Data Brief

China's State Key Laboratory System

A View into China's Innovation System

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Executive Summary

Since the early 1980s, the People's Republic of China (PRC) has built a system of State Key Labs charged with driving innovation in the defense and commercial sectors. Over time, SKLs have become an increasingly important component of China's larger innovation base—conducting cutting-edge basic and applied research, attracting and training domestic and foreign talent, and promoting global academic exchanges. China's oversight of SKLs and the opaqueness of its laboratory system pose national security challenges for the United States and its allies, especially for policymakers, academics, and industry leaders interested in collaborating with Chinese counterparts. Understanding China's SKL system and the role these laboratories play within China's broader innovation ecosystem is critical for navigating and managing risks from technology transfer and global technology competition.

This report assesses a CSET-curated dataset of 469 SKLs. Our findings include:

- China maintains at least 184 enterprise SKLs and 285 government-run SKLs housed at different state ministries, including the Ministry of Education, which oversees more than half of the government SKLs in our dataset.
- SKLs focus on a variety of science and technology (S&T) fields including biology, chemistry, earth science, engineering, information and communications technology (ICT), materials science, and physics. The largest concentration of SKLs in the dataset is in the field of biology.
- Human capital is an essential element of SKL development, and SKLs benefit from China's talent recruitment plans. At least 20 percent of the government SKLs in the dataset explicitly identified the number of employees that were talent program beneficiaries. SKLs pull talent from domestic and international sources via talent programs, such as Thousand Talents, as well as through exchanges and visiting scholar programs.
- While Chinese state media sources claim that China had 515 SKLs as of 2019 and aimed to reach 700 by 2020, this data brief finds no evidence that China reached its 700 SKL goal.

SKLs, and the broader system behind them, are constantly changing as the PRC continues to update its S&T policies. Beijing has and will likely continue to update and modernize SKL requirements, guidance, and policies as leadership works toward achieving indigenous innovation capabilities, particularly in strategically significant industries identified in Five-Year Plans and other relevant policy documents.

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Introduction

State Key Laboratories (SKLs; 国家重点实验室) are evolving to be one of the most important building blocks in China's innovation base. These laboratories, overseen by and most often co-located with universities and enterprises within China, receive funding, administrative support, and policy and developmental guidance from China's central government. They serve as a primary driver of China's strategic basic research efforts and ambitious science and technology (S&T) agenda in the commercial and military spaces. Most importantly, they are crucial to China's efforts to reduce its dependence on foreign technology. As the United States and other nations work to compete with China in emerging and foundational technologies, understanding the SKL system and the role these institutions play within China's broader innovation ecosystem will be critical for navigating and managing risks from technology transfer.

China has historically looked to the U.S. national laboratory system as a key driver of innovation within the United States, and since the 2000s has endeavored to build its SKL system in a similar fashion.[1] SKLs also serve as a primary vehicle through which China can train the next generation of scientists and engineers to drive the country's future developments. This is particularly critical, as China's leadership has increasingly emphasized the need for and importance of talent for national economic growth.[2]

In 2018, the Ministry of Science and Technology (MOST) claimed that there were 501 SKLs and the country was working to expand this number to 700 by 2020.[3] By the end of 2019, Chinese media claimed that there were 515 SKLs in operation. This brief uses a unique dataset compiled by the authors that identifies 469 SKLs—run by both government organizations and enterprises—to examine China's SKL ecosystem and to assess if progress in building, staffing, and funding has met China's stated goals. Although the dataset does not include all existing SKLs, we believe that it contains a sufficient sample size to draw conclusions about China's SKL goals, capabilities, and the SKL system writ large. This analysis is not intended to provide exhaustive information about all SKLs or all types of Chinese laboratories. Instead, in our assessment, as of 2022, there is little evidence that Beijing has achieved its 700 SKL goal, despite SKLs being a national priority.

Building an Innovation Base

Before assessing China specifically—and how SKLs fit into its strategic goals—it is essential to understand the key components and characteristics of an innovation base. The literature on innovation in S&T suggests that a country's ability to innovate depends on the interaction and development of the following factors:[4]

- Human capital in STEM fields.
- Institutional quality and capacity.
- Infrastructure such as high-performance computing and test facilities.
- Business and market conditions such as public-private-academic partnerships, ease of starting businesses and obtaining credit, market access, and support for developments before they are commercially viable.

Each element impacts the technology development cycle—encompassing basic and applied research, commercialization, and production. Basic research lays the scientific foundation upon which future technological advancements are made. Edward Teller famously said that "the science of today is the technology of tomorrow." The next step is moving a scientific discovery from the lab to the market—a role in the U.S. and market economies historically filled by corporate labs or startups.[5]

China's leaders are paying special attention to the "National Innovation System" (NIS) framework developed by the Organisation for Economic Co-operation and Development (OECD). The NIS framework "stresses the flows of technology and information among people, enterprises, and institutions" as key to the innovative process. The OECD argues that understanding the NIS within a given country may help them "identify leverage points for enhancing innovative performance and overall competitiveness."[6] Chinese leaders are likely modeling their S&T reforms, in part, after the NIS model. In 2007, MOST cohosted a conference with the OECD entitled a "Review of China's National Innovation System: Domestic Reform and Global Integration," in which representatives from within and outside China presented on the NIS framework.[7]

The NIS model also seems to be informing China's efforts to redesign its SKL system, as Chinese leaders hope to take a more holistic approach to the S&T development cycle—not only blurring the lines between transitions in the development cycle but also the building blocks of the national innovation base. This method of teaming researchers and developers as a strategy to tackle hard problems has long been hailed as a successful model, as was seen with Bell Labs in the United States.

China's leaders also view SKLs as an integral piece in their push to reduce the country's dependency on foreign technology. Multiple central government plans, including the Medium- to Long-Term Plan for Science and Technology Development (2006–2020) and the 13th and 14th Five-Year Plans, describe SKLs as vital components of China's innovation ecosystem and call for the construction of more SKLs, particularly within enterprises.[8] China's push to reduce foreign tech dependence builds on goals reiterated by the 13th Five-Year Plan for National Science and Technology Innovation (十三五国家科技创新规划) published in 2016, which sought to optimize China's layout of national scientific research bases and platforms, build national laboratories in major fields of innovation, and promote the construction of national scientific research and technological innovation bases.[9] Authoritative documents have described this concept as a "new normal" (新常态) in economic development, seeking to strengthen scientific research bases such as SKLs, which play an important role in nurturing original innovation, promoting disciplined development and "cutting-edge" technology research and development (R&D), achieving and leading in several disciplines, and producing "world-class results."[10] Chinese leaders have emphasized the significance of further reforming and developing SKLs as recently as 2022; at the National Science and Technology Work Conference in January, participants discussed the accelerated construction of the SKL system and the alleged completion of the plans to reorganize the SKL system.[11]

National Laboratories

China's research laboratory system comprises thousands of institutions of varying sizes and importance, and SKLs need to be studied in the context of the relevant institutions surrounding them. At the pinnacle of this system sit 20 National Laboratories (国家实验室), seven of which are designated as National Research Centers (国家研究中心). A complete list of these institutions is available in Appendix A. These institutions spearhead China's investments in basic R&D, whereas their subordinate SKLs pioneer specific lines of research, such as pattern recognition, coal extraction, and plant pigmentation. They are variously managed by government organizations—including the Ministry of Education (MOE) and Chinese Academy of Sciences (CAS)—but also by state-owned and private enterprises. Figure 1 below illustrates this hierarchy. Additional information on the Ministry of Industry and Information Technology (MIIT) Key Laboratories seen in this hierarchy can be found in Appendix B.

Figure 1: Hierarchy of National Laboratories in China

Source: Qingta Academic (青塔学术).

This approach is modeled loosely after the U.S. system of national laboratories, federally-funded research and development centers (FFRDCs), and university-affiliated research centers (UARCs). Despite maintaining several hundred personnel on average (which is sizeable by Chinese standards), Chinese leadership over the past decade determined that existing laboratories were lagging behind foreign counterparts, and sought to establish large national laboratories modeled after laboratories in the United States and Europe. Despite the progress that China has made in developing its laboratory ecosystem, the country has encountered several barriers in constructing a system of national labs, and these institutions differ significantly from the United States in their mission and function.

