Inputs into China's Space Programs: Vision, Policy, and Organization[1]

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Introduction

I thank the Commission for the opportunity to testify before it on the topic of China's space activities.

The first part of this statement surveys the state of policymaking and related processes in China's space sector. The second part considers the space establishment's record of innovation. The third part examines the pursuit of civil-military integration within the space industry. The fourth part discusses foreign sources of space technology. The final substantive section discusses the impacts of U.S. export controls on China's space sector.

Policies and processes in China's space establishment

The setting of policies and processes within which Chinese space activities occur has continued to evolve in recent years. This section examines continuities, changes, and other major features of the environment in which space programs are designed, adopted, and implemented. The major entities forming China's space establishment and their roles are described in the Appendix.

Space policy is still set within broader strategies to develop science and technology.

China's top leaders continue to emphasize that advances in science and technology are necessary to achieve the twin objectives of developing the economy and strengthening the military. This overarching agenda guides space policies and programs.

Space policies and programs figure in central-government plans for building an innovative, technology-intensive economy and increasing domestic consumption of high-technology goods. Developing space-related products and services serves the center's goal of transforming the economy and promoting exports with higher added value.

Space activities also feature in plans to transform the military into a modern, battle-ready force. As Chinese experts explain, space systems will enable the People's Liberation Army (PLA) to

[1] This statement is based on sources including: in-person interviews and consultations with current and former participants in the Chinese and U.S. space sectors; primary- and secondary-source documents in Chinese and English, including policy statements, media reports, trade and technical journal articles, and think-tank reports; and remarks made by authoritative Chinese and U.S. space-sector participants at public conferences in China and the United States.

harness the potential of the information revolution for military operations and fight technologically sophisticated adversaries.

Top leaders still pay close attention to space activities.

China's top leaders have taken a personal interest in their country's space activities since their beginnings in the 1950s. Chinese experts have long stressed that success in space starts with political leadership, sometimes identifying personal attention by senior officials as conducive to the advance of particular programs. This situation persists under the administration of Xi Jinping today. Leaders continue to frequently visit facilities and receive briefings on the progress of projects. Through his tripartite role as head of the party, state, and military, Xi himself oversees and dotes on civil, commercial, and defense space programs and related activities.

Leading small groups still facilitate inter-agency coordination.

Space programs require the participation of numerous and diverse entities, including civil and military units. A mechanism for achieving high-level coordination between these entities is the leading small group. These groups are designed to overcome the fragmentation of authority and barriers to communication across organizations involved in space activities. Often without a dedicated institutional home, the groups comprise representatives from existing offices in participating organizations on a project-specific basis. Leading small groups reportedly exst to oversee the programs for lunar exploration, human spaceflight, Earth observation satellites, and heavy-lift launch vehicle development. Officials at the highest levels lead or belong to several of these groups.

Expert input into policy decisions has grown more systematic.

The space sector is a highly specialized and technical domain of activity. High-level leaders making policy and programmatic decisions rely on expert input, which they receive through several channels. These channels appear to remain both formal and informal, but the transmission of expert advice to decision makers has grown more institutionalized and systematic. For example, space experts in the large industrial groups contribute policy advice through recently formalized advisory channels.

Policymaking and programmatic processes are increasingly developed and sophisticated.

Since 2006, space organizations have published a range of policy and programmatic documents, which, considered together, suggest that processes for designing and implementing space activities are growing more institutionalized, developed, and sophisticated. Space policy white papers, plans and strategies for space science and technology development, and other documents now identify priorities, set goals and schedules, and convey structured long-term visions for space activities in far greater detail, with greater transparency, and in language more accessible to international readers than in the past.

The implementation of on-going programs is the main current task.

Xi Jinping's administration is likely to preside over the maturation of major programs and their culmination in important technical achievements. The forthcoming milestones are several. By or around 2022, the lunar program expects to complete a sample-return mission, the human spaceflight program expects to complete the on-orbit assembly of a space station, and the Beidou satellite navigation system expects to begin providing global signal coverage. Today, major space organs are preoccupied with the implementation of these on-going programs. Their focus is effective program management, maintaining the pace and function of already established units, and carrying programs that have a record of success to fruition. Many of these activities are, within the Chinese context, still experimental and new, so particular units continue to face major technology development challenges. However, scientists and engineers now pursue their goals within more stable and institutionalized organizations and programs than previously.

