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Reorganization of China's Science and Technology System

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Abstract

China continues to dramatically increase the priority it gives to science and technology (S&T). This paper reviews China's reorganization of its S&T system, which is part of a broader Party and government restructuring plan. The most important elements of the bureaucratic reform were the establishment of a Central Science and Technology Commission (CSTC) and the reorganization of the existing Ministry of Science and Technology (MOST). These reorganizations have been carefully thought out and in gestation for the past several years. If the subordination of research and innovation to immediate policy goals is taken as a given, most of the reorganization measures are reasonable attempts to moderate the costs that would be expected with a campaign-style approach to S&T. At the same time, the measures are no panacea. Bureaucratic conflicts will persist, though shifted to different arenas, and the biggest challenges will persist: the subordination of research to security imperatives; divorce from international collaborative research; and narrower use of market incentives will all be very costly to China's science efforts and aspirations.

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Introduction

China continues to dramatically increase the priority it gives to science and technology (S&T). At the March 2023 meeting of the National People's Congress, China rolled out a major reorganization of its S&T system as part of a broader Party and government restructuring plan (Chinese Communist Party and State Council 2023). The most important elements of the bureaucratic reform were the establishment of a Central Science and Technology Commission (CSTC) and the reorganization of the existing Ministry of Science and Technology (MOST). The CSTC, a new Communist Party body, was created to oversee all aspects of S&T policy, while the existing MOST was reorganized to strengthen its ability to oversee and strategize the entire "innovation chain." At the same time, the ministry was streamlined, as other MOST functions were spun off into other parts of the bureaucracy.

These changes reflect four fundamental objectives of China's policymakers:

1. The creation of the CSTC formalizes and increases the priority given to mission-driven S&T development. It operationalizes an even more security-driven approach to policy and system development.

2. After several years of experimentation and bottom-up restructuring, Xi Jinping is now imposing more centralized direction of the system. The new bodies are intended to be the keystones to the entire revamped S&T system.

3. Reorganization is a fundamental step to realize the "new-style whole-of-nation system" of science, technology, and innovation. This system relies on organized consortia set up to manage the entire innovation chain from the solution of scientific and technical problems all the way through to the application of new knowledge in production, sales, and military uses. A streamlined MOST is expected to oversee the new-style whole-of-nation system by providing support and guidance to individual consortia, offering integrated leadership to the entire innovation chain.

4. The top-down emphasis on high-priority, results-oriented research inevitably pushes China's entire innovation system toward practical and applied research. However, because China's policymakers also value basic research as part of an expected long-term struggle for dominance with the United States, they have also taken steps to protect the position of basic research in the course of reorganization.

These reorganizations have been carefully thought out and in gestation for the past several years (a formal redesign process has been in place since 2018). If the subordination of research and innovation to immediate policy goals is taken as a given, most of the reorganization measures are reasonable attempts to moderate the costs that would be expected with a campaign-style approach to S&T. At the same time, the measures are no panacea. Bureaucratic conflicts will persist, though shifted to different arenas, and the biggest challenges will persist: the subordination of research to security imperatives; divorce from international collaborative research; and narrower use of market incentives will all be very costly to China's science efforts and aspirations.

Section 1: The New Central Science and Technology Commission

The newly created CSTC (中央科技委员会) takes its place as one of (now) ten similarly structured Party commissions. These CCP organs, created by Xi over the past ten years to superimpose a layer of direct CCP management and personal control over the government, now cover all key issue areas.[1]

1a. Membership and Composition

The membership of the CSTC has not yet been announced, but by examining the organization of other commissions, we can make some predictions with reasonable confidence. The CSTC will probably be chaired by Xi, although this may not be publicly "revealed" for months.[2] The vice-chair of CSTC will likely be Ding Xuexiang (丁薛祥), the newly appointed executive vice-premier. Ding has spent the past ten years as Xi's chief of staff and accompanies Xi on almost all his foreign and domestic travel. Ding has already presided over events demonstrating that he holds the technology portfolio. In fact, Ding began his career as a researcher in the Shanghai Materials Research Institute (in 1982) and first moved into a cadre position at the Shanghai Municipal Science and Technology Commission in 1999. Ding thus combines technological expertise and personal loyalty to Xi, making him a perfect fit for this job.

The bulk of the membership of CSTC will be made up of ministers of relevant central ministries. MOST will of course continue to play a crucial role (see below), and the Office of CSTC will be housed in MOST and staffed by MOST technocrats.

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[1] Like the other commissions, the CSTC has had a distinctive evolution through a series of less authoritative leadership small groups and commissions, which we do not consider in detail here.

[2] In fact, as of mid-June 2023, there had been no public activities of the three-month-old commission and no announcement of its membership or chairperson.

All the main economic ministries will be represented, as well as the Chinese Academy of Sciences and the Chinese Academy of Engineering. There will certainly be military representatives on the CSTC, given that oversight of military-civil fusion is one of its primary missions. However, an important unresolved question is the extent to which CSTC will absorb existing military technology groups. Early indications suggest that the CSTC will primarily represent civilian interests in the dual-use realm, while military-oriented matters will remain under the purview of the existing Central Military-Civil Fusion Development Commission and 995 Leading Small Group.

Premier Li Qiang is likely to also be a vice-chair of CSTC, although he is a newcomer to the central government administration. Among experienced central officials, Liu He will continue to play an important role (though likely not with a formal position in the commission). Liu has been one of the most important influences on technology policy for the past decade and is a close confidante of Xi. He stepped down as vice-premier in March, but he has told foreign visitors that he intends to continue to play an active role. We expect that Liu's influence will be at least equal to that of Ding for the immediate future and will provide an important element of continuity.

1b. CSTC's Function and Role

The CSTC consolidates three existing strategically important Leading Small Groups (LSGs) devoted to S&T affairs.[3] Its immediate predecessor was the "National S&T LSG," subordinate to the State Council, and chaired by Premier Li Keqiang. This LSG was created in 2018, during a previous round of restructuring. At that time, the office of this LSG was moved to the MOST, and Xi's close confidante Liu He (who was appointed vice-premier at that time) was made the vice-head of the LSG. Since the office had previously been housed at the State Council (as part of a larger LSG that consolidated education, science, and technology), these two changes clearly reduced the direct influence of the premier, who had traditionally had direct control over S&T policy in China. The second LSG absorbed into the CSTC was the "National S&T System Reform and Innovation System Construction LSG" established in 2012. In 2018, this LSG started to be chaired by Liu personally, thus cementing his direct personal influence. While this second S&T-related LSG nominally had lower rank than the main S&T LSG, its mission was specifically to design and implement institutional changes to strengthen the innovation ecosystem. In a sense, this second LSG's mission has now been accomplished with a series of initiatives culminating in the current reorganization; and it has now been absorbed into the CSTC. Finally, a third, strategic but task-oriented LSG has also been absorbed into

[3] A fourth LSG was also absorbed into the CSTC: the task-oriented National Laboratory Construction Leadership Small Group (中央国家实验室建设领导小组). This represents a different type of temporary, task-oriented LSG sometimes set up in the Chinese system. There is little public information about this LSG and we do not treat it further in this discussion.

the CSTC: the Medium- and Long-Term Science and Technology Development Plan (MLP) LSG. While the main part of the MLP LSG's work was likely completed when the 15-year plan kicked off in 2021, it may also have been responsible for overseeing implementation of the plan (which has never been publicly released). Such oversight will now be in the hands of CSTC.[4]

With the conversion from LSG to commission, the CSTC becomes more powerful and authoritative. While LSGs are predominantly coordinating bodies, the CSTC is a policymaking agency (决策议事协调机构). Moreover, unlike an LSG, the CSTC can issue authoritative documents and regulations in its own name. CSTC has thus been triply upgraded from its predecessor: it is a commission, rather than an LSG; it is a Party rather than a government body; and its mission consolidates that of three previous LSGs. The three LSGs have long been the primary institutions responsible for the top-level design of China's S&T affairs, all under the jurisdiction of the State Council system. Their dissolution signifies that the State Council will no longer be the main body responsible for the top-level design of S&T policies; instead, the Party will take on this role through the CSTC.

This is not merely a bureaucratic upgrading: The creation of the CSTC represents a fundamental expansion of China's ambition for government action in the S&T field and is seen as the directorate of China's response to the challenge of American sanctions. Sui Jigang (2023) of the Chinese Academy of Sciences explained the function of CSTC as follows:

> The innovation activities associated with key core technologies involve not only scientific research and technological development but also industrial production. They encompass interdisciplinary and multidisciplinary knowledge from various fields, as well as the participation of multiple sectors and entities. Accomplishing these activities requires substantial investment and team collaboration on a large scale. Therefore, efficient organizational capacity and cooperation mechanisms are needed to establish institutions, facilitate cross-departmental coordination, ensure resource supply, promote knowledge diffusion, and rectify "system failures." … In such complex endeavors, ordinary innovative entities generally lack the ability to coordinate various innovative forces. The entity responsible for organizing and coordinating these efforts must have sufficient political authority to mobilize diverse resources. This role can only be assumed by the government.