Several milestones have shaped China's national laboratory system and contributed to the construction of world-class research institutes:

- Established in 1984, the University of Science and Technology's National Synchrotron Radiation Laboratory was China's first National Laboratory, succeeded by four other institutions built between 1988 and 2003.[12]
- In 2006, the MOST approved the construction of more than 15 new National Labs, but as of 2021, only one (the Qingdao National Laboratory for Marine Science and Technology) has been built.[13]
- In 2017, MOST announced plans to reform China's national laboratory system by building or redesignating hundreds of SKLs, in addition to a handful of National Laboratories that specialize in certain subject areas. Six of the seven institutions built between 1984 and 2006 were reclassified as National Research Centers (国家研究中心) and are intended to be multidisciplinary in scope.[14]

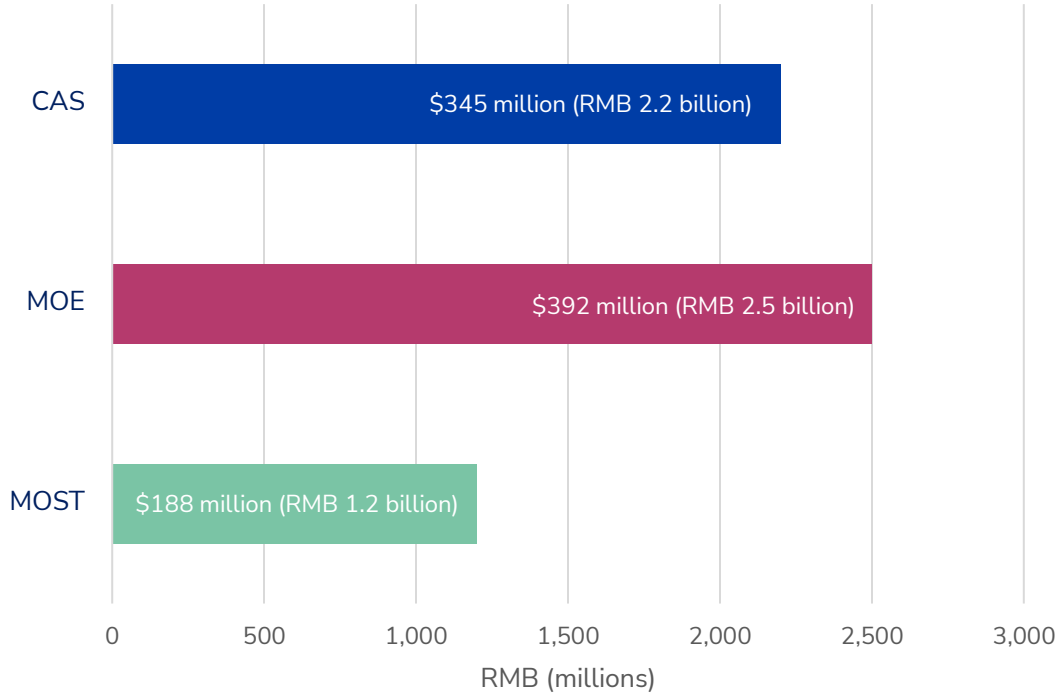
State Key Laboratories: Drivers of Innovation

China's SKL system comprises hundreds of the country's most elite research facilities. Founded on the premise of cooperation between universities, scientific research institutes, and enterprises, these laboratories are designed to facilitate the development of scientific disciplines, promote technological progress, and support China's transformation from a "follower" to a "leader" in innovation. Their mission is to carry out cutting-edge basic research, attract and train domestic and foreign talent, and conduct academic exchanges inside and outside China.[15]

The SKL system was founded in the early 1980s as a means to improve the level of basic research in China. In 1984, the former State Planning Commission (now the National Development and Reform Commission, or NDRC) implemented and organized the initial stage of SKL construction, which lasted from 1984 to 1997, according to archived Chinese government documents.[16] During this time, Beijing established 156 SKLs in two waves. The first set of 81 labs, focused on basic theoretical research, were established via funding from the state ($140 million, or RMB 910 million) and the World Bank ($86.34 million). The second batch of 75 SKLs focused on applied basic research and engineering and received $27.5 million (RMB 178 million) in funding from the Chinese government.[17] In 1990, the National Natural Science Foundation of China (NSFC) began evaluating the research performance and relevance of SKLs.

Most State Key Laboratories are preexisting research institutions supported by universities, enterprises, and the Chinese Academy of Sciences, which may be "promoted" to the title of "State Key Laboratory." [18] To better understand the more recent funding of these laboratories, Figure 2 below shows the 2019 budgeted amounts for "key laboratories and related facilities" from MOE, MOST, and CAS.

Figure 2: Comparison of Budgeted Amounts of Key Laboratories and Related Facilities from MOE, MOST, and CAS, 2019



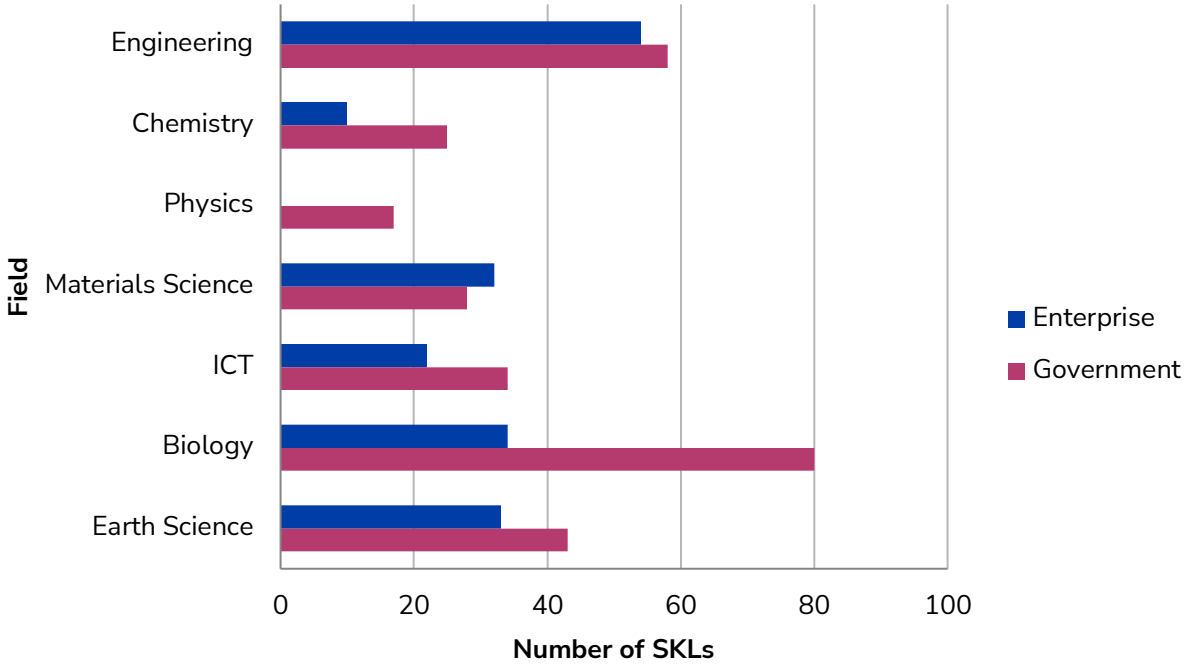
Source: CSET China State Council Budget Tracker (conversion values as March 2022).

Although most SKLs are managed by the Chinese government, an increasing number of laboratories are run by private companies following the 2006 "Guiding Opinions on Entrusting Converted Institutes and Enterprises with Building State Key Laboratories" (关于依托转制院所和企业建设国家重点实验室的指导意见).[19] Notably, 2006 was the same year that the PRC launched the "National Medium- and Long-Term Plan for Science and Technology Development," a seminal document that arguably launched China's indigenous innovation strategy.[20] In 2012, MOST adopted the "Provisional Administrative Methods for Entrusting Enterprises with Building State Key Laboratories," although the government had built similar prototypes with firms like Huawei.[21] Subsequent sections of this report discuss similarities and differences between SKLs run by government organizations and private enterprises.

