimensional high-resolution underwater sensing acoustic technology to achieve the high-precision detection of underwater resources and task targets (作业目标). **(2) Deep-sea communication technology:** Achieve breakthroughs in the new generation of digital underwater voice communication technology based on intelligent equalization (均衡) of ocean communication channels and realize long-distance, high-fidelity underwater acoustic communication and wireless information transmission for deep-sea tasks. **(3) Deep-sea resource development technology:** Research and develop key technologies for offshore natural gas hydrate trial production projects, floating liquefied natural gas (LNG) storage and regasification device technologies, and key technologies for deep-sea mineral, oil, and gas exploitation. **(4) Deep sea development assurance technology:** Achieve breakthroughs in smart ship dual-fuel engine technology, key technologies for deep-sea and ocean energy development, bionic flexible autonomous submersible technology, whole-sea deep work robots, deep-sea space station technology, and extreme environment marine corrosion-resistant steel technology.

12. Hydrogen energy technology

Focusing on the production, storage, transportation, and refilling of hydrogen, as well as the utilization of hydrogen energy, research and develop key technologies and core components to promote the development of hydrogen energy multi-scenario applications and the development of the hydrogen energy production chain.

Key directions: **(1) Hydrogen production technology:** Research and develop high-efficiency broad-spectrum solar energy photocatalytic water splitting of new high-efficiency catalysts and reaction systems for hydrogen production, 100kW high-temperature solid oxide electrolysis hydrogen production systems, and MW-class high-efficiency proton exchange membrane (PEM) water electrolysis for hydrogen production systems in order to improve hydrogen production efficiency. **(2) Storage, transportation, and refilling of hydrogen:** Research and develop hydrogen refueling station systems and equipment technology based on liquid hydrogen or compound hydrogen storage, new materials with high hydrogen content and low hydrogen absorption/desorption temperature based on light elements such as lithium, boron, nitrogen, carbon, magnesium, and aluminum, as well as solid-state hydrogen storage equipment and portable hydrogen storage devices. **(3) Hydrogen technology utilization:** Research safety technologies for the large-scale application of hydrogen energy, the key technologies for the efficient utilization of hydrogen-based fuels in

marine engines, the design methods of renewable synthetic fuels, and engine application technologies. Research and develop a 200kW-class low-cost, high-performance, long-life PEM fuel cell and cogeneration system, solid oxide fuel cell technology and a 30kW-class cogeneration system, hydrogen-rich gas smelting application technology, and natural gas hydrogen mixing technology and terminal application technology.

13. 3D bioprinting

Develop personalized regenerative medicine products with a superior anatomical structure, mechanical properties, and biological functions to achieve precise structural and functional regeneration of tissues and organs.

Key directions: (1) Research and development of stable and efficient bioinks (cells, materials, extracellular matrix, growth factors). (2) Research and develop new bioprinting technologies and equipment, and launch designs and applications for cell survival maintenance systems and bioreactors. (3) Develop multi-channel 3D microfluidic cell culture systems, develop 3D cell culture and multi-organ internal microenvironment simulation technology, and establish a miniaturized human body system. (4) Apply 3D bioprinting and microfluidic chip technology to develop in vitro organ chips that can be used for drug screening.

14. Cell-electronic hybrid (细胞电子混合) systems

Research and develop including semiconductor synthetic biology technology and self-driving chip intelligent sensor systems (ISS). Promote the development of intelligent electronic drug diagnosis and treatment systems, rapid discovery and high-throughput screening of chemical drugs, personalized medical diagnosis and treatment planning, new types of microbiological drivers (robots), and other applications.

Key directions: (1) Research the energy generation mechanisms of living cells and biomechanical equipment. (2) Carry out research on the biocompatibility of the biological front-end and electronic back-end. (3) Establish a precision control technology platform for cell semiconductors based on the multimodal combination of electricity, light, heat, and chemistry. (4) Develop a hybrid cell electronics (混合细胞电子学) system that can be used for a new generation of sensors and drivers. (5) Research and develop intelligent electronic medicine diagnosis and treatment systems for digital precision treatment. Build a fully automatic and precise controlled electronic drug system for the steady-state intelligent diagnosis and treatment of metabolic diseases to realize fully automatic closed-loop steady-state control.

15. New antibiotics for drug-resistant bacteria

To cope with the low efficiency of treatment caused by multi-drug resistant pathogens, develop new drugs for anti-drug resistant bacteria to improve safety, broaden the diversity of targets, and slow down the development of drug resistance.

Key directions: (1) Discover new compounds with the potential to fight drug-resistant bacteria and develop new technologies and methods. (2) Launch

research on the pathogenic mechanisms of drug-resistant bacteria and on their interactions with their host. (3) Promote the rapid detection and precise diagnosis of bacterial infections.

[Part V, "S&T improves the well-being of the people; put into practice the concept of building Shanghai into a people's city," omitted from translation]

VI. Optimize the S&T innovation talent system and promote all-round career development

Gather talent from all over the world, take the lead in implementing a more open and convenient talent recruitment policy, actively recruit and cultivate high-level talents, top talents and teams, and especially outstanding young talents, implement the talent-led development strategy, and build a global bastion of S&T innovation talent.