[4] In addition, two important bodies subordinate to the previous LSG—the National S&T Advisory Committee (国家科技咨询委员会) and the National S&T Ethics Committee (国家科技伦理委员会)—will continue and now report directly to the CSTC.

To fully understand CSTC's function and mission, it is necessary to go back and examine earlier high-level commissions and the high-priority "whole-of-nation" systems they designed and implemented. As will be discussed below, CSTC today will be in charge of designing and implementing a so-called "new-style whole-of-nation system." This is the crux of China's technology strategy today.

Section 2: Back to the Future: Top-Down Mobilization of Technological Innovation

The science, technology, and innovation reorganization in China signals a return to a more security-driven approach in policy and system development. It represents a classic response by China's leadership to address perceived acute external security threats, including efforts to hinder its technological advancement. The creation of a top-level commission to steer outcomes in large-scale, complex technological projects is designed to ensure sustained high-level leadership attention and engagement coupled with whole-of-nation support and mobilization of resources. The creation of CSTC strongly echoes three previous efforts.

2a. Directorates for Selective Mobilization

Top-level mobilizational commissions have been created three times previously in the People's Republic of China: first, in the early 1960s following the Sino-Soviet split; second, after the imposition of international sanctions in the wake of the 1989 Tiananmen Square crackdown; and third, in response to the U.S. bombing of the Chinese embassy in Belgrade in 1999. Each time, China established a top-level S&T decision-making body with extraordinary powers. Today's CSTC can be seen as the fourth iteration of this institutional response.

The first Central Special Commission (1962-late 1970s) developed out of China's efforts to develop nuclear weapons and ballistic missiles from the late 1950s. The Party Central Special Commission (CSC; 中央专委) was created in 1962 after the definitive split with the Soviet Union. With Premier Zhou Enlai at the helm, reporting directly to Mao Zedong and the Politburo Standing Committee, the CSC aimed to overcome bureaucratic fragmentation (Cheung 2022; Lu and He 2021). Civil-military integration was achieved through joint state, People's Liberation Army (PLA), and Party membership; Party dominance was maintained, but Zhou led both the CSC (a Party organ) and, as premier, the government. This enabled the CSC to coordinate 26 ministries and 900 separate entities. Interactive leadership-scientist coordination was facilitated by two-way

working ties with the scientific community. In effect, high-level mobilization of resources allowed Zhou to institutionalize personalistic policymaking. The successful development of China's nuclear weapons led to this experience being dubbed "Two Bombs, One Satellite" (两弹一星), referencing the atomic and hydrogen bombs and China's first satellite (and the ballistic missile that launched it), successfully tested between 1964 and 1970.

A second CSC (1989 to early 2010s) was established after the 1989 cut-off of access to Western high-tech and defense capabilities. This CSC 2.0 exhibited important differences from its predecessor: It was no longer a Party entity but functioned under the leadership of the State Council and the Central Military Commission (CMC). It served as an advisory and coordinating organ rather than having direct control. Despite its low formal rank, the actual policy influence and authority of CSC 2.0 were significant. A high-powered leadership line-up, with Premier Li Peng as head and deputies including a CMC vice-chairman and vice-premier, made the group authoritative. Civilian leadership with military cooperation ensured that strategic S&T projects remained under civilian control to serve national interests and limit undue militarization. Direct top-level political access meant that in practice the CSC made key decisions, such as those concerning space programs, even though it was formally a coordinating organ.

A third version of high-priority central mobilization directorate was established in the wake of the May 1999 Belgrade embassy bombing. Jiang Zemin ordered a major armament drive, akin to a new Two Bombs, One Satellite campaign, aimed at preventing the United States from threatening China by developing asymmetric strategic deterrence capabilities such as anti-access and area denial systems. The resulting CMC 995 LSG (1999–present) is a powerful yet enigmatic entity overseeing the 995 Project (new high-tech project, 高新科技项目), credited for much of the recent success in China's considerable defense modernization (Cheung 2022). Yao Youzhi of the Academy of Military Sciences asserts that without the 995 LSG, "the PLA would not have been able to get new generations of weapons as quickly as it has done" (2012). Given that the head of the 995 LSG is the CMC chairman, the group wields considerable decision-making authority.

The CSTC can thus be considered the fourth iteration of a security-driven, mobilizational approach to S&T development. As in earlier episodes, direction of the projects will be highly centralized and personalized. Indeed, Xi has already brought the locus of direct decision-making authority back under the CCP apparatus, demonstrating a shift toward more centralized control. Like the other Party commissions that now run all important policy areas, CSTC will require other organizations—including the State Council—to adjust and conform to its decision-making and coordination (CCP Central Committee 2018; State Council 2023). As with Zhou and Mao in the first CSC from 1962, the

commission will be an institutionalized expression of the strong personal interest and personalistic control that Xi exercises over the process. The success and influence of the CSTC within the broader Chinese innovation landscape are thus contingent upon this strong and committed leadership. Assuming Xi will be at the helm of the CSTC, it will become a dominant player in the science, technology, innovation, and industrialization ecosystem.

2b. Whole-of-Nation System

The mobilization of resources for high-priority national objectives in China has often been called the whole-of-nation system (举国体制).This term, derived from classical Chinese, clearly conveys the sense of subordination of the individual to the nation (it is also used to describe the selection of elite athletes for the Chinese Olympic team). However, it is vague about the specific mechanisms. In the earlier mobilizations described in this section, the emphasis was on the ability of the nation to commandeer and assemble the scarcest and highest quality manpower and technology and to mobilize almost unlimited resources. This was carried out by the top-down organization of multi-part teams, each part of which was entirely subordinate to the overall national objective. High-priority and top-down coordination were used to get teams from different sectors and bureaucratic systems to work closely together for the common good, as defined by the priority project.

This approach has led to impressive achievements in complex, large-scale strategic and defense-related, science and engineering programs from the 1950s to the present day. However, past iterations were tightly focused on a few ultra-high-priority military objectives, and the approach was heavily reliant on technology absorption and reverse engineering. It is clear that the old model, for all its impressive successes, was also limited. Today, the Chinese Party-state is dedicated to reinvigorating and broadening this innovation model, and the CSTC will be the key institution in this drive. It will attempt to do so in at least three important ways: (1) broadening the focus to include large-scale emerging technological domains; (2) emphasizing original innovation over technological borrowing and reinnovation; and (3) simultaneously developing technological fixes to insulate “bottleneck” sectors from the threat of technological embargoes.

2c. The New-Style Whole-of-Nation System

It is clear that the traditional whole-of-nation system could not simply be replicated in the vastly more complex environment in which China's technology strategy now operates. In fact, China has for several years been actively promoting an expanded and adapted "new-style whole-of-nation system." Shaping and scaling this new-style whole-of-nation system is the central and most urgent objective of the current S&T reorganization. While the whole-of-nation system was "a special way of resource allocation and organization, in which the government coordinated and allocated national resources and strengths to achieve specific goals and tasks," the new-style whole-of-nation system "inherits and innovates" the original system with the "new core mission of conquering key core technologies" (Jin 2022). Thus, the new-style system is an adaptation of the old whole-of-nation system both to China's contemporary more flexible and capable market economy and also to a new set of high-priority objectives.

In fact, the adaptation of old-style top-down mission-driven big science to market conditions has been underway for a while. An important milestone in this evolution was the creation of 16 "megaprojects" organized under the 2006–2020 MLP, each of which was organized as a complex organization under overall central government direction. In the 2010s, the term new-style whole-of-nation system began to be applied specifically to the 16 national megaprojects. In 2011, the Megaproject Office of the MOST organized a seminar on the new-style whole-of-nation system in Shanghai to accelerate the implementation of megaprojects "under the conditions of a socialist market economy and to leverage the government's leading role and the basic role of market resource allocation" (MOST 2023). In 2012, the Central Committee and the State Council issued "Opinions on Deepening the Reform of the Science and Technology System and Accelerating the Construction of a National Innovation System," which emphasized the need to "focus on leveraging the role of the new-style whole-of-nation system in implementing the national S&T megaprojects" by "adhering to government support and market orientation" (CCP Central Committee and State Council 2012). After Xi came into office, in his 2014 speech at the 17th Chinese Academy of Sciences Academician Conference and the 12th Chinese Academy of Engineering Academician Conference, he mentioned that the "ability of the socialist system in China to concentrate efforts on major undertakings (集中力量办大事) is an important tool for China to achieve its goals," and that China should "allow the market to play a decisive role in resource allocation, while at the same time better leveraging the role of the government … to promote independent innovation" (Xi 2014). In 2015, in the explanation of the "Suggestions of the CPC Central Committee on Formulating the 13th Five-Year Plan for National Economic and Social Development," Xi elaborated on the continuing implementation of

the existing 16 national megaprojects and the need to deploy a second round of megaprojects through 2030. In this context, he emphasized "leveraging the advantages of the new-style whole-of-nation system under the conditions of the market economy, concentrating efforts, collaborating in research, and providing support for mastering the strategic high ground, enhancing China's overall competitiveness, and safeguarding national security" (Xi 2015). In fact, a new list of 16 second-round megaprojects planned through 2030 has now been released (See Appendix for the full list).