As demonstrated by Figure 3, the scientific fields prioritized by government and enterprise-run SKLs differ slightly, with government labs prioritizing life and earth sciences; and enterprise SKLs placing more emphasis on engineering, information, and materials science. The fields identified in Figure 3 represent all SKL fields as labeled by the PRC government. Emerging technologies such as artificial intelligence (AI) are not easily captured in a single field, due to their interdisciplinary nature. The 2017 "New

Generation AI Development Plan" (新一代人工智能发展规划; hereinafter referred to as the 2017 AI Plan) highlights the role of SKLs in optimizing the layout and construction of a domestic AI innovation base. The 2017 AI Plan stipulates that both government- and enterprise-managed SKLs, in addition to national engineering labs, should focus on the cutting-edge of AI research.[22]

Figure 3: Distribution of Government and Enterprise SKLs, by Field



Source: CSET Corpus of State Key Labs.

Geographically, SKLs are spread across almost all Chinese provinces and administrative regions, with the exception of Tibet. The highest concentration of SKLs is located in Beijing, which hosts a total of 132 SKLs. Shanghai comes in second, however, with less than half the number of SKLs than Beijing, at 45. For more detailed information on geographic location, please see the accompanying CSET data visualization.[23]

SKL Personnel and Talent Recruitment

Human capital is an essential piece of SKL development, and SKLs benefit from China's talent recruitment plans. SKLs vary widely in the number and education level of staff members they employ. Although we lack detailed employment information for each SKL in China, we were able to track how many staff members were employed by 92 of the 285 government-managed SKLs in our dataset. The average government-

managed laboratory in our dataset employed 66 full-time staff, with the smallest (State Key Laboratory of Silicon Materials, 硅材料国家重点实验室) employing 23; and the largest (State Key Laboratory of Information Security, 信息安全国家重点实验室) employing 205 personnel. More generally, while most full-time personnel at each laboratory have PhDs, SKLs also employ dozens, and in some cases hundreds, of graduate students, who typically study at the university where the lab is based.

SKLs are also major beneficiaries of China's state-led talent recruitment programs. Of the 285 government-managed SKLs in our dataset, 59 specified both the number of full-time staff they employed and the number of staff that were recipients of two major talent recruitment programs: the Thousand Talents Plan (千人计划) or Changjiang Scholars Plan (长江学者奖励计划). Based on data from these 59, on average, nine people at each lab were recipients of either of these two talent recruitment plans. As a whole, 10 percent of personnel (304 individuals) employed at these 59 government-managed SKLs are talent plan awardees.

It is important to note that SKL personnel, most notably leadership, are often dual- or multi-hatted across China's S&T and political systems. For example, the director of the SKL of Semiconductor Superlattices—Li Shushen (李树深)—is also the president of the University of the Chinese Academy of Sciences.[24] Similarly, the director of the SKL of Software Development Environment—Li Wei (李未)—is simultaneously a member of the State Council's Academic Degrees Committee, the 10th and 11th Chinese People's Political Consultative Conference, MOE's Advisory Committee, and the director of MOE's Computer Teaching Steering Committee.[25]

In the commercial realm, the SKL of Space Power Technology under China Aerospace Science and Technology Corporation (CASC), has several researchers with concurrent positions. For example, Zhang Ping (张平） is a researcher at the SKL as well as a member of the National Alkaline Battery Standards Committee as well as the quality and reliability expert group of the China Academy of Aerospace Technology.[26] In many instances, there is also crossover between the academic community and commercial sector; for example, Shaanxi University of Science and Technology professor Liu Zhaotie (刘昭铁) is a member of the academic committee of the SKL of Efficient Development and Utilization of Fluoro-nitrogen Chemical Resources under state-owned defense giant NORINCO's Xi'an Modern Chemistry Research Institute.[27]

SKL leadership may also hold concurrent positions with overseas institutions. In 2013, the SKL of Solid State Lighting established the "Delft Research Center of the State Key Laboratory of Solid State Lighting" in the Netherlands, becoming the first SKL in China to establish a branch overseas.[28] Several of its personnel have held or currently hold

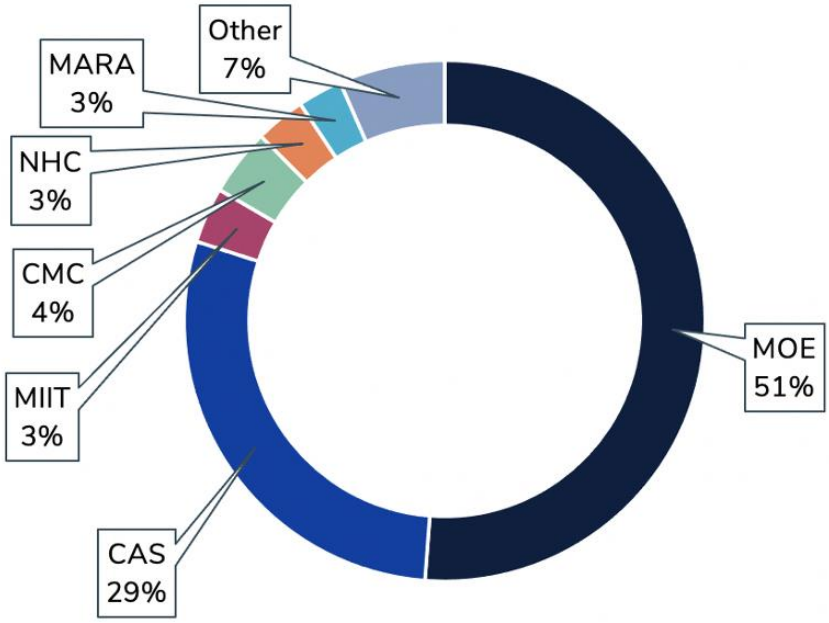
positions at institutions in both countries.[29] Additional information on SKLs' overseas connections is presented later in this brief.

Government-Managed State Key Laboratories

The title of "State Key Laboratory" carries significant weight, and these institutions draw on extensive networks of equipment, personnel, and capital provided by the state. The Ministry of Science and Technology's 2016 report on China's 266 (at the time of publication) government-managed State Key Laboratories is the most detailed source of information about the national laboratory ecosystem, and the last year for which public data is available. It specifies that government-run SKLs employ 35,000 staff members, including 24,000 full time researchers.[30] With nearly 650,000 instruments and over 3.5 million square meters of lab facilities, their fixed assets are collectively valued at more than $6.5 billion.[31]

Although a growing number of State Key Laboratories are managed by private enterprises, most are co-located with universities or CAS institutes, and are run by the MOE, CAS, or another cabinet-level department that reports to the State Council. Of the 266 publicly acknowledged government-run SKLs, more than half are run by MOE, about one-third by CAS, and around 3 to 4 percent by the Ministry of Industry and Information Technology (MIIT), National Health Commission (NHC), Ministry of Agriculture and Rural Affairs (MARA), and Central Military Commission (CMC), as demonstrated in Figure 4.

Figure 4: Distribution of Government Units Responsible for State Key Laboratories



Source: CSET Corpus of State Key Labs.

Other ministries house their own key laboratories.[32] Although beyond the scope of this paper, several SKLs maintain close working relationships with China's military-industrial complex and are also key contributors in China's military-civil fusion (MCF; 军民融合) development strategy, which involves the sharing of resources and information across the military and civilian sectors. There are a handful of such examples present in the dataset used for this analysis, including some housed in People's Liberation Army hospitals, including one of China's leading Cancer SKLs—the SKL of Cancer Biology—housed within the PLA's Fourth Military Medical University under the CMC.[33] A few other SKLs are overseen by large Chinese defense conglomerates like NORINCO, the CASC, China Electronics Technology Corporation, among others. As a result of this co-location, there are several examples of SKLs that are housed within enterprises and academic institutions that are subject to U.S. export control and sanctions lists. Details of these examples in our dataset can be found in Appendix C.