(i) Build a team of S&T innovation talents to lead development

Given the strategic needs of the country and to shape Shanghai's new competitive advantages, cultivate the advantages of talent development and establish the "Gathering Global Talents in Shanghai" ("海聚英才") talent plan system, form an S&T talent training support mechanism with scientific categorization, clear hierarchy, and organic connections, and promote the integrated development of talents, projects, and bases in order to strive to create a team of high-level S&T talents who can meet the development needs of the new era.

1. Gather world-class high-level S&T innovation talent

Vigorously gather and cultivate a group of high-level S&T innovation talents and teams with international influence. Key tasks: (1) Optimize training mechanisms for high-level S&T innovation talents. Increase steadfast support for the team of leading S&T talents, give full play to the role of various S&T talent plans, and build a team of high-level S&T innovation talents with global competitiveness. (2) Strengthen the incubation of high-level S&T innovation talent teams. Relying on high-level scientific research institutes and new research institutes and benchmarking against internationally accepted rules and standards, optimize and improve management and operating mechanisms, provide a career platform for world-class innovation teams, and build a batch of interdisciplinary, integrated innovation teams for emerging and cutting-edge fields.

2. Cultivate outstanding young S&T innovation talent

Increase support for outstanding young S&T talents and support young talents that concentrate on research and make contributions. Key tasks: (1) Establish and improve a future-oriented training mechanism for young S&T innovation talent. Give full play to the role of institutions of higher education in cultivating young talents and increase the training of young talents in basic disciplines such as mathematics, physics, chemistry, biology, and earth sciences, as well as cutting-edge interdisciplinary disciplines. Select outstanding PhDs at home and abroad to focus on training and

expand the influence and coverage of the “Super Postdoc” program. (2) Optimize the support system for young S&T innovation talents. Guide institutions of higher education, scientific research institutes, enterprises, and other linkages in supporting the development of young talents and create a multi-disciplinary and multi-industry integration exchange platform and development opportunities for young talent. (3) Optimize trust and incentive mechanisms. Encourage young talents to devote themselves to research and bravely climb to the heights of science. Improve the coverage of awards for young S&T talents and encourage and support young S&T talents who participate in international exchanges.

3. Build a basic cutting-edge technology innovation team

Cultivate original innovation capabilities in an all-round way and guide scientists to closely integrate scientific research interests with national strategic needs. Key tasks: (1) Optimize natural science funds. Explore the establishment of funds with more diversified funding channels, expand the scale of the funds, provide all-round support for basic research talents in fields in which Shanghai has an edge, and encourage scientists in Shanghai to carry out cutting-edge research and explore the “uncharted territories” of basic scientific theories. (2) Strengthen the incubation of basic research talent teams. Strengthen forward-looking deployment in strategic areas, support scientific issues surrounding major original basic frontiers and key and core technologies, focus on key research directions, and provide long-term stable support to talents and teams engaged in scientific research.

4. Strengthen support for S&T talents in key industries

Focusing on key areas such as integrated circuits, biotech and pharma, and AI, accelerate the formation of a cluster of S&T innovation talents. Key tasks: (1) Gather applied research talents in key and core technology fields. Focus on supporting the development of applied research talent teams who undertake key and core technology research. (2) Gather demand-oriented technology development talents. Develop a catalog of talents in key fields (S&T) that are in short supply and implement dynamic adjustments, include the talents listed in the catalog in the scope of priority support and services, and give full play to the catalog’s guiding role in the establishment of curricula and on-the-job training in institutions of higher education. (3) Intensify efforts to support skilled laboratory talents. Attach importance to the training of skilled laboratory personnel, improve remuneration and performance incentives, improve the reform of serial titles for experimenters, and unblock career development channels.

5. Develop a team of entrepreneurial talents in technology

Encourage all kinds of talents to start S&T businesses and create a group of entrepreneurs with benchmarking effects and high growth potential. Key tasks: (1) Optimize a support plan for S&T entrepreneurial talents. Increase the support of the S&T talent plan for S&T entrepreneurial talents and encourage talents to start their own businesses in various forms such as competitions, projects, and rewards. (2) Increase support for technological entrepreneurship. Support the development of innovation and entrepreneurship vehicles such as makerspaces, incubators,

accelerators, and university science parks. Give full play to the leading role of entrepreneurial guidance funds and encourage financial institutions to develop financial services that meet the needs of innovative and entrepreneurial talents. (3) Support the innovation and entrepreneurship of young college students and foreign talents. Give full play to the role of university student entrepreneurship funds, implement continuous assistance, full guidance, and one-stop services for self-employed students, and establish a multi-level offshore entrepreneurship support system.

6. Strengthen the team of S&T service talents

Accelerate the establishment of a professional, market-oriented, and international team of professionals in S&T services. Key tasks: (1) Strengthen the establishment of a team of technology transfer talents. Relying on the Shanghai Technology Exchange and the National Technology Transfer Talent Training Base (国家技术转移人才培养基地), optimize the technology transfer service talent training system and support enterprises and other social forces to promote the incubation of technology transfer talents. (2) Strengthen the team of innovative and entrepreneurial service talents. Relying on innovation and entrepreneurship vehicles such as technology business incubators, makerspaces, and university science parks, build a gradient, multi-level, and professional innovation and entrepreneurship service talent team. (3) Support the development of popular science talents. Support S&T centers, museums, art galleries, and other institutions in various fields to cultivate diversified science talents. (4) Cultivate hybrid technology service talents. Focus on supporting the development of talents in S&T consulting, technical standards development and application, intellectual property services, and financial services.