Similar statements are also in the innovation-driven development strategy outline by the State Council and CCP Central Committee in 2016 (CCP Central Committee and State Council 2016).

The new-style whole-of-nation system has been steadily rising in importance. It was adopted as an official objective in the Resolution of the October 2019 Fourth Plenum (CCP Central Committee 2019); and in September 2022, Xi presided over the formal adoption of a resolution on "improving" the new-style whole-of-nation system at a key Party commission. While only excerpts of the document were released, they provide a wordy but informative definition:

> The new-style whole-of-nation system refers to an organizational model and operating mechanism that is oriented toward the major needs of the country, targets key core technologies and "bottleneck" areas, leverages the decisive role of the market in resource allocation, better utilizes the role of the government, strengthens the mechanism for implementing responsibilities, utilizes the vast domestic market demand, and integrates national strategic scientific and technological forces and social resources to jointly tackle major technological challenges. What is "new" in this "new-style" system is better integration between a proactive government and an efficient market, under conditions of a dialectic unity of a self-reliant technology great power and international scientific and technological cooperation (Commission on Deepening Reform 2022).

This account makes it clear that the new-style whole-of-nation system is designed to subordinate research and engineering efforts to specific national objectives, but also that those objectives have multiplied. While official accounts often emphasize breakthrough technologies and impressive engineering achievements, it is evident that many projects are designed for import substitution, providing insulation from current and potential technology embargoes (Zhu 2022). This system thus serves both as an emergency response mechanism to technology embargoes and as part of the broader strategy for technology self-sufficiency.

2d. CSTC Mission: Conclusion

With the background on the new-style whole-of-nation system, it is straightforward to interpret the formal statement of mission given to CSTC on its creation. According to the reform plan, CSTC responsibilities include four primary functions. These functions can be categorized as system-level, mission-oriented, and task/resource allocation-oriented:

a. Strengthening the Party's centralized leadership over S&T work and guiding construction and reform of the innovation system. As a Party body with jurisdiction over everything, the CSTC is well-equipped to navigate the complexities of competing ministries, agencies, and sprawling local and central initiatives (system level).

b. Studying and deliberating on major national S&T development strategies, plans, and policies. The CSTC's role includes setting priorities, overseeing the drafting of top-level S&T development plans, and managing consensus among competing agencies (mission level).

c. Setting specific national S&T tasks and major research projects and overall allocation of resources to national labs and other strategic resources (task and resource level).

d. Promoting the integration of military and civilian S&T development (system level).

In summary, the CSTC will now play a crucial role in shaping China's S&T landscape through its multifaceted responsibilities, which encompass mission, resource allocation, and system-oriented tasks. The revamped authoritarian leadership system appears to be better integrated and coordinated, allowing the CSTC to navigate the complexities of the nation's innovation system and foster collaboration between military and civilian S&T development. The result should be more effective decision-making and implementation of S&T initiatives, combined with a stronger harnessing to high-priority national objectives.

Section 3: Ministry of Science and Technology Reorganized: Mission and Function

MOST is poised to undergo a significant transformation, becoming more of a strategic planning and coordination agency in line with its role staffing the CSTC. Wang Ningli summarized the restructuring into two key words: "centralization" and "streamlining." Centralization refers to the concentration of authority, decision-making, and control within a single central entity, "consolidating the power of macro-regulating S&T tasks under the CSTC, and strengthening top-level design for S&T development." (quoted in Meng 2023). Streamlining entails reducing some operational management and oversight functions to create a leaner operation, transferring these responsibilities and their corresponding budgets to other agencies. For example, with MOST's tightened focus on strategy and planning, the agency is expected to step away from directly managing projects and programs, adhering to the principle of "separating athletes from referees." (Wu 2023). In fact, this objective was also included in the 2018 governmental reorganization plan (CCP Central Committee 2018), so today's restatement implicitly acknowledges that this was not achieved by the earlier reorganization.

MOST's reorganization is designed to strengthen and focus MOST's core mission, giving MOST more authority and influence. This strategic shift aligns with the principles of the new-style whole-of-nation system, discussed earlier. For example, MOST should focus more on technology transfer and the execution of specific products within its oversight of the whole innovation chain. However, the transfer of several important categories of operational responsibility to different agencies will result in a loss of money and resources to MOST. The most important of these losses to MOST are the direct management of research projects and the oversight over high-technology zones (HTZs). These changes are discussed in turn in the upcoming sections, after we examine the adaptation of MOST's core mission to today's complex environment.

3a. The Core Mission of MOST

MOST will retain its core mission of strategizing and steering China's scientific and technological development, even as the priority of that mission is elevated to a higher level. According to the enabling document, the new MOST is supposed to strengthen four key functions: (a) promotion of the new-style whole-of-nation system; (b) optimization of management of the entire science, technology, and innovation chain; (c) promotion of knowledge transfer (commercialization) of S&T achievements; and (d) promotion of the integration of S&T with economic and social development (CCP Central Committee and State Council 2023). The functions being strengthened all relate to the expansion of authority to cover the entire innovation chain, from research and development (R&D) to application, and on to knowledge transfer and incorporation

into production or national defense. Thus, MOST's restructuring is designed to adapt it more completely to the mission-driven, national-security-imperative nature of current S&T policy. It is the practical result that is to drive the nation's S&T effort.

Existing elements of MOST's core mission that are affirmed and should be strengthened include the intensification of macro-guidance, strategy, and supervision of S&T. In addition, MOST maintains responsibilities for 11 specified science and research activities, including "national basic research and applied basic research, national laboratory development, and national major S&T projects." (CCP Central Committee and State Council 2023). According to one account, after being "slimmed down," MOST's major functions will be managing national labs, national major S&T projects, promoting basic research, and coordinating multiple departments in the functions related to knowledge transfer (Wu 2023).

As part of the restructuring, MOST will continue to operate as a government ministry under the State Council. At the same time, it will host and manage the General Office of the CSTC, thereby maintaining a close relationship with the substantially upgraded new key Party body. Since the CSTC will most likely be chaired by Xi himself, it will possess greater decision-making authority in the S&T realm than any previous entity, and MOST's importance will correspondingly increase. The gives increasing importance to MOST's capabilities, and in particular its ability to manage the entire innovation chain—all the way through to successful applications—and in particular the new-style whole-of-nation system.

3b. Whole Innovation Chain and New-Style Whole-of-Nation System

MOST's core mission is being adapted to cover the "whole innovation chain," with an increased stress in technology transfer and the realization of specific designated products. To a certain extent, this dovetails with the traditional whole-of-nation discussed earlier. After all, the whole point of such an effort was to tightly link the needed scientific research and specialized manufacturing facilities with the final product designated by the top leadership, in that case, nuclear weapons and ballistic missiles. Similarly, the new-style whole-of-nation system promotes organizations that coordinate the innovation chain for specific products. It seeks to achieve mastery of "key and core technologies" by linking research with manufacturing capacities and designated objectives. Thus, the new-style whole-of-nation system represents a top-down effort to structure the whole innovation chain for scores of key core technologies.

However, this apparently simple fact raises some not-so-simple issues. With scores of high-priority items, a crucial question that arises is which projects should be given the highest priority, and how should planners balance resources among the numerous

priority claimants. Moreover, over the past few years, many localities have invested substantial effort and resources in the creation of "innovation consortia" (创新联合体), which are also the core elements of the new-style whole-of-nation system. Which of these should be supported and which are seen primarily as competitors for scarce innovation resources? China's S&T development effort has entered a new era, characterized by its bigger, broader scope and more systemic changes. The reorganization is designed to enable MOST to guide and coordinate a multitude of initiatives, reflecting the comprehensive and ambitious nature of China's S&T system.

On one hand, policymakers recognize that a strength of the existing initiatives is their diversity. These initiatives are managed by various entities, including the central government, local governments, and even corporations like Huawei. Acknowledging this diversity, policymakers are making concerted efforts to ensure that the instruments employed are market friendly, or at least not too distortionary. Thus, MOST's challenge should be understood as centralizing oversight, raising urgency, and steering resources toward central government priorities, while not doing too much damage to the diverse, grassroots, and often profit-seeking drivers of China's current innovation system.