In addition to SKLs, the PRC has an adjacent set of Defense S&T Key Laboratories (DSTKLs; 国防科技重点实验室) that are overseen by the State Administration for Science, Technology and Industry for National Security (SASTIND) and likely the Central Military Commission's (CMC) Equipment Development Department.[34]

Ministry of Education SKLs

Within the 285 government SKLs, the MOE is the largest SKL administrator in China and is responsible for overseeing the activities of 149 SKLs spread across dozens of universities. According to the China Association of Science and Technology's *Science and Technology Review*, SKLs employed more than fifty thousand permanent staff members by the end of 2019, including 393 academicians of the Chinese Academy of Sciences and 271 of the Chinese Academy of Engineering. CAST also claims that government funding for SKLs has gradually increased each year from $220.7 million (RMB 1.4 billion) per year initially to $993 million (RMB 6.39 billion) in 2019 (as of March 2022 conversion rates).[35]

Among MOE's 149 SKLs, just a handful of universities house a significant number of labs. As demonstrated in Table 1, Tsinghua University hosts 13 SKLs, and Peking and Zhejiang universities host 12 and 10 respectively. Although most SKLs are hosted by a single institution, several are co-hosted by two or more universities or research bodies. For example, the State Key Laboratory of Chemical Engineering is co-hosted by Zhejiang University, Tsinghua University, Tianjin University, and the East China University of Science and Technology.

Table 1: Top Academic Institutions that Host SKLs

Academic Research Body	Number of SKLs
Tsinghua University	13
Peking University	12
Zhejiang University	10
Nanjing University	7
Jilin University	7
Shanghai Jiao Tong University	7
Huazhong University of Science and Technology	6
Fudan University	5
Wuhan University	5
Beijing Normal University	4
Shanghai Institute of Biological Sciences (CAS)	4
Sichuan University	4
Sun Yat-sen University	4
Tianjin University	4
University of Science and Technology of China	4
Xi'an Jiaotong University	4

Source: CSET Corpus of State Key Labs.

There does not appear to be a concentration of SKLs by subject at various universities. As demonstrated in Table 2, both Tsinghua and Zhejiang universities host a wide range of SKL subjects, spanning chemistry, earth sciences, biology, information science, materials science, engineering, and medical science.

Table 2: Number of SKLs at Tsinghua, Peking, and Zhejiang Universities, by Field

SKL Fields	Tsinghua University	Peking University	Zhejiang University
Biology	1	3	3
Chemistry	-	1	-
Earth Science	1	1	-
Engineering	6	1	3
ICT	3	3	3
Materials Science	1	-	1
Physics	1	3	-

Source: CSET Corpus of State Key Labs.

In addition to 149 SKLs, MOE also runs more than "480 MOE Key Labs" (教育部重点实验室) among which exceptional institutions may eventually be designated SKLs.[36] Most MOE Key Labs focus on life sciences and engineering, and are distributed among China's top universities. According to the 2015 "Measures for the Construction and Operation Management of Key Laboratories of the Ministry of Education" (教育部重点实验室建设与运行管理办法; hereinafter referred to as the 2015 Measures), universities under MOE must incorporate lab construction and basic operation funds into their annual budgets and guarantee research facilities and equipment for MOE labs. In order for a lab to become an MOE Laboratory, it must meet the following conditions:[37]

- Have a clear research direction and objectives, with distinct characteristics, and have important influence in the given field; have the ability to undertake major national and local scientific research tasks; have the conditions to train high-level talents; be able to conduct extensive domestic and foreign academic exchanges and cooperation.
- Be led by a well-known academic leader and maintain an excellent research team with a reasonable age and knowledge structure.
- Include a laboratory area that is no less than 3000 square meters, and equipment valued at no less than $3.2 million (RMB 20 million).

- Generally be an industry, local, or school-level key research institution that has been in good operation for more than two years, and has a relatively complete management system.

MOE also stipulates that its key laboratories should focus on training and attracting both domestic and foreign talent. The 2015 Measures state that MOE Key Labs should establish a visiting scholar system and work to attract outstanding talents to carry out cooperative research, conduct extensive academic exchanges with high-level research institutions domestically and overseas, and serve in international academic institutions.[38] MOE Key Labs are actively engaging in visiting scholars programs. In March 2015, for example, the MOE Key Laboratory for Computational Physical Sciences at Fudan University advertised that its visiting scholars program planned to fund 8 scholars annually, with each scholar receiving a maximum of $7,900 (RMB 50,000) in funding. According to the announcement, the funding includes experimental material fees, data fees, international and domestic travel expenses, boarding/lodging, city transportation, and living allowances.[39]

Chinese Academy of Science SKLs

CAS is the second-largest administrator of SKLs, overseeing 83 labs. In addition to SKLs, CAS also manages a network of 216 "CAS Key Labs" (中国科学院重点实验室) some of which may eventually be promoted to SKLs. CAS' SKLs appear to maintain a similar research pattern to their CAS-level counterparts. The majority of CAS SKLs are focused in the fields of earth science, life science, and information science. Among the 78 SKLs, there are 57 unique CAS Institutes that oversee these labs, including Shenyang Institute of Automation, the Changchun Institute of Applied Chemistry, and the Institute of Genetics and Developmental Biology, all of which each oversee three SKLs. Compared to the MOE, as Table 3 below illustrates, CAS Key Labs are more likely to specialize in earth science or biology, with nearly half of CAS Key Labs dedicated to one of those three fields.

Table 3: Distribution of CAS and MOE SKLs, by Field

Field	Number of MOE SKLs	Number of CAS SKLs
Biology	34	19
Chemistry	14	12
Earth Science	12	23
Engineering	43	4
ICT	17	12
Materials Science	20	6
Physics	9	7
Total	**149**	**83**

Source: CSET Corpus of State Key Labs.

Enterprise-Managed State Key Laboratories

Enterprise-managed SKLs are labs housed within and operated by firms at the behest of the PRC government that are designated from various preexisting research departments or offices within enterprises—both state- and non-state-owned. They are designed with the intention of strengthening cooperation between industry, academia, and the broader research community to promote the transformation of basic research into advanced applications.

Beijing outlined its desire to officially establish SKLs within enterprises in 2006, in conjunction with the release of the Medium- to Long-Term Plan for Science and Technology Development (2006–2020). In the 2006 "Guiding Opinions on Relying on the Transformation of Institutions and Enterprises to Build State Key Laboratories," MOST asserts that enterprise-managed SKLs act as an important base for conducting basic research on industry applications, gathering and training S&T talent, and conducting S&T exchanges. They also act as instruments to promote industry-university research.[40] For example, China's Trina Solar (天合光能) in May 2012 announced the establishment of the State Key Laboratory of Photovoltaic Science and Technology within its company. According to the company's official announcement, Trina Solar planned to rely on this SKL to build a "strategic alliance of technological innovation" by collaborating with top global R&D institutions, including the Solar Energy Research Institute of Singapore, Australian National University, and the U.S Department of Energy's National Renewable Energy Laboratory.[41] Two years later in 2014, Trina Solar claimed to have cooperated with ANU to develop high-efficiency solar cells, worked with SERIS on the R&D associated with integrated back contact solar cells, and held an annual meeting with participants from the German Institute of Solar Energy Research and the Department of Energy's NREL.[42]

At the highest level, MOST is responsible for developing management methods and regulations for enterprise SKLs—providing macro-level guidance, preparing and organizing overall development plans, approving the establishment, construction, and adjustment of enterprise SKLs through inspections and other means, as well as studying enterprise SKLs to formulate better overall SKL policy.[43] The 2012 "Provisional Administrative Methods for Entrusting Enterprises with Building State Key Laboratories" (依托企业建设国家重点实验室管理暂行办法; hereinafter referred to as the 2012 Provisional Administrative Methods) states that MOST is the "macro management department" (宏观管理部门) of enterprise SKLs, and the science and technology management department or other relevant department within the enterprise is responsible for day-to-day supervision and oversight. In their day-to-day operations, the relevant S&T or other departments within the enterprise remain in

charge of laboratory management; providing personnel, funding, facilities, and drafting policies; organizing recruitment and appointing leadership; and conducting annual assessments in conjunction with MOST; among other responsibilities.[44]

How Corporate R&D Centers Become SKLs

There are several prerequisites to becoming an enterprise SKL. According to the 2012 Provisional Administrative Methods, labs must meet the following conditions in order to apply to become an enterprise SKL.[45]

- Carry out basic and "pre-competitive" (竞争前) technology research in line with national industrial development policies and trends.
- Maintain strong research reputation with respect to their given industry, and the ability to undertake major national scientific research tasks.
- Possess a high-level scientific research team with a reasonable structure.
- Possess good scientific research experimental conditions and centralized scientific research facilities.
- Be an enterprise legally registered in China (excluding Hong Kong, Macau, and Taiwan).
- Have existed as a departmental, local, or ministerial key laboratory for at least two years, and have a standard and effective management and operation system.
- Have a competent department and supporting unit that can guarantee the provision of construction and operation funding for the enterprise SKL.