Strengthen support for industrial talents and the incubation of young talents

Create a team of S&T innovation talents that meet the needs of the construction of S&T innovation centers and the needs of economic and social development in the new era.

Main tasks: (1) Strengthen the support of industrial talents and formulate a list of talents in key areas (S&T) that are in short supply. (2) Strengthen the incubation of young talents, implement the “Strong Base Incentive Plan,” and select and cultivate 1,000 young future top talents every year. Increase support for “Super Postdocs” and select and cultivate 500 outstanding PhDs at home and abroad every year.

(ii) Improve the system and mechanisms to stimulate the vitality of S&T innovation talent

Establish and improve a more open and inclusive S&T talent system and mechanisms, build a scientific, standardized, and efficient talent governance system, form a talent system with global competitiveness, and fully stimulate the innovation and entrepreneurship of all types of talents.

1. Implement more attractive policy measures for overseas talents

Intensify efforts to recruit high-end overseas talents to create a better environment for overseas talents to work and live in Shanghai. Key tasks: (1) Implement a more open and convenient overseas talent recruitment policy. Give full play to the autonomy of employers in selecting, recognizing, and employing talents and consolidate the main responsibility of "responsibility lies with the employer" ("谁聘请、谁负责") in order to provide more convenience for employers in hiring overseas talents to work in China. (2) Optimize the work permit system for foreigners to come to China. Pilot programs to promote the application of work permits for foreign talents and teams during the entrepreneurial incubation period and facilitate the application of work permits for foreign young talents, members of scientific research teams, and key technology companies. (3) Introduce innovative measures for the recruitment of overseas talents. Introduce a series of measures in foreign talent visas, residence permits, and permanent residence applications, improve and perfect the social security system for overseas talents, and explore mechanisms and ways of attracting talents that are more in line with international rules. (4) Improve the service system for overseas talents in Shanghai. From the perspective of language environment and cultural integration and through the establishment of the "Overseas Talent Services Home," publish multilingual policy service information and provide more accurate and content-rich quality services for overseas talents in Shanghai to further create an environment for attracting overseas talents from near and far.

2. Improve the use and incentive mechanism that is conducive to the best use of talent

Guided by the value of talents, establish a more flexible mechanism for the use of talents and improve the incentive mechanism oriented toward increasing the value of knowledge. Key tasks: (1) Give employers greater autonomy. Support institutions of higher education and research institutes in formulating recruitment plans. Set job conditions, release recruitment information, and independently organize open recruitment in accordance with relevant national regulations and the needs of scientific research activities. (2) Give full play to the important role of enterprises in the recruitment and allocation of talents. Support employers in recruiting and cultivating S&T talents with outstanding contributions and optimize support mechanisms for public products such as S&T talent databases for enterprises to attract and cultivate talent. (3) Improve distribution mechanisms oriented toward increasing the value of knowledge. Optimize performance-based salary increase mechanisms for scientific research personnel in municipal scientific research institutes and implement checklist-style management (清单式管理) and annual salary systems for team leaders who undertake major strategic tasks full-time as well as for recruited high-end talents. (4) Give full play to the leading role of talents in major S&T tasks. Carry out winner-takes-all open competition[9] to recruit technical research teams, broaden the

[9] Translator's note: The idea behind "winner-takes-all open competition" (揭榜挂帅), in the context of PRC science and technology projects, is that the government openly lists the technological breakthrough(s) it desires. Any individual or group in society, not just a select few, are then eligible to win a cash award if they succeed in making the breakthrough. This concept is also known as the "bounty system" (悬赏制).

scope of the “contracting system” (“包干制”) for project expenditures, and provide talents with a support mechanism for basic research, applied basic research, and technological innovation and development.

3. Improve evaluation and flow mechanisms to inspire talents

Deeply implement the categorization and evaluation of S&T innovation talents and talent flow mechanisms to fully inspire the innovative vitality of talents. Key tasks: (1) Optimize the evaluation system for S&T innovation talents. Give full play to the role of employers as the main body for talent evaluation and standardize the categorization and evaluation mechanism for S&T talents for different types of talents engaged in basic research, applied research, the conversion of S&T achievements into practical applications (成果转化), and S&T management services. Abolish the “four onlys,”[10] implement a basic research masterpiece evaluation system, and explore a diversified talent evaluation mechanism. (2) Further decentralize the evaluation authority of professional titles. Promote the decentralization of the evaluation power of senior professional titles of natural science research personnel to qualified scientific research institutes and give full play to the leading role of scientific research units in the evaluation of professional titles. (3) Support scientific research personnel who work part-time or leave their jobs to start businesses in accordance with regulations. Encourage institutions of higher education, research institutes, and enterprises to provide “two-way posts” (“双向设岗”) for S&T innovation talents and support scientific research personnel in leaving their posts to establish enterprises to carry out the conversion of S&T achievements into practical applications.