On the other hand, there is no doubt that policymakers are determinate to concentrate resources and step up centralized control. Sui Jigang (2023) argues that "China's scientific and technological innovation forces are relatively dispersed; diverse innovative entities are not closely connected; and there are [various internal] obstacles in the scientific and technological system. As a result, the overall efficiency of the national innovation system is not high." Many analysts are calling for "a more focused approach" (Zhang et al. 2023), with the urgency enhanced by the threat of U.S. "chokeholds" on key technologies and inputs. Huang Shoufeng (Xiamen University) states "the new-style whole-of-nation system aims to uphold national security as its highest objective" (2022). Indeed, Qin Wenbo from the Shanghai Academy of Sciences emphasizes the need to "prevent excessive generalization of the new-style whole-of-nation system" (2023), while Li Zhe from Chinese Academy of Science and Technology for Development points out that the new-style whole-of-nation system has a specific scope of application and is mainly aimed at key core technology breakthrough tasks for national strategic needs. Li stressed that it is important to note that *not* all key core technology breakthrough tasks are suitable for the new-style whole-of-nation system. For example, as Li notes, technology innovation activities for market competition or frontier basic research activities for free exploration are generally not suitable for the application of the new-style whole-of-nation system. By focusing on fostering a more efficient and integrated system, MOST aims to bolster the nation's capacity for S&T innovation in the face of external challenges.

3c. Institutional Features of the New-Style Whole-of-Nation System

At present, the new-style whole-of-nation system is fundamentally characterized by five key institutional features. These features are shared with local government innovation consortia as well. Chinese sources do not provide a comprehensive description of these features, and indeed, details of the new-style whole-of-nation system are generally considered classified. Thus, this description is put together from a variety of descriptive sources.

1. A specified target is established by government. The target is most often a specified final product, but it could also be a specific technological achievement. This emphasis on the final step of the innovation chain implies a heightened focus on converting technologies into practical applications that benefit the economy, state, and military. While this process is often referred to as "commercialization," more accurate terms are technology transfer or technology adoption, becasue this process does not necessarily entail the development of profitable innovations for the marketplace.

2. A consortium of actors is organized by government with a strong lead actor, who is assigned responsibility for achieving the target. The lead actor (most often a state-owned enterprise or a research institute) may organize an authoritative project team, often cross-disciplinary, to provide guidance and coordination over the entire innovation chain, from basic research to final product adoption.

3. Membership in such a consortium is diverse, typically including research institutes, national laboratories, research universities, state-owned enterprises, private businesses, and various zones, in particular national high-technology industrial development zones and national innovation demonstration zones. This multi-type membership is sometimes called a "five-in-one" collaborative innovation model (Shen 2020); or a combination of "government-industry-university-research-use" (Lei 2021).

4. Incentive systems for each type of actor are revamped to further the mission. For instance, research institutes commit to—and are rewarded for—specific technical targets and ambitious knowledge transfer goals, which other success indicators (such as academic publications) are downgraded.

5. Organizational mechanisms seen as "market friendly" are strongly encouraged. This includes extensive use of contracting, which includes subcontracting of tasks to small, specialized enterprises, and competition for clearly specified goals. Another favored mechanism is the "open solicitation and announcement of leaders" (揭榜挂帅), which involves the publication of specific technological

challenges with an open invitation for firms, research institutes and even individuals to submit proposals for address the challenge.[5] In some cases, the open solicitation includes requests for identification of technologies that should be targeted.[6] "The introduction of competition mechanisms in collaborative innovation … clarifies the core objectives of S&T research, gathers various market entities to participate in research, and improves resource allocation and incentive mechanisms" (Huang 2023).

These five institutional features characterize the new-style whole-of-nation cases as well as local government-organized innovation consortia (Zhejiang S&T Office 2021). Indeed, there is no clear line between them: No authoritative or official list of central innovation consortia has ever been openly published, and there are certainly locally sponsored consortia that enjoy very high-priority and official support. Indeed, it is almost certainly the task of MOST to determine a "top-level design" to ensure an unimpeded flow of resources toward the highest priority consortia. This will not be a simple task. The press has many examples of local innovation consortia. A single province, Zhejiang, has announced its intention to organize fifty innovation consortia between 2023 and 2027 (Zhejiang S&T Office 2023). Clearly, there are already hundreds of innovation consortia being organized in China's provinces, along with as many as fifty national projects.

To add to the complexity, the new whole-of-nation consortia exhibit a variety of structures, as flexibility is considered a key feature of the new-style system by Chinese sources. Some consortia may feature state firms or research institutes serving as "general contractors" for specific import substitution tasks. Since organizational details of Chinese consortia are typically considered classified, Changhai Zhu (2022) refers to the U.S. Apollo moon landing project to exemplify the role of government as general contractor, after which the lead firm or agency structures the division of labor, dividing tasks among groups and soliciting bids from competing entities. This process is followed by signing subcontracts for batch production and long-term supply. In a slightly different model, coordinators play a crucial role in working with existing firms to share technology, encourage entry, and promote collaboration. Changhai Zhu illustrates this model with Japan's very large-scale integrated circuit plan, where the government helped companies overcome the collective action dilemma. For a description of a specific consortium with many representative features, see text box Case Study: GaN Millimeter Wave Devices.

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[5] The term 揭榜挂帅 is difficult to translate directly. It is a historical idiom referring to the posting of the top examination results in traditional China, reflecting the "winners" of what was seen as a relatively open process.

[6] In some cases, this can produce an almost comic effect. In this cases, local governments solicit their citizens for help in identifying technologies that should be designated as emergency bottleneck technologies.