Once all of these conditions are met, the relevant department within the enterprise submits their application materials, including the "Enterprise State Key Laboratory Construction Application Report" (企业国家重点实验室建设申请报告), to MOST. The 2012 Provisional Administrative Methods specify that it takes about two years to receive approval as an enterprise SKL. Once this construction period is completed, an enterprise SKL has one month, upon notice from MOST, to accept the designation.[46]

In day-to-day operations, the entrusted (依托) enterprise unit plays the primary leadership role. Once an SKL is established, the enterprise in question is in charge of selecting a director and other management roles; the 2012 Provisional Administrative Methods state that the lab director should be a "high-level academic leader in the field" with strong organizational and management skills, and should generally not exceed the age of 60. This director is appointed for a term of five years (but cannot be reappointed for more than two consecutive terms) and must work at the lab for at least eight months of the year. The 2012 Provisional Administrative Methods stipulate that

the director should, in most cases, be someone who is not employed by the entrusted enterprise unit.[47]

Enterprise SKLs are also required to maintain an internal Academic Committee (学术委员会) whose members are similarly appointed by the entrusted or operating enterprise. This committee is responsible for managing objectives, research directions, major academic activities, annual work plans, and other summary and review activities. The 2012 Provisional Administrative Methods state that the Academic Committee should be composed of no more than 15 experts from universities, research institutes, industry associations, and enterprises "at home and abroad." No more than one-third of these 15 members should come from the entrusted enterprise, and the same expert cannot be a member of the academic committee of more than three SKLs at one time. It is mandated to meet at least once per year, with at least two-thirds of the total number of members in attendance.[48] Table 4 demonstrates this membership pattern via the SKL of Comprehensive Technology on Automobile Vibration and Noise and Safety Control, whose entrusted unit is First Automobile Works (FAW) Group Corporation (第一汽车集团).

Table 4: Makeup of the Second Academic Committee of the SKL of Comprehensive Technology on Automobile Vibration and Noise and Safety Control

Name	SKL Academic Committee Position	Employer
Sun Fengchun	Director	Beijing Institute of Technology
Wang Deping	Deputy Director	FAW Group
Chen Hong	Member	Tongji University
Deng Weiwen	Member	Beihang University
Gao Zhenhai	Member	Jilin University
Wang Jianqiang	Member	Tsinghua University
Wei Xiaohui	Member	Jilin University
Cheng Hong	Member	University of Electronic Science and Technology of China
Jiang Weikang	Member	Shanghai Jiao Tong University
Zuo Xiaodong	Member	China Information Security Research Institute
Mao Dongxing	Member	Tongji University
Li Dan	Member	FAW Group
Wu Bilei	Member	FAW Group

Source: SKL of Comprehensive Technology on Automobile Vibration and Noise & Safety Control, July 2020.[49]

The 2012 Provisional Administrative Methods articulate that the lab should be composed of "fixed" (固定) and "mobile" (流动) staff. Fixed, or permanent, staff is defined as 50-150 researchers, technicians, and a small handful of managers with labor contracts. Mobile staff refers to visiting researchers and scholars, post-doctoral researchers, graduate students, and other temporary employees. Notably, the 2012 Provisional Administrative Methods also suggests that enterprise SKLs focus on training the "young and middle-aged scientific backbone" (中青年科研骨干).[50]

As of 2014, MOST has identified 16 research areas as "relevant" for SKL development, listed in Table 5 below.

Table 5: Key Fields for New Enterprise SKL as of 2014

Field	Subfield(s)
High-efficiency energy-saving technology	Industrial energy saving and high-efficiency energy storage
Advanced environmental protection	Pollution control and treatment
Resource recycling	Efficient development and comprehensive utilization of resources
Electronic core components	New power electronic devices and systems
Biomedicine	Translational medicine and innovative medicine
Agricultural biotechnology	Biological breeding
Aviation and aerospace equipment	Aviation equipment manufacturing
Marine engineering equipment	Deepwater offshore engineering construction equipment
Intelligent manufacturing	High-end intelligent manufacturing equipment
Nuclear energy	Nuclear power safety and nuclear material handling

New functional materials	Preparation and protection of special functional materials
High-performance composite materials	n/a
Low- and new-energy vehicles	n/a
Construction and maintenance of transportation infrastructure	Bridge and other traffic engineering safety and health
Smart grid technology	n/a
Safe production and occupational hazard control technology	n/a

Source: Ministry of Science and Technology.[51]

Although these SKLs are housed within enterprises (and therefore share personnel and resources), the PRC government remains at the helm of SKLs and plays a significant role in their development. One example of this dynamic can be seen in the context of the SKL of New Power Semiconductor Devices, whose entrusted unit is Zhuzhou CRRC Times Electric, a subsidiary of China Railway Rolling Stock Corporation (CRRC). In December 2016, Hunan Provincial Science and Technology Department deputy director He Xiuming was present and played an active role in the establishment of the SKL's academic committee, alongside CRRC personnel.[52]

As a way to streamline the innovation process from basic to applied research, Beijing has co-located enterprises, universities, research institutions, and SKLs to form industry clusters, or *jiqun* (集群). According to state-owned media, industrial clusters refer to the grouping of enterprises, R&D entities, and other relevant institutions related to the industrial supply chain in a specific area, through division of labor and cooperation, to form an industrial organization capable of competing internationally.[53] Researchers at CAS claim that this cluster-based innovation is the "main direction of breakthrough in implementing the national strategy of innovation-driven development in China," as they promote the global competitiveness of a given industry by utilizing global and local resources and R&D cooperation.[54]

Along these lines, a key player within China's S&T industry has expressed interest in aligning China's SKL development with that of Bell Laboratories in the United States. The Bell System encompassed all aspects of the telecommunications sector for most of the twentieth century, and allowed its R&D arm, Bell Labs, to make critical

contributions in basic research.[55] A significant portion of its historical success was due to the overlapping priorities over the U.S. government and the domestic telecommunications industry, a phenomenon that is now present in current-day China.

The Bell Labs model has been praised by Liu Ruopeng, founder of China's Kuang-Chi (光启) Group—a leader in China's advanced materials industry and home of China's State Key Laboratory of Metamaterial Electromagnetic Modulation Technology.[56] Liu's revelation surfaced in discussions surrounding the establishment of a consortium of SKLs in Shenzhen. In conversation with state-owned media outlets, Liu argued that Shenzhen is in a unique position to house such an organization, as it is home to leading Chinese S&T companies such as his own Kuang-Chi, as well as Huawei, ZTE, China General Nuclear Power Corporation, and BGI, all of which operate their own SKLs at the behest of the PRC government. In comparison to other SKLs overseen by SOEs or universities, Liu believes that those in Shenzhen have the potential to operate in a similar fashion to Bell Labs, as it did under AT&T and Western Electric, thanks to their role in carrying out basic scientific research on core technologies within specific strategic industries, in conjunction with support from the government.[57]

State Key Labs and the World

SKLs across all fields actively engage internationally through academic exchanges, collaborative projects, programs, and publications, symposiums and conferences, and even formal cooperation agreements. International cooperation and foreign talent acquisition are important missions for China's SKL system, and they contribute to the Chinese Communist Party's (CCP) overall S&T goals.