(iii) Create an open and inclusive environment for S&T innovation talent

Give full play to the role of various districts and S&T innovation centers, strengthen assurance of people-centered (以人为本) comprehensive service, improve support for the endeavors of talents and for their quality of life, and cultivate an excellent ecosystem of innovative and entrepreneurial talents.

1. Give full play to the talent incubation functions of key areas

Give full play to the innovation incubation role of platforms and spaces to provide support for talent executives and entrepreneurship. Key tasks: (1) Give full play to the main role of each district in supporting talent innovation and entrepreneurship. Encourage all districts to build S&T innovation talent brands, strengthen the implementation of talent policies and link up supporting facilities, and provide all-round support for talent innovation and entrepreneurship. (2) Give full play to the talent gathering function of key regions. Support key areas including Zhangjiang Science City, Zhangjiang National Independent Innovation Demonstration Zone (张江国家自主创新示范区), Lin-gang Special Area, the Yangtze River Delta Ecological and

[10] Translator's note: The "four onlys" (“四唯”) refer to only considering publications authored, job titles held, academic degrees earned, and awards previously won when hiring, promoting, or giving awards to scientific researchers. PRC media always use the "four onlys" in the pejorative sense. Rather than relying solely on the superficial indicators of scientific greatness embodied in the "four onlys," the government and employers should also consider individual researchers' experience and other strengths.

Green Integrated Development Demonstration Zone (长三角生态绿色一体化发展示范区), and Hongqiao Business District (虹桥商务区) to accelerate the gathering of high-level talents in basic research and key domains.

2. Strengthen assurance of people-centered talent services

Be people-centered, strengthen comprehensive guarantees and public services, and support talents in actively investing in technological innovation. Key tasks: (1) Optimize housing guarantees for talents. Actively revitalize stock resources, encourage the construction of talent apartments with multiple market mechanisms, and adopt a simultaneous mechanism of "renting, selling, and subsidizing," and strive to solve the problem of S&T innovation talent housing. Encourage scientific research institutes to use their own resources to introduce support measures to ensure the settlement of young talents. (2) Build a high-level talent service system. Promote the development of market-oriented talent service institutions and provide service support for the entities employing talents. (3) Promote digital talent services. Optimize talent policy services such as "Policy BeiDou" and promote the "one-code integration" ("一码集成") of talent services. Continue to build a global high-level S&T expert information platform and formulate a system of S&T innovation talent development indicators and measurement methods that benchmark against internationally accepted rules and standards. (4) Strengthen theoretical research on talents. Give full play to the role of talent theory research bases and promote the development of talent theory based on demand.

3. Cultivate a group of talent activity brands

Expand international influence, build a group of top event brands, and gather global innovative and entrepreneurial talents. Key tasks: (1) Enrich the exchange platform for top S&T innovation talents. Continue to build the Pujiang Innovation Forum, the World Laureates Forum, and other S&T innovation talent exchange brands. (2) Inspire an atmosphere for innovation and entrepreneurship. To build the "Gathering Global Talents in Shanghai Innovation and Entrepreneurship Summit" ("海聚英才创新创业峰会") into a brand project with global influence, promote the establishment of a normal and long-term mechanism for the "Gathering Global Talents in Shanghai" cloud selection meeting, and transform the Shanghai Oversees Returnees Talents Innovation and Entrepreneurship Conference, Shanghai Innovation and Entrepreneurship 50-Youth Forum, and other activities into important platforms for innovation and entrepreneurship. Enhance the influence of activities such as China Innovation Challenge (Shanghai), Yangtze River Delta International Innovation Challenge, Shanghai International Maker Competition, and the "Entrepreneurship in Shanghai" Competition. (3) Establish a normalized communication channel for talents. Promote the institutionalization, scientification (科学化), and normalization of the work of contacting and serving experts, and encourage S&T innovation talents to conduct interactive exchanges through diversified channels.

4. Shape the city's culture of technological innovation

Create a cultural atmosphere in which the whole of society respects talent and

respects innovation. Key tasks: (1) Promote the spirit of scientists. Encourage S&T workers to focus on scientific research, study diligently, and steer from vanity regardless of fame or gain. (2) Promote entrepreneurship. Encourage entrepreneurs to be explorers, organizers, and leaders of innovative development. (3) Promote the spirit of craftsmanship. Encourage high-skilled talents to persevere and focus, strive for perfection, be meticulous, and pursue excellence. (4) Strengthen propaganda on the innovative achievements and contributions of S&T talents. Organize events such as the Shanghai S&T Innovation Talent Week to tell the Shanghai story of S&T innovation as regards various outstanding overseas, youth, and women talents.

[Part VII, "Focus on Zhangjiang, promote the construction of an S&T innovation center incubation zone," omitted from translation.]

[Part VIII, "Build an open and collaborative space for innovation, construct a higher-level global innovation network," omitted from translation.]

[Part IV, "Construct a municipal science culture, create a nationwide benchmark for the high-quality development of science popularization," omitted from translation.]