Another important task is designing new programs.

While carrying out these activities, the space establishment as a whole also faces major decisions about the next set of long-term goals to adopt. Units within the system are now envisioning and designing the programs that will shape the course of China's space development beyond 2020. The highest levels of government will decide which of these proposals to adopt. If successful, these new programs will become the signature achievements of the Xi administration in the space arena.

Innovation in China's space sector

The Chinese space establishment's record of achievement includes remarkable feats of technology development, adaptation, and refinement, but it has yet to blaze trails toward original objectives and historical firsts in space.

Innovation to date

Since the late 1990s, China's space programs have made steady progress and achieved major technology milestones. In a general sense, China's space programs already match or approach U.S. and Russian programs in core areas of space engineering. China's space establishment assures independent access to space for cargo and humans aboard nationally built and operated vehicles. China is only the third country in history to independently place humans in orbital habitats. China is now the only country possessing and operating a stand-alone facility capable of supporting humans on short-term stays on orbit. If the program proceeds on schedule, by or around 2022 China may be the only country to operate an independent national space station capable of supporting humans on medium- to long-term stays in space.

At the same time, China's space agencies and firms are building large, complex space-based systems expected to function as infrastructures supporting a modernized national economy and military back on Earth. The Beidou satellite navigation constellation, high-resolution Earth-observation satellites, and a growing fleet of communications satellites are the backbones expected to support emerging and strategic technology-intensive industries. In this role, space systems are to enable and foster innovation in a range of adjacent and downstream sectors serving commercial, civil, and defense users. These sectors encompass activities as diverse as commercial data processing, fisheries management, and public security.

Factors conducive to success

The success of China's space establishment in these respects owes to several factors. Three in particular stand out.

> **Resources and commitment**. For at least the past 15 years, the Chinese state has been in a unique position to invest in science and technology programs. While estimates of state spending on space activities are contentious and data on this subject scarce, it is clear to outside observers that Chinese space organizations are steadily and reliably funded at levels suited to their programmatic objectives. The enormous size of China's internal market for space-based products and services also creates opportunities for sectoral growth and development virtually unparalleled elsewhere.
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> **Strategic vision**. Chinese space organizations owe their success to what has over the years coalesced into a coherent overarching vision for space development. This vision is at once ambitious and realistic. It encompasses bold, technologically demanding, and large-scale programs. Yet the intrinsic technical feasibility of China's goals in space is not in doubt, since for now these consist largely in reproducing earlier achievements of the Soviet Union/Russia and the United States. The aspirations are lofty, but known to be within reach. As a result, space organizations enjoy a stable and predictable policy and programmatic environment, within which they can reliably forecast and organize their activities with a view to optimal long-term results.
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> **Volume and scale**. The sheer volume of China's total space activities – whether measured by total number of launches, satellite platforms built, programs executed, or other indicators – in and of itself creates circumstances that foster continued success. Particular examples of these volume effects, including practice and learning-by-doing effects, are discussed below in the section on civil-military integration. The volume of activities also creates opportunities for rapid workforce development, yielding long-term benefits likely to become apparent only in the coming decades.

Challenges ahead

Like actors pursuing other demanding, technology-intensive endeavors, China's space organizations face technical, commercial, and economic risks. These imperil their efforts at innovation in distinct ways.

> **Technical risks**. Technical risks facing China's space establishment include the self-evident likelihood of major failures, delays, and ballooning costs within space programs. Such problems are typical of the space programs of even the most established spacefaring states. Technical challenges are not necessarily indicative of fundamental problems; many are transient obstacles that can be overcome with time, labor, and money.
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> **Commercial risks**. Commercial risks imperil those actors within China's space industry that are oriented toward domestic and international markets, rather than government customers. For example, China's satellite operators serving consumer markets may face competition from terrestrial alternatives to space-based telecommunications. Prospective exporters of Long March launches may face a new glut of supply depreciating global launch prices.
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> **Economic risks**. Economic risks exist for the space establishment as a whole. To an extent, the funding of and, by implication, the progress of space activities is likely to track

the rest of the economy. If major disturbances (such as an unmanaged mass of defaults on obligations by local governments) upset the fiscal landscape, then space activities may be affected, but perhaps only episodically. In the unlikely event that China faces a larger economic downturn, space budgets are likely to contract indefinitely, slowing the pace of technical progress.