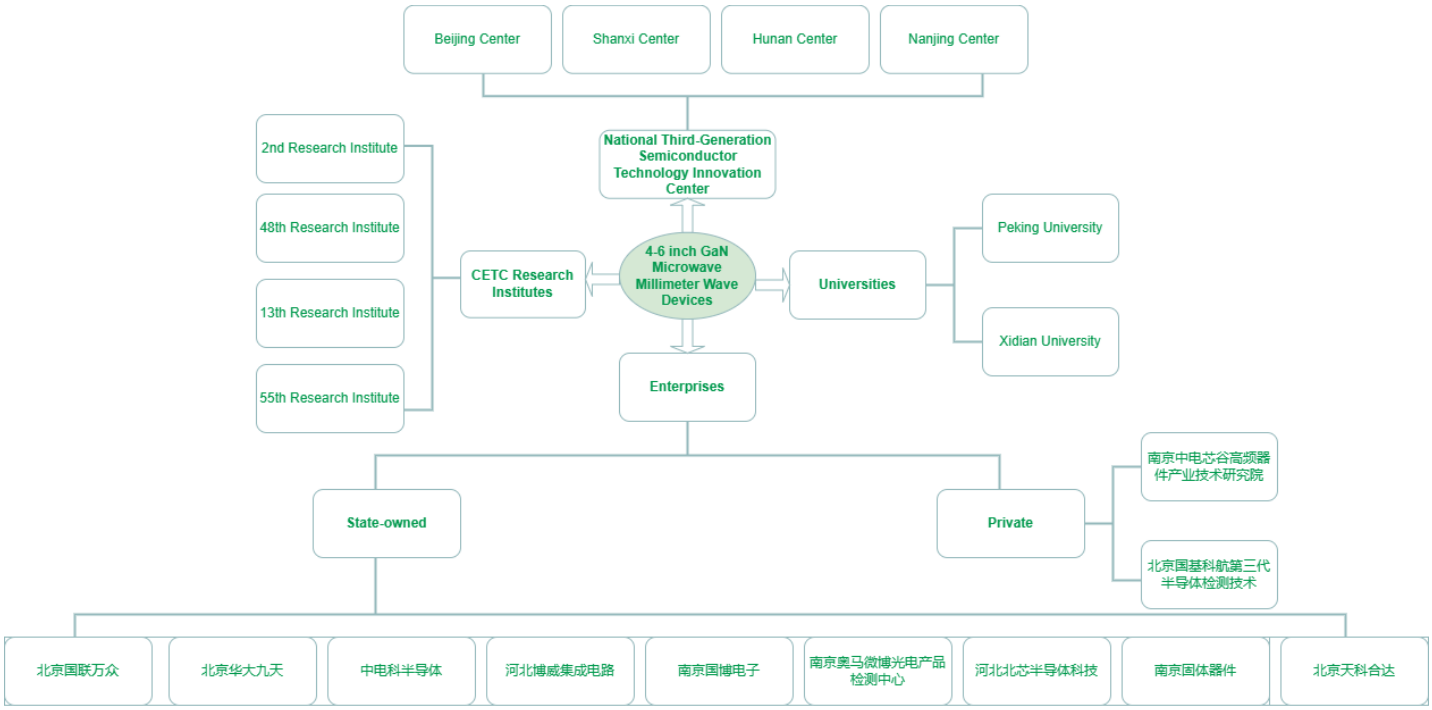
CASE STUDY: GAN MILLIMETER WAVE DEVICES

The case of 4–6 inch gallium nitride (GaN) microwave millimeter wave devices can demonstrate a new-style whole-of-nation consortium. The third-generation semiconductor is representative of a consistently high-priority sector. At a symposium in March 2023, Liu He emphasized that the government needs to help to overcome market failures, guide long-term investments, and assist in building skills, while market forces should be utilized to establish an "enterprise-based" mechanism that mainly relies on entrepreneurs to achieve the "healthy development of the IC [integrated circuits or semiconductors] industry" (Ma 2023A). Third-generation semiconductors, represented by GaN and silicon carbide, are expected to see a major expansion in use, particularly in applications such as power electronics, automotive components, renewable energy systems, and electric vehicle charging. Their properties make them well-suited for high-power, high-frequency, and high-temperature applications, as well as military applications, where efficiency and reliability are crucial. According to a report by Alibaba Damo Academy, third-generation semiconductors will experience rapid growth of demand for applications including 5G base stations, new energy vehicles, ultra-high voltage transmission, data centers, and other uses (Cheng 2020). These are designated as "cutting-edge technology fields" in the national 14th Five-Year Plan.

The 4–6 inch GaN microwave millimeter wave devices" are one of the 16 "demonstration directions of key products and end-to-end manufacturing process for the year 2022" jointly announced by the Ministry of Industry and Information Technology (MIIT) and Office of the State-Owned Assets Supervision and Administration Commission of the State Council (MIIT 2023). The selection process for entities is related to the entities' ability to independently develop and localize the products thus avoiding "foreign blockades" (Liu Yixuan 2023). According to MIIT (2019), the applicant organizations must "possess core independent intellectual property rights, have strong continuous innovation capabilities, produce high-quality products, and have related key performance indicators at the leading level among domestic similar products." The project is a state-initiated consortium where the China Electronics Technology Group (CETC) plays a dominant role. The leading institute is the National Third-Generation Semiconductor Technology Innovation Center (of CETC), with 21 participating entities shown in Figure 1. Among them are four national technology innovation centers, four research institutes (all belonging to CETC), 11 enterprises, and two universities.

As the figure shows, only two of the enterprises are private, and the remainder are state-owned. The establishment of the leading institute was approved by MOST, aiming to "target national strategic needs, coordinate national strengths, [and] focus on key core technologies." In September 2022, the first meeting of the advisory council of this institute was held in Beijing. It currently has six regional centers, among which the Beijing, Shanxi, Hunan, and Nanjing centers are active participants in this project (Wang 2022).

Figure 1. Twenty-One Participating Entities in 4–6 Inch GaN Microwave Millimeter Wave Devices Technology



In fact, while government approval is an essential part of every innovation consortium, in practice different lead agencies of different types may proactively organize consortia, acquiring government buy-in for their ideas. Notably, Huawei is the driver of several innovation efforts, related to its effort, with strong government support, to evade and replace U.S. technology sanctions. The Chinese Academy of Sciences has a Strategic Projects series that involves coordination with external companies and other actors. HTZs often have programs with resident Keypoint Labs, which contribute to the innovation process. Many local governments have “supply chain bosses” whose job is to understand local supply chains and identify gaps where producers are dependent on imports. Lastly, targeted incubators provide support to start-ups operating in specific bottleneck areas. Obviously, not all these initiatives should be considered part of the new-style whole-of-nation system, but they partake of the same spirit of accelerated, top-down, mission-driven research and they share the same institutional features.

3d. MOST's Core Mission: Conclusion

Now that China has established significant momentum in establishing these consortia at many levels, it will be the mission of MOST and CSTC to winnow, shape, and guide these initiatives on a national scale. In principle, that guidance will take the form of keeping the government out of many aspects of the innovation process, as well as raising the urgency—and increasing government involvement—of certain other aspects. The limitation of a "government takes responsibility for everything" approach has been recognized by S&T policymakers. Wang Zhigang, minister of science and technology said, "we should tailor our organizational approach to specific scientific, technological, and innovation problems" rather than following a one-size-fits-all mentality. He stressed that "government is the main entity *neither* for S&T innovations, nor for solving key core technological problems" (quoted in Liu Yin 2023). Academic policy experts have gone further: "the new whole-of-nation system differs significantly from the past because China's market economy has grown substantially, and not all issues need to be addressed through a national system. For example, in fields such as artificial intelligence applications, market players are very active and have already played an important role, and we need to protect this driving force." (Yang Hongshan of Renmin University, quoted in Hongru Wang 2023).

On the other side, there is no question that the degree of government resource mobilization for the highest priority projects is increasing. The application to the new-style whole-of-nation system in the 16 megaprojects—initially introduced in 2006—and in the second round of 16 megaprojects introduced in 2020 (see Appendix Table A1), has been repeatedly lauded by policymakers and held up as a model. This makes it clear that mission-driven government-directed research will continue and claim a greater share of national resources. It will be the job of MOST and CSTC to strategize this allocation and achieve greater efficiency in resource use without starving less-urgent projects of essential resources.

Section 4: Slimming Down MOST

MOST's new heightened focus on its core mission means that it will have to surrender direct oversight in three important areas.

4a: Transferring Sectoral Technology Strategy

Technology and innovation planning and oversight roles for specific sectors will be reallocated to other ministries that are closer to that production sector or function. For example, agricultural R&D will now be overseen by the Ministry of Agriculture, while pharmaceuticals and health will fall under the Health and Family Planning Commission. Furthermore, the Ministry of Human Resources will be responsible for overseeing human resource management and programs to attract foreign scientists (CCP Central Committee and State Council 2023). The "streamlining" of bureaucracy involves reshuffling disparate elements and then bringing them together under a single entity or department. That means bringing together specialized S&T-related activities under various line ministries and commissions, so that they can better "leverage their departmental advantages." (Wang Ningli cited in Meng 2023)

This reorganization is consistent with the renewed emphasis on the whole innovation chain and specifically the knowledge transfer, or commercialization link. Since line ministries like the Ministry of Agriculture, the MIIT, and even the Health and Family Planning Commission are closer to the firms and agencies realizing the end-products of innovation, they are seen as having a better grasp of the commercialization link. In line with this view, oversight of technology transfer intermediary organizations (科技中介组织) is being transferred from MOST to MIIT. Clearly, these beneficiary ministries are supposed to strengthen their attention to innovation and give more attention to knowledge transfer.

While the purpose of streamlining is to eliminate duplication and achieve better coordination and control, it is not immediately obvious that one approach or the other is superior. For example, Xie Xiaoliang argues that joint management of drug and vaccine research projects by MOST and the National Health Commission was inefficient and slowed the response to COVID-19 during the pandemic, so the restructuring should improve efficiency (quoted in Fan Wang 2023). However, these reorganizations will undoubtedly lead to new problems, as unclear divisions of responsibility persist or even get worse. Many experts warn of the continuing need to clearly delineate responsibilities between the MOST and various other ministries, especially in terms of the management and operation of existing projects (Fan Wang 2023).

4b. Management of High-Technology Zones and Technology Intermediaries

Probably the most consequential of the losses to MOST is the transfer of oversight of HTZs to MIIT. This is part of a bundle of functions, including the HTZs themselves, high-technology demonstration projects, technology services, and technology marketplaces and intermediaries that will now be managed by MIIT. This reorganization is intended to bring to an end more than two decades in which two separate but related types of zones were overseen by MOST and MIIT respectively. MOST has run national hi-tech industrial development zones, while MIIT has overseen national economic and technological development zones. There are differences in emphasis and operating procedures between the two, but also many areas of overlap.