X. Build a more dynamic innovation ecosystem and promote the modernization of the innovation governance system and governance capabilities

Through systematic, holistic, and coordinated S&T system and mechanism reforms, build a more efficient, open, and dynamic innovation ecosystem, form a modern S&T innovation governance system and governance capacity, instill Shanghai with a scientific spirit that it may become a city of wisdom, a city of creation, a city of opportunity, and a city of ideals with surging innovative dreams, and strive to become the “first practitioner of innovative ideas.”

(i) Strengthen the dominant position of enterprises in technological innovation

Vigorously support innovation and entrepreneurship, promote enterprises in upgrading their innovation capabilities, support small, medium-size, and large enterprises and various innovation entities that integrate and innovate, and strongly support high-quality development.

1. Support the development and growth of innovative enterprises. Support crowd-creation spaces and incubators with relevant tax preferential policies in accordance with regulations, accelerate the incubation of S&T-based small and medium-size enterprises (SMEs), implement the high-tech enterprise incubation project and the S&T giant (incubation) project, and promote the listing and incubation of scientific innovation enterprises. Support leading S&T companies that combine upstream and downstream industries and industry-academia-research institute (产学研) scientific research forces to form an innovation consortium to promote the upgrading of the production chain, supply chain, and innovation chain. Support the rapid development of the entire chain of S&T innovation enterprises through multiple

methods such as corporate R&D subsidies, government procurement of innovative products, and initial purchase orders.

2. Fully stimulate the innovation vitality of state-owned enterprises (SOEs). Promote the steady increase in R&D investments by SOEs, carry out pilot projects for the innovative and comprehensive reform of SOEs, cultivate a group of state-owned S&T innovative enterprises that are in line with national strategies and have a high degree of market recognition and fully reflect the differentiated development needs of state-owned S&T enterprises in terms of salary distribution, selection and employment, and equity incentives. Promote the deepening of the market-oriented reform of SOEs in key industries to encourage innovation and improve a more flexible and efficient evaluation mechanism and salary system for S&T personnel.

3. Promote foreign-funded enterprises in exerting innovation spillover effects. Encourage multinational companies to establish foreign-funded research and development centers, global R&D centers, and foreign-funded open innovation platforms in Shanghai, and encourage foreign-funded research and development centers to participate in the construction of various R&D innovation bases and platforms. Support foreign-funded enterprises in participating in government scientific research projects, encourage foreign-funded enterprises, institutions of higher education, and scientific research institutes to build collaborative innovation platforms, and jointly carry out technological research and personnel training.

Implement high-tech enterprise incubation projects

Centering on the growth chain of enterprises, support the incubation of various types of technological enterprises and the improvement of their innovation capabilities. By 2025, the number of high-tech enterprises in the city will exceed 26,000, and the number of high-tech enterprises per 10,000 corporate legal persons will be steadily increased.

Main tasks: (1) Intensify efforts to support the construction of various incubators and makerspaces. (2) Implement a plan for the growth of high-tech SMEs, focus on "professional, meticulous, specialized, and innovative" ("专精特新") enterprises, and cultivate a group of "invisible champions" who master key and core technologies and possess core competitiveness. (3) Promote the accumulation and cultivation of high-tech enterprises. (4) Implement the small technology giant (cultivation) project to promote the emergence of a number of unicorns.

(ii) Promote the deep integration of technology and finance

Promote the joint development of the S&T Innovation Center and International Financial Center, strengthen the pull of the STAR Market,[11] promote innovation in S&T financial products and services, and increase the multi-channel supply of venture capital. Form an ecosystem for the sustainable development of S&T finance with a significant increase in the total amount of S&T credit, an accelerated concentration of

[11] Translator's note: The STAR Market (科创板) is also known as the Sci-Tech Innovation Board of the Shanghai Stock Exchange. It was launched in July 2019 and markets itself as China's equivalent of the NASDAQ exchange in the United States.

venture capital, effective S&T insurance, diversified social capital investments, and efficient coordination of multi-level capital markets.

1. Enlarge the brand effects of venture capital in Shanghai. Strengthen the leveraging effect of government guidance funds and strengthen support for early-stage S&T startups. Carry out pilot projects for the mixed ownership reform of state-owned venture capital institutions and innovate supervision and evaluation, incentive and restraint mechanisms, and equity transfer mechanisms. Establish a private equity and venture capital equity share transfer platform to broaden the exit channels for equity investment and venture capital.

2. Improve the accuracy of technology financial services. Under the premise of compliance with laws and regulations, controllable risks, and sustainable business, encourage banking institutions to strengthen cooperation with external investment institutions, actively explore diversified financial service models for technology, promote the development of intellectual property (IP) pledge financing, improve the credit product system for technology and a service system for government financing guarantees, improve the credit information sharing mechanism for S&T enterprises, and explore the establishment of a joint credit-granting mechanism across provinces (municipalities) for the Yangtze River Delta. Encourage insurance funds to carry out financial equity investment in compliance with laws and regulations, encourage banks and insurance companies to strengthen the construction of S&T institutions, and develop financial products that meet the characteristics of the development of S&T enterprises and technology trade. Explore a legally compliant bond holding and multi-level custody system. Support financial institutions in using financial S&T to improve the financing efficiency of technology companies, strengthen the construction of a composite technology and financial talent team, and enhance S&T and financial service capabilities.