International Academic Exchange

Academic exchanges are SKLs' most common form of international collaboration. SKLs actively encourage foreign scholars and experts in their respective fields to carry out joint research projects and present guest lectures. At the same time, SKLs send some of their own personnel overseas to share their work. The SKL of Integrated Automation for Process Industry, for example, has invited well-known foreign experts from the United States, the U.K., Hong Kong, Japan, Germany, France, and other countries to visit the laboratory and give lectures to hundreds of research personnel.[58] In 2019, at the recommendation of the laboratory, seven internationally renowned experts from Harvard, the University of Washington, Australian National University, Newcastle University, Polytechnic University of Valencia, and more were awarded the title of "Honorary Professor" of Northeastern University in Shenyang.[59] This kind of international partnership is common; but historically, China's SKLs have been far more likely to invite foreign researchers to come to China and share information than the reverse.

SKLs also allocate specific funding for scholars who can take academic leave from their home institutions. For example, the SKL of Integrated Automation for Process Industry provides foreign scholars a monthly salary of about $6,195 USD (40,000 RMB) as well as a team of research assistants and academic secretaries to assist with research work. Scholars are also offered well-equipped, hotel-style apartments in addition to regular offices. This laboratory's program has hosted professors from the University of Southern California and the Polytechnic University of Valencia in Spain.[60]

According to Chinese researchers, since 2008, more than 99 percent of SKL papers have been co-authored, and the number of papers produced alongside international institutions increased from 19 percent in 2008 to 27 percent in 2017. This is higher than China's overall rate of international academic collaboration, which hovered around 19 percent during the period of 1999–2019.[61] Within that same time period, SKLs published 93,300 papers co-authored with researchers from institutions in 186 countries and regions, with U.S. collaboration comprising more than 46 percent

(43,000 papers). The United Kingdom and Australia rank second and third in co-authorship, respectively.

Conferences and Colloquia

Conferences and symposia offer another mode of international collaboration for SKLs. For instance, the SKL of Electroanalytical Chemistry hosts the biennial International Electroanalytical Chemistry Symposium in addition to cooperating on research projects with Cornell University, the University of California, Santa Cruz, the University of Cordoba in Spain, and Monash University in Australia.[62] Other SKLs send their own researchers to international conferences. In 2019, for example, a professor from the SKL of Ocean Engineering was invited to give a presentation at the 2019 International Ocean Engineering Research Forum held in Osaka, Japan.[63]

The SKL of Space Weather has an especially robust international collaboration program. It works with researchers and experts from the Universities of Massachusetts and Alabama in the United States, the Austrian Institute for Space Research, Kyoto University in Japan, the Space Research Institute of the Russian Academy of Sciences, the French Radiation Research Center, Germany's Max Planck Society, the Taiwan Space Weather Start Research Program, and more.[64] Many of these interactions have come as a result of China's National Space Weather Symposium, held annually by the NSFC's Department of Earth Sciences.[65] Furthermore, the Space Weather SKL has organized a specific "Space Weather Team" consisting of six Chinese scientists and nine international scholars.[66] The conditions of the Space Weather Science Fund specify that its two main purposes are to promote international and domestic cooperative research and attract scientific and technological experts from all over the world.

Formal Cooperation Agreements

SKLs have also found more formal avenues for cooperation with international entities through cooperation agreements. For example, in May 2018, Southeast University and the University of Birmingham in the United Kingdom signed a comprehensive strategic cooperation agreement and established the Southeast University-University of Birmingham Biomedical Engineering Joint Research Center. The SKL of Bioelectronics, housed within Southeast University, has led and participated in the international cooperation plan by facilitating academic exchanges in cutting-edge fields such as artificial intelligence and big data. It also established an international cooperation base for new technologies and innovative applications of mass spectrometry with Jiangbei New District of Nanjing. China recognizes international cooperation bases such as this

one as an “important window of cooperation,” especially since the lab has further cooperated with institutions such as Purdue University, the Swiss Federal Institute of Technology, the Technical University of Munich, and the University of Washington in Seattle on various research projects. In addition to the Bioelectronics SKL’s domestically-based international cooperation base, it has also established a Joint Research Center with the Allen Institute for Brain Research, based in Seattle.[67]

Similarly, the SKL of Precision Spectroscopy has initiated a China-U.S.-Canada international cooperation project to research the overall optimization control of complex industrial processes. The lab has signed cooperation agreements with the University of Michigan, the University of Southern California, and the University of Concordia in Canada. The project has received funding from the NSFC worth $457,000 (RMB 2.9 million).[68]

Although there is evidence that enterprise SKLs also collaborate with international institutions, the information is not as widely advertised. The SKL of High-Power AC Drive Electric Locomotive System Integration), for example, has issued guidelines for projects to attract and gather high-level S&T professionals at home and abroad.[69]

Conclusion

As China strives to foster cutting-edge basic research and improve its capacity for discovery and innovation, SKLs are likely to remain a critical piece of China's broader S&T ecosystem. Despite a number of bureaucratic obstacles and hurdles, including those stemming from the COVID-19 pandemic, Chinese leaders continue to lay out ambitious goals for the country's laboratory system. Although as of 2022 there is little evidence that China has reached its goal of developing 700 SKLs, this delay should not be taken to mean that China is still lacking in infrastructure or scientific capacity. On the contrary, the significant progress that China has made in building a laboratory system from nothing over the past four decades illustrates the vast amounts of capital and resources that have been poured into developing China's basic and applied R&D capabilities.

Beijing's focus on increasing the quality of the SKL system—both by fostering new talent and resources at the new labs and re-envisioning the existing ones—will likely have a significant impact on China's innovation base. Chinese media outlets note that the entire system appears to be poised for reorganization, which would refocus on fostering original innovation and reaching breakthroughs in key strategic technologies.[70] To do this, new policies are focused on attracting and training talent as well as channeling additional funding toward R&D.[71] There are also plans to expand the size of individual laboratories and strengthen the link between laboratories' collaborative innovation and work that serves the needs of the country. The 2018 "Several Opinions on Strengthening the Construction and Development of State Key Laboratories" (关于加强国家重点实验室建设发展的若干意见), for example, sought to form a SKL system with "clear goals, reasonable layout, and leading development" by the end of 2020.[72]

Beijing is still approving new SKLs, which is unlikely to change as China continues toward its goal of establishing 700 such labs. The Chinese government has already announced the approval of several new labs, including the SKL of Organic Electronics and Information Display (省部共建有机电子与信息显示国家重点实验室) at Nanjing University of Posts and Telecommunications, the SKL of Non-Human Primate Biomedicine (省部共建非人灵长类生物医学国家重点实验室) at Kunming University of Science and Technology, as well as the SKL of Hazard Factors and Risk Prevention and Control for Agricultural Products Quality and Safety (省部共建农产品质量安全危害因子与风险防控国家重点实验室) co-hosted by the Zhejiang Academy of Agricultural Sciences and Ningbo University, among others.[73] The Chinese government has communicated its intent to establish several new entities at the national laboratory level. For example, the Sichuan Provincial Government in

December 2020 announced the establishment of the Tianfu Laboratory (天府实验室) that will focus on a variety of key research areas, including aerospace, life sciences, advanced nuclear energy, electronic information, and more.[74] The lab officially opened in June 2021.[75]

As U.S. policymakers, industry leaders, and academics weigh the future trajectory of S&T cooperation and competition with China, it will be crucial to consider the role that SKLs play in China's larger S&T ambitions, especially in various foundational and emerging technologies critical to national security. China's holistic approach to S&T development—with SKLs, universities, Chinese government and military researchers working together—complicates ongoing and future potential relationships with U.S. partners, raising concerns related to technology transfer and research security.

As for technology transfer and export controls, the opaqueness of the Chinese laboratory system makes identifying end users of information, equipment, software, and/or technology difficult. Many of the SKL entrusted units have been added to U.S. sanctions and export control lists over the past two decades, including universities like Tianjin University and the Harbin Institute of Technology, both of which are on the U.S. Department of Commerce's Entity List, as well as companies like Huawei and China Shipbuilding Industry Corporation, which are on the U.S. Department of Treasury's Non-SDN Chinese Military-Industrial Complex Companies (CMIC) List.[76] However, there are notable gaps that prevent the relevant SKLs from being captured under these various lists.