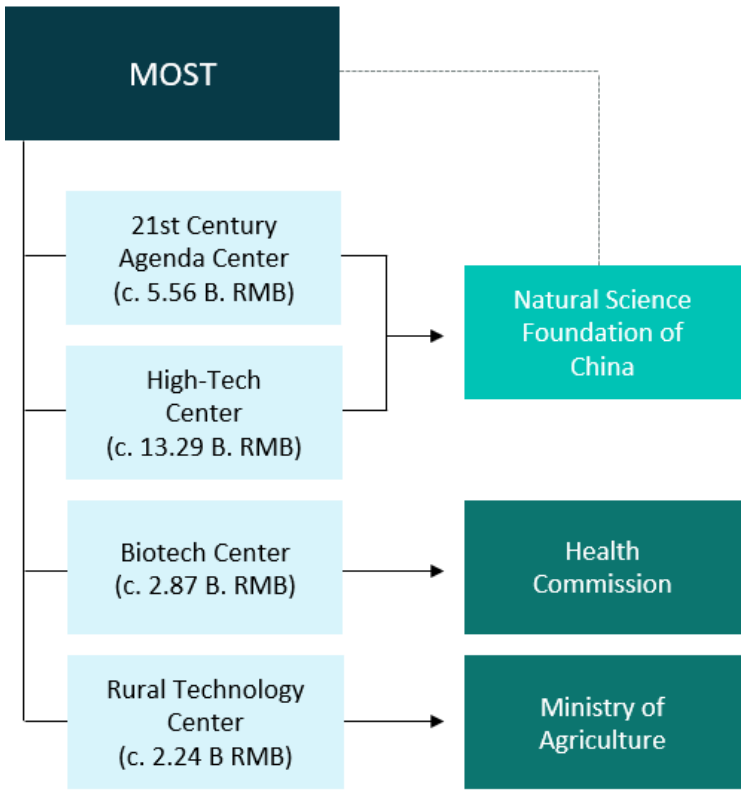
Control over HTZs is undoubtedly prized by MOST. The HTZs are large and important. According to MOST's data, in 2020 the 169 HTZs accounted for 13.3 percent of China's total GDP, and firms in those zones accounted for 49 percent of enterprise R&D outlays as well as 49 percent of China's international patent applications (MOST 2022). While MOST does not "own" the zones, they have been managed and directed by the Torch High Technology Industry Development Center under MOST. Loss of the zones means a substantial loss of resources for MOST, but also the bureaucratic discretion and flexibility that comes from having a set of subordinates that are eager to please their superiors. Visiting HTZs gives MOST officials photo opportunities and on-the-ground inspection and feedback.

The transfer of the HTZs also raises some obvious questions about regulatory authority over key links in the innovation chain. After all, overall management of the innovation chain is supposed to remain with MOST, but MIIT will now oversee zones, as well as technology intermediaries and marketplaces (Xu Weilin cited in Fan Wang 2023). Besides being painful for MOST, this reallocation presents risks of new bureaucratic conflicts and misaligned incentives. Indeed, by some accounts, the transfer is still contested, and there are significant unresolved issues relating to ultimate control (China Manufacturing Think Tank 2023).

4c. Professional Research Agencies

An important reorganization that sheds considerable light on China's technology strategy is the transfer of professional research agencies out of MOST's direct authority. Professional research agencies were established in China beginning in the 1980s to manage the scientific research process, establishing guidelines for research proposals, evaluating proposals, and monitoring and evaluating research. During the 2018 reorganization, the professional research agencies were supposedly carved out of MOST as part of the effort to "remove government from the direct management of scientific research projects and delegate tasks to professional project management agencies" (CCP Central Committee and State Council 2018). Ultimately, eight professional management agencies were given new, expanded authority, and four of those remained under MOST's direct control. Now all of these four are being transferred to other supervisory agencies, effectively removing MOST's control over them. Two are going to the Natural Science Foundation of China (NSFC), one to the Health and Family Planning Commission, and one to the Ministry of Agriculture (see Figure 2).

Figure 2. MOST Reorganization and 2022 Budgets



The transfer is a tacit admission that the objectives of the 2018 reorganization were not adequately achieved. Apparently, the temptation for MOST bureaucrats to continue to interfere with research funding and support their own pet projects and preferred researchers, was too great to resist. One relatively pungent public comment said some researchers "used the same project but changed the name and emphasis, and applied for project support from different ministries, leading to poor results in S&T research and even waste of research funds." (China Manufacturing Think Tank 2023). Indeed, Rao Yi, a biologist at Peking University who has been an outspoken advocate for the independence of the scientific research mission, has taken the occasion of this reorganization to re-emphasize his views and, in essence, take a victory lap (Rao 2023). Back in 2004, Rao and co-authors Lu Bai and Zou Chenglu had argued in an article in *Nature* that MOST should undergo systemic reforms with proposals strikingly similar to the current restructuring (Rao, Lu, and Zou 2004). At that time, projects in the same S&T domain were overseen by both the MOST and other corresponding ministries, inevitably converting professional S&T matters into administrative matters. MOST managed vast amounts of funding, with each subordinate division overseeing an overly broad range of projects, and empowering lower-level administrators over scientific experts, even though MOST staff lacked "the necessary expertise and professionalism to effectively address practical technology issues." They had proposed reducing the MOST's financial management authority over specific projects and allowing professional research agencies to more directly establish funding guidelines and manage projects. Rao (2023) now argues that the current reorganization has correctly, if belatedly, taken up his proposals.

Of these research agencies, by far the most significant is the High-tech R&D Center, which had a 13.2 billion RMB budget for S&T spending in 2022 (see Table 1). The High-tech R&D Center is responsible for managing basic research and high-tech projects, including most of the key projects in the National Key R&D Program, as well as the management of national key laboratories (High-tech R&D Center n.d.). Second in importance, with less than half the budget—even after a major bump upward in 2022—was the 21st Century Agenda Center, with 5.5 billion RMB. The 21st Century Agenda Center is responsible for managing projects related to sustainable development, such as resources, environment, ecology, oceans, climate change, and disaster prevention (21st Century Agenda Center n.d.). Both agencies were transferred to the national NSFC, which remains indirectly overseen by the MOST. The Biotech Center and Rural Technology Center are substantially smaller, but both are significant and achieved big budget increases in 2022. The completion of the transfer of professional research agencies will substantially reduce MOST's budgetary oversight while simultaneously increasing the NSFC's oversight by about 40 percent (See Appendix for NSFC's annual budget breakdown).

Table 1. Research Agencies S&T Budgets, 2021 and 2022

Institution Name	2021 S&T Budget	2022 S&T Budget
21st Century Agenda Center	2.81	5.56
High-Tech R&D Center	NA	13.29
Biotech Center	1.71	2.87
Rural Technology Center	0.74	2.24

This proposal aligns with the recent decentralization of power from the ministry to other agencies. The Ministry of Agriculture and the Health and Family Planning Commission are big beneficiaries and now have more instruments for managing the innovation chain in their respective areas. To be sure, this is not necessarily consistent with the desire to give the professional research agencies more independence and professionalism. While agriculture and health bureaucrats may indeed be better informed about their respective fields than MOST bureaucrats, they will have even stronger incentives and opportunity to intervene in the research process. According to Li Zhimin (vice president of the China Association for S&T Evaluation), the restructured MOST will retain some evaluation and supervision activities, which could help reduce fraud and waste. Moreover, project evaluation and approval would be divided among agencies, rather than being handled by a single ministry, which should provide some external checks on individuals (Wang and Zhou 2023).

4d. Slimming Down MOST: Conclusion

MOST is being freed to concentrate on its core mission unencumbered, and that core mission has been expanded and raised in priority. However, MOST is also being stripped of a set of important administrative functions that will result in its budget and span of control being reduced, all else held constant. In significant ways, this restructuring represents a tacit admission that the previous round of restructuring, in 2018, was unsuccessful, and that MOST did not fully live up to the very high hopes and expectations that were placed on it at that time. Like any bureaucratic reorganization, this one will bring a new set of conflicts and the discovery that the new arrangements are not any better than the old ones. After all, “streamlining” depends on how one defines the tasks and functions that are being brought together. To examine these changes in greater depth, it is essential to analyze the way that Chinese policymakers are thinking about the innovation process, and in particular the relationship between basic research and applied technologies.

Section 5: Basic Research: Protecting and Redefining

The new-style whole-of-nation system emphasizes results-oriented projects, but Chinese policymakers are also striving to promote basic, cutting-edge research. In a May 2021 speech to academicians, President Xi identified the top priority as "strengthening original and leading S&T research and resolutely winning the battle of key core technologies" (Xi 2022). In this year's third Politburo study session, Xi devoted a large part of his speech to basic research. From his perspective, basic science often has long research cycles—where the new-style whole-of-nation system can come into play—and that to promote basic research, national strategic S&T forces need to be enhanced. National laboratories should play "the leading role," research institutes should play "the organizational role," top-tier research universities should play "the key player role," and leading S&T enterprises should play "the roles of problem setters, solvers, and assessors" (Ma 2023B). Clearly, in Xi's conception, all of China's S&T assets will work smoothly together to make China an innovation superpower.

However, there are inherent trade-offs among these ambitious goals. In particular, basic research, which seeks to generate new knowledge on a global scale, is inherently unpredictable and difficult to plan or guide, as it explores the *ex ante* unknown. When successful, basic research often yields a public good, as the principles behind new discoveries are generally accessible to scholars worldwide. Conversely, "winning a battle for core technologies" entails replicating knowledge that already exists but is dominated by a competing power. This involves breaking down the monopoly power of a rival by mastering their existing technologies. In this context, there is little or no uncertainty regarding the fundamental principles at play, and success contributes minimally to the creation of new knowledge or global public goods. Understood in this way, it is clear that the increased priority to the new-style whole-of-nation system tends to draw resources from basic research and that one of the implicit goals of the reorganization of the S&T system is to protect basic research and mitigate the impact of this shift. At the same time, basic research itself is being redefined and reshaped in ways that make it closer to applied research.