3. Strengthen the pull of the STAR Market. Utilize hierarchical classification to cultivate key industry enterprises to go public on the STAR Market and promote the transfer of selected enterprises on the New Over-the-Counter (OTC) Market to the STAR Market for listing. Research the establishment of a long-term investor system, improve the old stock reduction system, explore risk hedging tools such as individual stock options, and improve the flexibility of the sponsorship follow-up mechanism. Relying on the Shanghai Technology Exchange, explore technology asset disclosure systems for listed companies on the STAR Market.

Strengthen the linkage between S&T innovation centers and international financial centers

Give full play to the supporting role of S&T finance for S&T innovation centers and provide strong financial support and services for S&T innovation and entrepreneurship.

Main tasks: (1) Give full play to the innovative role of the Shanghai Stock Exchange's STAR Market, implement the "Light of Pujiang" ("浦江之光") initiative, and improve the establishment of the reserve bank of listed companies on the STAR Market. (2) In key areas such as integrated circuits, biotech and pharma, and AI, give play to the leading role of state-owned venture capital to build a state-owned technology innovation investment company valued at over RMB 100 billion. (3) Encourage commercial banks to develop credit products and services for S&T enterprises and support the construction of S&T branches and special S&T branches. Accelerate the development of S&T insurance and support the development of S&T enterprises and the construction of major S&T projects. (4) Improve the establishment of infrastructure for S&T finance and give full play to the assurance role of the Shanghai S&T finance information service platform.

(iii) Promote the conversion of S&T achievements into practical applications

Follow the laws of market economics and S&T innovation, take efforts to go beyond system and mechanism bottlenecks for the conversion of S&T achievements into practical applications, further increase guidance and incentives for the conversion of S&T achievements into practical applications, and promote close linkages between the upstream and downstream of the innovation chain.

1. Promote the reform of the systems and mechanisms for the conversion of S&T achievements into practical applications. Accurately implement categorization reforms. In coordination with the new round of comprehensive innovation and reform pilot projects in Shanghai, promote the conversion of S&T achievements by institutions of higher education and research institutes and the implementation of policies, and strengthen system integration, collaboration, and efficiency. Promote the reform of the conversion of S&T achievements into practical applications by SOEs and medical institutions and deepen the system reform in the distribution of rights and interests for S&T achievements. **Promote the pilot reform of the ownership of on-the-job S&T achievements.** Explore agreements between pilot units and accomplishers of achievements to give them a proportion of ownership through rewards or paid transfers or the long-term right to use the achievements, and encourage pilot units to establish and improve corresponding decision-making mechanisms, management systems, and work processes. **Strengthen policy coordination.** Support the development of special reform pilot projects for the conversion of S&T achievements into practical applications and strengthen the integration and coordination between the conversion of S&T achievements into practical applications and the system of state-owned assets management, taxation policies, and intellectual property rights.

2. Improve the market-oriented allocation of technical elements. Promote the high-quality development of the technology market. Support the Shanghai Technology Exchange as it builds a national intellectual property and S&T achievement property rights trading institution and carry out operational services such as intellectual property transfer and licensing across the country. Consolidate the function of a national-level regional technology transfer center, improve the function of Shanghai's public service platform for the conversion of S&T achievements into practical applications, and provide in-depth services for various technology market elements. **Support capacity building for technology transfer.** Support institutions of higher education and scientific research institutes that establish full-time institutions for the conversion of technology into practical applications and improve achievement disclosures, decision-making implementation, assessment and evaluation, income distributions, incentives and constraints, and other systems for the conversion of S&T achievements into practical applications. Incubate market-oriented and specialized technology transfer institutions, encourage the development of technology transfer services such as patent operations, S&T evaluation, proof of concept, technology investment and financing, and achieve branding, large-scale, and international development. **Build a high-level technology transfer service talent team.** Rely on the National Technology Transfer Talent Training Base to unite social forces, and build the Shanghai Institute of Technology Transfer (上海技术转移学院). Form a technology transfer and talent cultivation ecosystem of domestic and international integration and interaction where professional training and academic education go hand in hand, and talent training and ecosystem building complement one another. Create a bastion of talent cultivation for domestic technology transfers. **Deepen the construction of vehicles for the conversion of S&T achievements into practical applications.** Support the establishment of specialized and regional conversion of S&T achievements into practical applications, or innovation and entrepreneurship clusters, in all districts. Promote university science parks to become the "first stop" for the conversion of S&T achievements of institutions of higher education and the "core incubator" for regional innovation and entrepreneurship. Arrange specialized international technology transfer channels to provide convenient space and channels for the efficient cross-regional flow of global innovation resources, innovative talents, and innovative achievements.

Implement the Three-Year Action Plan for the Conversion of S&T Achievements into Practical Applications

By 2023, the city's activity in the conversion of S&T achievements into practical applications and the quality of conversion service capabilities and technological transactions will increase significantly, and a sound technology market system will be fundamentally established that is unified and open with complete functionality that guarantees equal and efficient access to factors of production (生产要素) by different market players. By 2025, the innovation power of enterprises will be fully released, the supply of S&T achievements of institutions of higher education and research institutes will be further improved, and a national hub technology trading market and an international technology trading center will be fundamentally built.