On the issue of research security, the Chinese Party-state's strong oversight over SKLs makes academic collaborations more challenging to navigate. Moreover, China's stated ambitions to overtake the United States in critical and emerging technologies—in conjunction with Chinese legal, illegal, and extralegal means of acquiring foreign technology—pose significant risks to the U.S. research enterprise. This is not to say that all collaborations with SKLs should cease; on the contrary, numerous parties have demonstrated the vital importance of ongoing collaboration between the United States and China.[77] However, policymakers should have a clear-eyed understanding of the potential risks and benefits of collaborating with research entities in China and ensure transparency and reciprocity in the depth and breadth of research partnerships. China's SKLs represent an investment in China's future S&T capacity and will likely drive key aspects of its economic development and future defense S&T progress.

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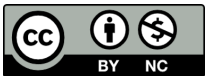

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Appendix A: China's 20 National Labs and Research Centers

Name (Chinese)	Name	Year Established	Entrusted Unit(s)	City
国家同步辐射实验室	National Synchrotron Radiation Laboratory	1984	University of Science and Technology of China	Hefei
正负电子对撞机国家实验室	Beijing National Laboratory of Electron Positron Collider	1984	Institute of High Energy Physics (CAS)	Beijing
北京串列加速器核物理国家实验室	Beijing National Laboratory of Tandem Accelerator Nuclear Physics	1988	China Institute of Atomic Energy	Beijing
兰州重离子加速器国家实验室	Lanzhou National Laboratory of Heavy Ion Accelerator	1991	Institute of Modern Physics (CAS)	Lanzhou
沈阳材料科学国家研究中心	Shenyang National Laboratory for Materials Science	2000	Institute of Metal Research (CAS)	Shenyang
北京凝聚态物理国家研究中心	Beijing National Research Center for Condensed Matter Physics	2003	Institute of Physics (CAS)	Beijing
合肥微尺度物质科学国家研究中心	Hefei National Laboratory for Physical Sciences at the Microscale	2003	University of Science and Technology of China	Hefei
北京信息科学与技术国家研究中心	Beijing National Research Center for Information Science and Technology	2003	Tsinghua University	Beijing
北京分子科学国家研究中心	Beijing National Research Center for Molecular Sciences	2003	Peking University, Institute of Chemistry (CAS)	Beijing
武汉光电国家研究中心	Wuhan National Laboratory for Optoelectronics	2003	Huazhong University of Science and Technology, Wuhan Institute of Physics and Mathematics (CAS), China Shipbuilding Industry Corporation 717th Research Institute	Wuhan

青岛海洋科学与技术国家实验室	Qingdao National Laboratory for Marine Science and Technology	2006	China Ocean University, Ocean Institute (CAS), National Oceanic Bureau First Institute, Huanghai Aquatic Research Institute, China Aquatic Science Research Institute, Qingdao Marine Geological Institute	Qingdao
磁约束核聚变国家实验室	National Laboratory for Magnetic Confinement Nuclear Fusion	2006	Hefei Materials Science Research Institute (CAS), Nuclear Industry Southwest Physics Academy	Hefei
洁净能源国家实验室	National Laboratory for Clean Energy	2006	Institute of Chemical Physics (CAS)	Dalian
船舶与海洋工程国家实验室	National Laboratory of Naval Architecture and Ocean Engineering	2006	Shanghai Jiao Tong University	Shanghai
微结构国家实验室	National Laboratory of Microstructures	2006	Nanjing University	Nanjing
重大疾病研究国家实验室	National Laboratory for Critical Disease Research	2006	Chinese Academy of Medical Sciences	Beijing
蛋白质科学国家实验室	National Laboratory of Protein Science	2006	Institute of Biophysics (CAS)	Beijing
航空科学与技术国家实验室	National Laboratory of Aeronautical Science and Technology	2006	Beihang University	Beijing
现代轨道交通国家实验室	National Laboratory of Modern Rail Transit	2006	Southwest Jiaotong University	Chengdu
现代农业国家实验室	National Laboratory of Modern Agriculture	2006	China Agricultural University	Beijing

Appendix B: MIIT Key Laboratories[78]

Name (Chinese)	Name	Entrusted Unit(s)
卫星导航与移动通信融合技术工业和信息化部重点实验室	Key Laboratory of Sat-nav and Mobile Communication Integration	Beihang University
空天信自旋电子技术工信部重点实验室	Key Laboratory of Aerospace Spintronic-info Technology	Beihang University
大数据精准医疗实验室	Key Laboratory of Big data-based Precision Medicine	Beihang University
工信部低维量子结构与器件重点实验室	Key Laboratory of Low-dimensional Quantum Structures and Devices	Beijing Institute of Technology
工信部语言工程与认知计算重点实验室	Key Laboratory of Language Engineering and Cognitive Computing	Beijing Institute of Technology
智能科技风险法律防控工信部重点实验室	Key Laboratory of Law-based Technology Risk Management	Beijing Institute of Technology
自主智能无人系统工信部重点实验室	Key Laboratory of Unmanned Autonomous Intelligent Systems	Harbin Institute of Technology
物联网智能技术工信部重点实验室	Key Laboratory of Internet of Things (IoT) Intelligent Technology	Harbin Institute of Technology
航天等离子体推进工信部重点实验室	Key Laboratory of Aerospace Plasma Propulsion	Harbin Institute of Technology
核安全与先进核能技术工业和信息化部重点实验室	Key Laboratory of Nuclear Safety and Advanced Nuclear Energy	Harbin Engineering University
船舶智能系统与技术工业和信息化部重点实验室	Key Laboratory of Smart Ship System and Technology	Harbin Engineering University
海洋信息获取与安全工业和信息化部重点实验室	Key Laboratory of Marine Information Acquisition and Security	Harbin Engineering University
飞行器体系贡献度与综合设计工业和信息化部重点实验室	Key Laboratory of Aircraft System Contribution and Comprehensive Design	Northwestern Polytechnical University
智能交互与应用工业和信息化部重点实验室	Key Laboratory of Intelligent Interaction and Application	Northwestern Polytechnical University
光场调控与信息感知工业和信息化部重点实验室	Key Laboratory of Light Field Regulation and Information Perception	Northwestern Polytechnical University
空间核技术应用与辐射防护工业和信息化部重点实验室	Key Laboratory of Space Nuclear Technology in Radiation Protection	Nanjing University of Aeronautics and Astronautics
航空发动机热环境与热结构工信部重点实验室	Key Laboratory of Aeroengine Thermal Environment and Thermal Structure	Nanjing University of Aeronautics and Astronautics

空间光电探测与感知工信部重点实验室	Key Laboratory of Space Optoelectronics Detection and Sensing	Nanjing University of Aeronautics and Astronautics
电磁仿真与射频感知工信部重点实验室	Key Laboratory of Electromagnetic Simulation and RF Sensing	Nanjing University of Science and Technology
特种装备可靠性设计与控制实验室	Key Laboratory of Special Equipment Design for Reliability	Nanjing University of Science and Technology
车联网技术创新与测试评价实验室	Key Laboratory of Internet of Vehicle (IoV) Technology Innovation	China Academy of Information and Communications Technology
医学人工智能工信部重点实验室	Key Laboratory of Medicine AI Research	China Academy of Information and Communications Technology
		Tsinghua University
		Beijing Tongren Hospital
新一代人工智能标准与应用实验室	Key Laboratory of New-Generation Artificial Intelligence Standards and Application	China Electronics Standardization Institute
工业互联网大数据技术工业和信息化部重点实验室	Key Laboratory of Industrial Internet Big Data Technology	China Industrial Internet Research Institute
工业软件工程化与应用技术工业和信息化部重点实验室	Key Laboratory of Industrial Software Engineering and Applied Technology	China CEPREI Laboratory (MIIT Fifth Institute of Electronics)
新一代信息安全与隐私保护标准化技术工业和信息化部重点实验室	Key Laboratory of New Generation of Information Security and Privacy Protection Standardization Technology	China Electronics Standardization Institute
移动应用创新与治理技术工业和信息化部重点实验室	Key Laboratory of Mobile Application Innovation and Governance Technology	China Academy of Information and Communications Technology
代谢工程与生物合成技术工业和信息化部重点实验室	Key Laboratory of Metabolic Engineering and Biosynthesis Technology	Nanjing University of Science and Technology
语言信息智能处理及应用工业和信息化部重点实验室	Key Laboratory of Intelligent Processing and Application of Language Information	Nanjing University of Science and Technology
半导体微纳结构与量子信息感知工业和信息化部重点实验室	Key Laboratory of Semiconductor Micro-Nano Structures and Quantum Information Perception	Nanjing University of Science and Technology
空天信息材料与物理工业和信息化部重点实验室	Key Laboratory of Aerospace Information Materials and Physics	Nanjing University of Aeronautics and Astronautics