5a. An Implicit Goal of Science, Technology, and Innovation Reorganization: Protect and Promote Basic Science

Protecting and promoting basic science is an implicit goal of China's science, technology, and innovation reorganization. In the pursuit of transforming China into an innovation superpower, sustained support for basic science is indispensable. This long-term goal aligns with a plausible economic strategy endorsed by President Xi, which emphasizes focusing on "key technologies with first-mover advantage and cutting-edge basic technologies that will be the drivers of future development" (Guo 2022). This approach

serves not only as a response to the current situation but also as a political motivator, rallying the population for a new technological leap forward instead of admitting to the adverse impact of sanctions. Evidently, for Xi, fostering both basic and cutting-edge research and winning the battle of key core technologies are integral to building a technology superpower, establishing S&T self-reliance, and "winning" the technology competition with the United States. Furthermore, policymakers demonstrate their awareness of the trade-offs between these objectives by implementing measures to protect basic science from the competition induced by a higher priority given to technology applications. Consequently, this delicate balancing act is essential for China's long-term success in the global technology arena.

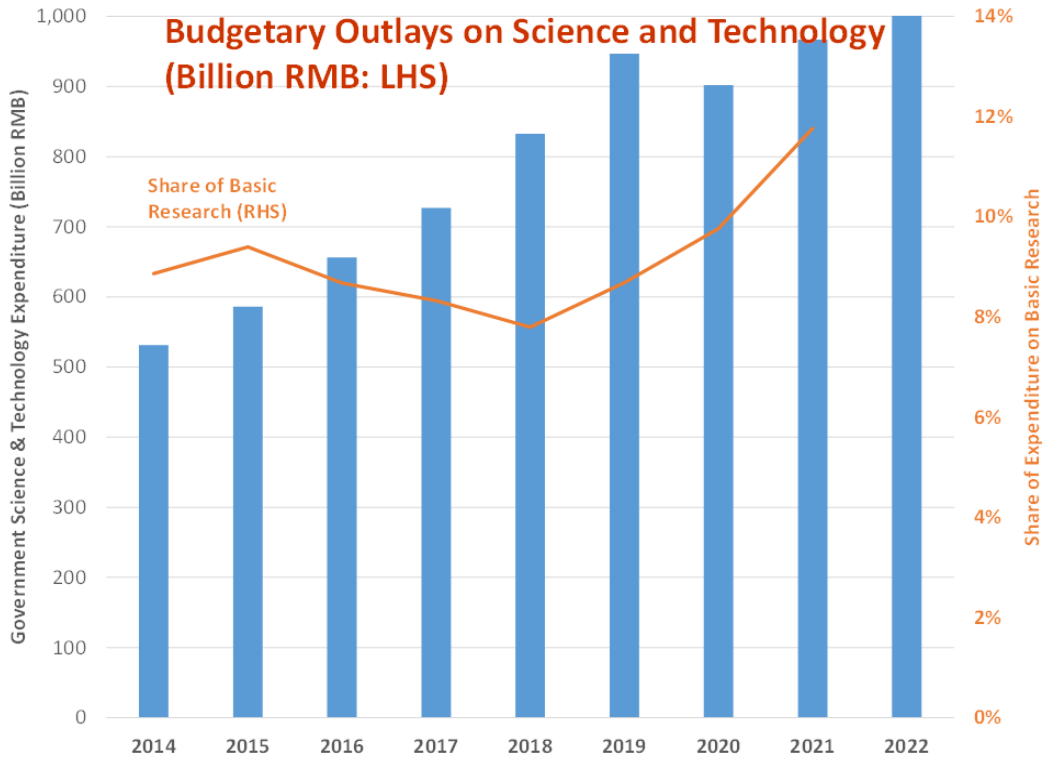
The current restructuring exemplifies the efforts to strike a balance between fostering basic research and advancing specific technology applications. A number of experts (cited in Fan Wang 2023), interpret the consolidation of S&T functions into the NSFC as a strong signal of enhancing basic research. This is consistent with official recognition since at least 2020 that disruptive innovation requires some support for "free (scientific) exploration (自由探索)"and that such support requires "no fault" support of some research and a higher tolerance for failure (MOST and other Ministries 2020). These measures, along with continuing policy rhetoric in support of basic research, may suggest a simple posture of support for basic research. In fact, however, direct financial support for "free exploration" is a very small part of so-called "basic research," and the overall picture is far more complex and warrants further analysis.

5b. Basic Research and the Budget

Unlike the case in the United States, basic research in China is primarily funded by the government. According to the National Development and Reform Commission (NDRC), in 2020, Chinese government investment accounted for approximately 92 percent and enterprise investment accounted for about 4 percent of the total 150.4 billion RMB invested in basic research funds (NDRC 2021). Government plans during the 14th Five-Year Plan period (2021–2025) are to continuously enhance central government funding, while simultaneously guiding enterprises and other entities to increase their investment in basic research (Dong 2021). However, actual fiscal trends are far more mixed. As Figure 3 shows, Chinese fiscal expenditures on S&T grew very rapidly up until 2019, but between 2019 and 2022, S&T spending grew at a notably slower pace, less than 2 percent per year. Despite this deceleration, the share of S&T fiscal expenditure allocated to basic research increased from 8 percent in 2018 to 11.8 percent in 2022, resulting in an annual growth rate of approximately 13 percent for basic research. This shift in budgetary focus toward basic research has coincided with the increased emphasis, through whole-of-nation consortia, on applied research.

A significant fiscal reform is envisaged as part of the S&T system reorganization, but details of that reform are not yet available. Budgetary pressures have thus clearly constrained the growth of basic research funding. Consequently, the basic research share of R&D decreased in 2022, falling to 6.3 percent from 6.5 percent, despite the Five-Year-Plan pledge to raise this share to 8 percent by 2025.

Figure 3. Annual Government S&T Expenditure and Share of Basic Research[7]



Also, as Table 2 shows, the total fiscal support to NSFC has generally kept growing since 2018, except for the year of 2020. Though the funding growth dipped in 2020 and 2023, the foundation's major basic research arm, the Natural Science Fund, has been growing robustly in the past three years, even amid the so-called fiscal hardship times. This trend suggested the central government's commitment to basic research is not empty.[8]

[7] Data are from the National Science and Technology Funding Statistics Report (全国科技经费投入统计公报) and the National General Public Budget Expenditure (全国一般公共预算支出决算表) by the Ministry of Finance.

[8] All the NSFC budget information is collected from the official website of NSFC.

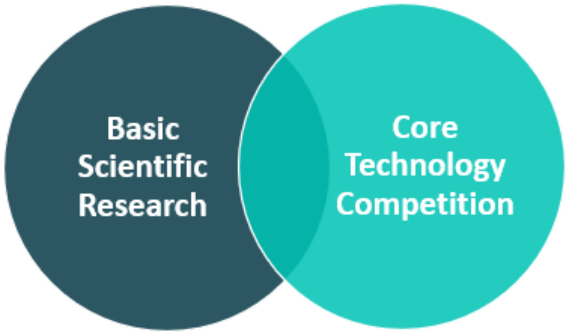
Table 2. NSFC Total Annual S&T Budgets and the Natural Science Fund Budgets

	NSFC Budget	Annual Growth Rate of NSFC Budget	Natural Science Fund Budget	Annual Growth Rate of Natural Science Fund Budget
2018	30.19	2.80%	28.77	4.82%
2019	33.85	12.12%	32.06	11.40%
2020	33.18	-2.00%	30.91	-3.58%
2021	37.31	12.47%	33.56	8.59%
2022	42.68	14.38%	36.80	9.63%
2023	42.79	0.25%	37.70	2.45%

5c. The Relationship Between Basic Research and Technology Competition

In the realm of scientific research and technology development, there are significant trade-offs involved in managing the relationship between basic research and competition over core technologies; however, there are also essential areas of overlap, as Figure 4 shows, which can sometimes lead to serendipitous breakthroughs when a revolutionary discovery disrupts a technological monopoly. In certain domains, basic research can swiftly translate into practical outcomes. Examples of such areas include the development of third-generation semiconductors based on GaN or silicon carbide, as opposed to traditional silicon, the core of one of the new-style whole-of-nation system consortia described earlier. Given that these materials are already being considered for specific applications, such as high-voltage environments, adverse conditions, electric vehicles, and power storage, investigating their fundamental material properties could lead to immediate practical applications. Another notable area is the interplay between quantum computing and artificial intelligence, where basic research may have unforeseeable but likely rapid implications. Chinese policymakers and the public have shown considerable interest in these overlapping areas between basic research and technology competition. Many of the second-wave megaprojects encompass areas where basic research and technology competition overlap. In other words, the existence of these megaprojects demonstrates that Chinese S&T policymakers place significant emphasis on the translation of basic research into tangible outcomes.