Main tasks: (1) Implement a strong "core" project to enhance the innovation

capabilities of enterprises. Promote the reform of the state-owned assets and SOE system and inspire enterprise innovation. Strengthen the dominant position of enterprises in technological innovation and promote the concentration of various innovative elements in enterprises. (2) Implement a strong “base” project to enhance the ability to source resources. Establish and improve a full-cycle management system for S&T achievements to inspire conversions. Build a full-time institution for technology transfer to improve service capabilities. (3) Implement “energy enhancement” works to enhance technology transfer service capabilities. Consolidate the capacity to convert S&T achievements into practical applications and serve the entire innovation chain. Vigorously develop specialized technology transfer institutions and expand the service market. Vigorously cultivate talents for technology transfer services and upgrade the energy of the industry. (4) Implement “efficiency enhancement” works to optimize technology market allocation capabilities. Consolidate the functions of technology-related trading venues and promote the integration of essential resources. Strengthen financial capital to support the conversion of S&T achievements into practical applications and input capital power for the achievements. Improve the layout of the international technology transfer network and improve resource flow efficiency. Improve technology contract registration policies and optimize technology market services. (5) Consolidate organizational guarantees, implement policies, improve service networks, and strengthen information services.

Establishment of the Shanghai Technology Exchange

Through five to 10 years of hard work, gradually build a hub-type technology trading venue with sound functions, efficient services, transparent mechanisms, and stable operations, enhance the ability to allocate factors of production in the technology market, promote the coordinated development of technology, data, and capital, and other factor of production markets, and maximize benefits and efficiency in technology transactions.

Main tasks: (1) Establish a national intellectual property and S&T achievement property rights trading institution and carry out operational services such as the transfer and licensing of IP and S&T achievement property rights across the country. (2) Improve institutional systems that adapt to technology rights and interests transactions. Improve mechanisms for information disclosure, technology transactions, and authentication services and provide professional, efficient, and standardized technology transaction processes. (3) Build an intelligent, service-oriented, and professional technical trading platform, improve transaction efficiency, protect transaction power, and provide liability exemption mechanisms. (4) Create a win-win and mutually beneficial ecosystem for all elements of technology transactions and establish service guarantee systems, such as transaction plan customization, professional organization configurations, and comprehensive consulting.

(iv) Enhance S&T innovation governance capabilities

Continue to advance the reform of S&T systems and mechanisms and accelerate

the formation of a modern S&T innovation governance system and governance capabilities that are compatible with the S&T innovation center.

1. Promote scientific research institution system and mechanism innovations. **Accelerate the reform of modern scientific research institutes.** Improve the differentiated management and stable support mechanism of scientific research institutes oriented by mission and innovation performance, deepen and expand the autonomy of institutional management, personnel, and salary, and promote the management of rules and regulations. Coordinate and promote the performance evaluation pilots of scientific research institutes and strengthen the application of results. **Promote institutional innovation in public institution-type[12] new R&D institutes.** For public institution-type new R&D institutes engaged in strategic, forward-looking, disruptive, and interdisciplinary research with uncertain administrative levels and indefinite organizations that are not subject to job settings or total salary restrictions, implement comprehensive budget management, explore the implementation of negative checklist management (负面清单管理) for the use of funds, construct a profit distribution mechanism that fully reflects the value of innovation factors of production such as knowledge and technology, and improve corresponding institution registration mechanisms, asset allocation mechanisms, and other such mechanisms. **Promote the prosperity and development of enterprise-type and social organization-type new research institutes.** Establish and improve the identification and dynamic management mechanisms of enterprise-type and social organization-type new research institutes and implement the performance evaluation and merit-based subsidy mechanisms for new-type research institutes.

2. Improve laws and policies on technological innovation. **Promote the rule of law in technological innovation.** Actively implement the *Regulations of Shanghai Municipality on Promoting the Construction of S&T Innovation Centers* and promptly promote the formulation and revision of local regulations such as the Regulations on S&T Progress, Science Popularization, and the Sharing of Scientific Instruments and Facilities. Strengthen the coordination of laws and regulations in related fields such as commercial affairs, finance, and opening up to the outside world. **Promote S&T innovation decision-making.** Give full play to the supporting role of strategic experts and think tanks in decision-making, strengthen policy pre-evaluation and post-evaluation, and improve policy evaluation, feedback, and adjustment mechanisms.

3. Strengthen guarantees for financial investment in S&T. **Increase financial investments in S&T.** The municipal and district people's governments shall increase financial investment in S&T year by year, focusing on supporting basic research, research on major general purpose key technologies, research on social

[12] Translator's note: "Public institutions" (事业单位) are organizations created and led by PRC government departments that provide social services. Unlike state-owned enterprises (SOEs), public institutions do not create material products and do not generate income. Public institutions are not considered government agencies, and their employees are not civil servants. Most public institutions are fully or partially government-funded, but some fully privately funded (but still government-led) public institutions exist. Public institutions typically provide services in areas such as education, science and technology, culture, health, and sanitation.

welfare-related technologies, and the conversion of S&T achievements into practical applications. Broaden the funding channels for basic research, encourage social capital [13] to invest in basic research, and explore diversified investment methods such as co-building new research institutes, joint funding, and donations. Encourage enterprises to invest in joint establishment of scientific plans with the government to guide and encourage enterprises to increase their investment in basic research and applied basic research. **Optimize financial technology investment methods.** Strengthen the coordination of financial investments in S&T and optimize and integrate related special funds. Improve the categorized management of financial investments in S&T and accelerate the reform of the "contracting system" for expenditures.