多功能轻量化材料与结构工业和信息化部重点实验室	Key Laboratory of Multifunctional Lightweight Materials and Structure	Nanjing University of Aeronautics and Astronautics
飞行器数学建模与高性能计算工业和信息化部重点实验室	Key Laboratory of Aircraft Mathematical Modeling and High Performance Computing	Nanjing University of Aeronautics and Astronautics
大数据与商务智能技术工业和信息化部重点实验室	Key Laboratory of Big Data and Business Intelligence Technology	Harbin Engineering University
航行器跨介质技术工业和信息化部重点实验室	Key Laboratory of Aircraft Trans-Medium Technology	Harbin Engineering University
寒区交通基础设施智能化与安全保障技术工业和信息化部重点实验室	Key Laboratory of Intelligentization and Safety Assurance Technology of Transport Infrastructure in Cold Areas	Harbin Institute of Technology
无线专用通信智能网络技术工业和信息化部重点实验室	Key Laboratory of Intelligent Network Technology for Wireless Dedicated Communication	Harbin Institute of Technology
储能与电力变换技术工业和信息化部重点实验室	Key Laboratory of Energy Storage and Power Conversion Technology	Harbin Institute of Technology
医药分子科学与制剂工程工业和信息化部重点实验室	Key Laboratory of Pharmaceutical Molecular Science and Pharmaceutical Engineering	Beijing Institute of Technology
信息安全的数学理论与计算工业和信息化部重点实验室	Key Laboratory of Information Security, Mathematical Theory and Computing	Beijing Institute of Technology
社会治理智联网技术工业和信息化部重点实验室	Key Laboratory of Social Governance Intelligent Networking Technology	Beijing Institute of Technology
语言信息与智能计算工业和信息化部重点实验室	Key Laboratory of Language Information and Intelligent Computing	Beihang University
特种车辆无人运输技术工业和信息化部重点实验室	Key Laboratory of Unmanned Transportation Technology of Special Vehicles	Beihang University
		Beijing Tage Zhixing Technology Co., Ltd.
		Inner Mongolia North Hauler Joint Stock Co., Ltd. (NORINCO)
先进航空机载系统工业和信息化部重点实验室	Key Laboratory of Advanced Aviation Airborne Systems	Beihang University

Appendix C: SKLs with Supporting Units on U.S. Export Controls and Sanctions Lists

The following table includes SKLs with at least one supporting unit that is subject to U.S. government export controls, sanctions lists, or both. Since some SKLs have more than one supporting unit, we have identified and underlined which specific entity is subject to U.S. trade restrictions. More specifically, the table below identifies SKLs with supporting units on one of the following U.S. government screening lists:

Entity List, Bureau of Industry and Security, U.S. Department of Commerce

Unverified List **(UVL)**, Bureau of Industry and Security, U.S. Department of Commerce

Non-SDN Chinese Military-Industrial Complex Companies List **(NS-CMIC List**), Office of Foreign Assets Control (OFAC), U.S. Department of Treasury

In addition, we have noted if a supporting unit is one of China's Seven Sons of National Defense (国防七子), a group of seven Chinese universities administered directly by MIIT that maintain strong ties to China's defense ecosystem. These are denoted with a *.

SKL Name	Entrusted Unit(s)	Applicable U.S. Screening List(s)
State Key Laboratory of Chemical Engineering	Tsinghua University, Tianjin University, East China University of Science and Technology, Zhejiang University	Entity List
State Key Laboratory of Urban Water Resources and Water Environment	Harbin Institute of Technology*	Entity List
State Key Laboratory of Pest Control and Resource Utilization	Sun Yat-Sen University	UVL
State Key Laboratory of Software Development Environment	Beihang University*	Entity List
State Key Laboratory of Networking and Switching Technology	Beijing University of Posts and Telecommunications	Entity List

State Key Laboratory of Virtual Reality Technology and Systems	Beihang University*	Entity List
State Key Laboratory of Information Photonics and Optical Communication	Beijing University of Posts and Telecommunications	Entity List
State Key Laboratory of Precision Testing Technology and Instruments	Tianjin University, Tsinghua University	Entity List
State Key Laboratory of Electronic Thin Films and Integrated Devices	University of Electronic Science and Technology of China	Entity List
State Key Laboratory of Optoelectronic Materials and Technology	Sun Yat-Sen University	UVL
State Key Laboratory of Polymer Materials Engineering	Sichuan University	Entity List
State Key Laboratory of Coagulation Technology	Northwestern Polytechnical University*	Entity List
State Key Laboratory of Explosion Science and Technology	Beijing Institute of Technology*	Entity List
State Key Laboratory of Rail Transit Control and Safety	Beijing Institute of Technology*	Entity List
State Key Laboratory of Internal Combustion Engine	Tianjin University	Entity List
State Key Laboratory of Rolling Technology and Continuous Rolling Automation	Tianjin University	Entity List

State Key Laboratory of Advanced Welding and Connection	Harbin Institute of Technology*	Entity List
State Key Laboratory of Robotics and Systems	Harbin Institute of Technology*	Entity List
State Key Laboratory of Mechanical Structure Mechanics and Control	Nanjing University of Aeronautics and Astronautics*	Entity List
State Key Laboratory of Hydraulics and Mountain River Development and Protection	Sichuan University	Entity List
State Key Laboratory of Oncology in South China	Sun Yat-Sen University	UVL
State Key Laboratory of Ophthalmology	Sun Yat-Sen University	UVL
State Key Laboratory of Biotherapy	Sichuan University	Entity List
State Key Laboratory of Oral Disease Research	Sichuan University	Entity List
State Key Laboratory of Optical Fiber Communication and Network Technology	FiberHome Technologies Group	Entity List
State Key Laboratory of Wireless Communication Access Technology	Huawei Technologies Co., Ltd.	Entity List; NS-CMIC List
State Key Laboratory of Electromagnetic Metamaterials Modulation Technology	Kuang-Chi Group	Entity List
State Key Laboratory of Nuclear Power Safety Monitoring Technology and Equipment	China Guangdong Nuclear Power Engineering Co., Ltd.	Entity List

State Key Laboratory of Wide Bandgap Semiconductor Power Electronic Devices	China Electronic Technology Group Corporation 55th Research Institute	Entity List
State Key Laboratory of Manned Deep-Sea Equipment	China Shipbuilding Industry Corporation No. 702 Research Institute	Entity List; NS-CMIC List
State Key Laboratory of Intelligent Manufacturing of Special Vehicles and Transmission Systems	Inner Mongolia First Machinery Group	Entity List; NS-CMIC List
State Key Laboratory of Satellite Navigation Systems and Equipment Technology	China Electronics Technology Group Corporation 54th Research Institute	Entity List
State Key Laboratory of Cognitive Intelligence	iFlytek	Entity List
State Key Laboratory of Pulsed Power Laser Technology	PLA National University of Defense Technology	Entity List
State Key Laboratory of Aerodynamics	China Aerodynamics Research and Development Center	Entity List
State Key Laboratory of Complex Electromagnetic Environment Effects on Electronics and Information System	PLA National University of Defense Technology	Entity List
State Key Laboratory of Automatic Target Recognition	PLA National University of Defense Technology	Entity List

Endnotes

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