Figure 4. The Relationship Between Basic Research and Technology Competition

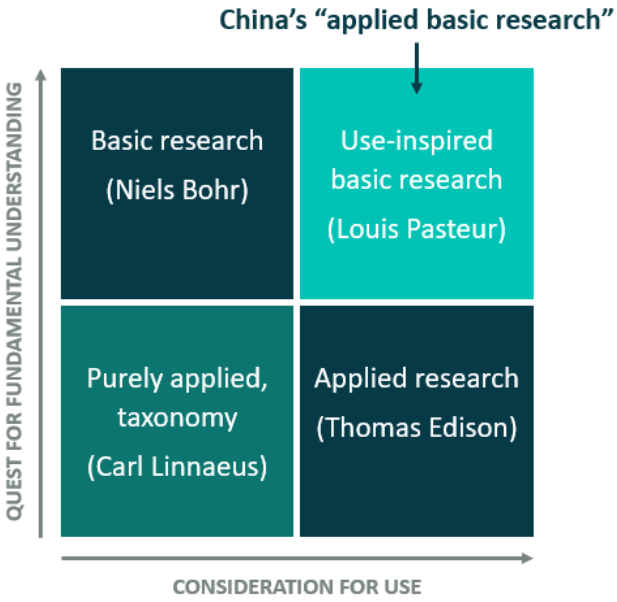


5d. Redefining Basic Research

A subcategory of basic research, namely applied basic research (应用基础研究), is being given increased legitimacy and visibility, leading to a shift in the scientific landscape and an effective redefinition of the concept of basic research. In October 2020, during a press conference, MOST minister Wang Zhigang expressed that "in the next step, China will place basic research and applied basic research in an even more important position within the overall national S&T work" (quoted in Zhao and Lv 2020). The concept of applied basic research can also be understood as use-inspired basic research. This term was introduced by Donald Stokes in his influential book, *Pasteur's Quadrant* (1997). Through this notion, Stokes emphasizes the importance of conducting fundamental research that is both inspired by and applicable to real-world challenges and societal needs, ultimately bridging the gap between pure scientific exploration and practical application. Increasingly, China advocates for the adoption of the *Pasteur's Quadrant* approach, which emphasizes the pursuit of scientific knowledge driven by societal needs. This mission-oriented research, inspired by societal demands, seeks to protect fundamental science while simultaneously advancing essential economic and social interests.

The definition of basic research has been broadened to include many gray area mission-oriented projects, which means that pure basic research has not increased as significantly as the numbers might suggest. Additionally, while oversight of basic research has been transferred to professional research agencies, their evaluation criteria have become more mission-oriented and potentially more subjective. They are rated on factors such as compliance with national needs, the solution of specified technical challenges in key and core technologies, and the attainment of high international standing. Inevitably, this leads to a shift in the center of gravity of basic research.

Figure 5. Four Classes of Research



China strongly publicizes cases highlighting the breakthrough importance of applied basic research in China, but the Chinese official emphasis on these cases can be misleading, for several reasons. These include wishful thinking, effective propaganda that promotes the potential for leapfrogging to, and even surpassing, the global frontier, and strategic focus on areas where mission-oriented, directed research is most likely to yield productive outcomes, making it an efficient gamble. In any case, it is crucial not to overlook the broader shift toward prioritizing applied research and knowledge transfer. Although the emphasis on basic science is evident, it may not be sufficient to counterbalance the prioritization of these other goals. The underlying challenge lies in striking a balance between advancing fundamental research and addressing the needs for practical applications and knowledge transfer, ultimately fostering sustainable scientific and technological progress.

"Mission-oriented basic research inspired by societal need" is indeed a genuine phenomenon, but the interpretation of societal needs varies between countries. In most nations, societal needs encompass altruism, profit, and individual obsession, alongside government mandates. In China, however, societal needs are being interpreted almost exclusively through the lens of Xi's preoccupation with security. This divergence highlights the complex landscape of research priorities and the challenges that policymakers face in striking a balance between basic research and technology applications.

Section 6: Preliminary Evaluations and Conclusion

China's new innovation system is characterized by a massive mobilization of resources in the service of national security, harkening back to the Maoist era in terms of purpose and apex organization design. However, this mobilization is taking place within the context of a broad and often thoughtful systemic restructuring. Chinese policymakers are making critical choices to limit costs by employing market-compatible instruments and organizations and protecting basic research while prioritizing a targeted approach to ensure the practical applicability of emerging technologies.

Despite these efforts, we observe potential inefficiencies in China's new innovation system. In the first place, there will be substantial waste inherent in large-scale endeavors that are overly techno-nationalist in focus and redundant from a global perspective. A voluntary and involuntary retreat from globalized science, occurring just as the world is in the midst of a technological revolution, will likely have significant costs. Although Chinese authorities aim to retain and manage global links, their success in doing so will likely be limited at best. More broadly, inefficiency will be caused by specific features of the current Chinese restructuring, including those that are directly influenced by Xi's central role and personal preferences. These include the fact that Xi's vision of China as an innovation superpower essentially demands that scientists and bureaucrats do everything at once, creating disruptive innovations and incremental market-responding improvements at the same time, without seriously facing inevitable trade-offs. This means that ongoing debates about resource allocation between basic and applied research are unlikely to be resolved in a constructive fashion. For all the talk of "strategic guidance" of the innovation process, it is unlikely that there is actually a strategic vision that can coherently add value to the activities of China's scientists, engineers, and entrepreneurs.

At a more practical level, there are numerous potential administrative hitches due to the restructuring of the MOST. Bureaucratic streamlining programs come and go, and it is not immediately clear that the most recent division of responsibilities among MOST and MIIT—for example with respect to HTZs—is superior to what preceded it. The wave of centralization and harmonization of incentives may also fall short of what policymakers expect. Where policymakers see duplication and excess competition, others may perceive a fertile entrepreneurial milieu that can only be weakened by further government intervention. To a significant extent, policymakers are gambling that by spending more money and mobilizing more human and organizational resources, they can get more of everything, and achieve their policy priorities without undermining other parts of the innovation ecosystem. Whether or not this turns out to be true will not be apparent for several years.

With such an extensive program, a wide range of outcomes is inevitable, encompassing both notable successes and abject failures. Given these potential pitfalls, there is a higher probability of success in areas that can sustain continuous resource inputs, such as quantum computing and space programs. In contrast, areas that depend heavily on global cooperation and market integration, like high-end chip production, will face more challenges. It is crucial to take this program seriously, as while efficiency may decline, the effectiveness in achieving strategic goals might still be sufficient to satisfy Chinese policymakers. After all, China's reshaping of its innovation system is largely a response to perceived external threats, and the program's impact on China's perceived security is likely to count for more than its impact on economic efficiency in the eyes of China's policymakers.

The program will, in turn, have major implications for other countries with which China maintains strong S&T ties. The current reorganization will clearly exacerbate strains on the globalization process and prompt reactions from other countries, including the United States. At the same time, there are many elements of China's new innovation system that remain ambiguous and require further study. For example, the precise operations of innovation consortia, the government's specific role within these consortia, the total scope of the new-style whole-of-nation system, and the precise role of the CSTC are all areas where our understanding is still partial and needs to be expanded. The fact that an increasing proportion of the Chinese innovation system is being treated as classified, and information availability is being systematically reduced, makes this understanding increasingly challenging. For all these reasons, China's new innovation system highlights the complex interplay of research priorities, global collaboration, and strategic interests in shaping the future not only of China's technological landscape but of global conflict and cooperation.

Appendix

Table A1. List of Second-Round Megaprojects (2021–2030)

S&T Innovations 2030 Major Projects	Fields
Aero Engines and Gas Turbines	Advanced Manufacturing
Deep Sea Space Station	Space and Ocean Exploration
Quantum Communication and Quantum Computer	Electronic Information
Brain Science and Brain-like Research	Biological Health
National Cyberspace Security	Electronic Information
Deep Space Exploration and Space Vehicle In-Orbit Service and Maintenance System	Space and Ocean Exploration
Independent Innovation in Seed Industry	Agriculture
Clean and Efficient Utilization of Coal	Energy Environment
Smart Grid	Energy Environment
Integrated Information Network of Space and Earth	Electronic Information
Big Data	Electronic Information
Intelligent Manufacturing and Robotics	Advanced Manufacturing
Key New Materials R&D and Application	Advanced Manufacturing
Beijing-Tianjin-Hebei Comprehensive Environment Management	Energy Environment
Health Protection	Bio-Health
New Generation Artificial Intelligence	Electronic Information

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