4. Improve the management of IP and S&T data resources. Further improve IP protection mechanisms. Promote the construction of the China (Shanghai) Intellectual Property Protection Center, focus on key industrial areas, and provide services covering the city's rapid review of intellectual property rights (IPR), rapid confirmation of rights, and rapid rights protections. Establish and complete mechanisms for IP credit evaluation, public disclosure of trustworthiness, and joint punishment for dishonesty, and strengthen judicial protection of IPR. Explore new modes of IP protection in new fields and formats such as big data, cloud computing, AI, and blockchain. Strengthen the overseas protection of IPR and international cooperation. **Accelerate the improvement of S&T data management mechanisms.** Incorporate good data management into the management requirements of S&T programs and projects, promote the hierarchical and orderly opening of S&T public data under the precondition of security, and promote the safe and orderly flow of data across borders in the Lin-gang Special Area on a pilot basis. Build an international big data center for Shanghai S&T resources and build a global S&T data information resource hub.

(v) Strengthen the capacity of S&T innovation emergency systems

Strengthen the emergency response capacity of S&T innovation, guarantee national S&T security, and provide a safe and stable development environment for the establishment of the S&T Innovation Center in Shanghai.

1. Strengthen emergency capacity reserves for S&T innovation. Promote the formation of a long-term mechanism for policies and measures that have garnered good social response and benefits during the COVID-19 pandemic. Establish an emergency response mechanism with quick responses, quick preparations, and quick starts to provide institutional support for organizing and carrying out emergency S&T research.

2. Strengthen S&T risk prevention and resolution capabilities. In accordance with the principles of encouraging innovation, inclusiveness, and prudence, strengthen

[13] Translator's note: The Chinese term 社会资本, translated literally as "social capital," and its synonyms "social funding" (社会资金), "social investment" (社会投资), and "social financing" (社会融资), refer to any source of funding outside of government budget outlays. These terms encompass investment by private individuals and private institutions. However, investment from state-funded entities such as state-owned enterprises (SOEs), including state-run banks, also falls under the umbrella of "social capital."

forward-looking research on and assessment of potential disruptive innovations, strengthen new technology safety early warning and supervision, and effectively prevent and resolve major risks in the field of S&T.

(vi) Strengthen the establishment of scientific research integrity and S&T ethics

Promote the construction of a S&T supervision system, continue to improve S&T evaluation, strengthen scientific research integrity, S&T ethics construction, and supervision by society, and create a good scientific research ecosystem.

1. Establish and improve S&T supervision and evaluation work systems. Improve the supervision and evaluation of S&T projects and promote the convergence of pre-event supervision and post-event supervision. Give full play to the role of all sectors of society in monitoring misconduct in scientific research and seriously investigate and deal with violations of regulations and violations of trust. Strengthen supervision and inspection information sharing and mutual recognition of results, build an S&T credit information platform, and promote the interconnection of S&T credit information in the Yangtze River Delta.

2. Promote the establishment of scientific research work style (科研作风), of academic style (学风), and of scientific research integrity. Establish a scientific research work style, academic style, and scientific research integrity work system that integrates education, self-discipline, prevention, supervision, and punishment. Strengthen the review of scientific research integrity and improve procedurally standardized, open, and fair investigation and handling mechanisms for scientific research misconduct. Vigorously promote the spirit of scientists, strengthen education and propaganda on the integrity of scientific research personnel, implement principal responsibility for innovation (创新主体责任), and support all sectors in jointly creating a good scientific research ecosystem for single-minded research, the pursuit of excellence, and fair competition.

3. Improve the establishment of S&T ethics. Strengthen S&T ethics education and training, increase S&T workers' awareness of consciously abiding by S&T ethics, and support academic groups in playing their role in the supervision and maintenance of S&T ethics. Promote the establishment of a responsible ethical review mechanism in the fields of biology, health, medicine, and AI and advocate responsible research and innovation.

(vii) Strengthen organizational assurance

Strengthen overall planning and coordination and accelerate the formation of an S&T innovation governance situation characterized by central and local linkages, urban synergy, departmental coordination, and the participation of the whole of society. **Deepen coordination mechanisms,** actively serve national strategies, rely on the ministry-city cooperation mechanism, and strive to undertake more major national tasks, major projects, and major reform measures. Establish a coordinated and joint promotion mechanism for municipal districts and departments to create a development environment conducive to S&T innovation. **Clarify the division of responsibilities,**

accelerate the implementation of the main responsibilities of all districts, departments, and units, refine work tasks, formulate timetables and roadmaps for planning related tasks, improve assessment and incentive mechanisms, and ensure planning implementation. **Strengthen propaganda and promotion,** make full use of multiple media channels and communication methods to propagate and introduce the results of the planning internationally, domestically, and to all sectors of society.