In addition to these general and ever-present risks, China's space establishment now enters a stage in which new challenges to innovation arise.

World "firsts." Having nearly completed building a suite of core space capabilities, China's space establishment now aspires to produce historical firsts and make unique advances. For example, China's scientific community aspires to make distinct contributions to global space science and exploration. Identifying such niches and filling them is difficult, even for longer-established spacefaring states.

Staying the course while setting new goals. Leading figures in the space sector must now sustain a sprawling complex of institutions and facilities implementing demanding programs, while also steering this establishment toward the next set of objectives. The complexity and magnitude of this task are unprecedented for China's space community.

Cross-sectoral policy coordination. To realize the innovation potential and other social returns on public investment in space activities that they envision, policymakers must coordinate space activities with a range of other policies, including an array of cross-sectoral and industrial reforms and regulatory measures in other parts of the economy. As the technological sophistication and complexity of China's hybrid socialist-market economy grows, so do the challenges presented by this monumental task.

The promise of civil-military integration in the space sector

Several experts appearing before the Commission have discussed Chinese policymakers' pursuit of civil-military integration and related goals, including through reforms of the defense industries. The guiding principle of civil-military integration was adopted formally in its current version by the administration of Jiang Zemin in 1997.

Within the space sector, it is helpful to think of civil-military integration as the principle that civil-commercial and defense high-technology programs should be mutually supportive. Industrial reforms and development in the space sector should maximize the synergies and complementarities between the civil-commercial and defense segments of the sector. For example, in a narrow sense, technical space professionals should make the most of commercial off-the-shelf solutions to meet defense needs. Similarly, they should explore the commercial potential of defense systems.

Advantages and potential of civil-military integration

Both Chinese and international analysts agree on the substantial benefits of pursuing civil-commercial and defense space activities in a simultaneous and coordinated fashion. These benefits reflect the interchangeability of facilities, personnel, equipment, and certain products between civil-commercial and defense programs. At minimum, utilizing these resources toward both civil-commercial and defense ends reduces the long-run fixed costs of programs. Moreover, space technologies originally developed for military applications are now embedded into national and global infrastructures. These systems support a vast range of economic activity and generating benefits beyond the context of their initially intended military use.

Analysts often characterize space technology items as “99%” dual-use or otherwise represent nearly all space items as indistinguishably civil-commercial *and* defense-applicable in nature. While experts agree that many space items are indeed dual-use, it is most helpful to think of the *capacities* required to conducts civil and commercial programs as often applicable to defense objectives and vice-versa. It is often in this systemic and diffuse sense that Chinese policymakers and decision makers reason about the viability of civil-military integration in the space sector.

The potential and benefits of civil-military integration are apparent in at least three dimensions of space programs and activities: organizational efficiencies to result from pursuing the parallel development of civil-commercial and defense space activities; manufacturing and operational processes applicable to both types of activities, and dual-use articles of hardware.

Organizational efficiencies in dual development

Simultaneously pursuing commercial and defense space activities brings synergies, complementarities, and economies at the levels of individual facilities and of the space industry as a whole. Units within China’s large space industrial groups, Casc and Casic (discussed in the Appendix), are poised to capture these benefits because they make both commercial and defense products.

In the industries of other major spacefaring nations, firms and programs have benefitted from the integration of their commercial and defense activities on an organizational level. In the United States, the major commercial communications satellite manufacturers also build a range of other satellite platforms for NASA and the Department of Defense. The same is true of major U.S. manufacturers of satellite sub-systems and components. In launch vehicle manufacture, both U.S. policymakers and specialists have identified important complementarities and synergies between the commercial and defense launch segments.

In China, the parallel, concurrent, and coordinated implementation of commercial and defense programs similarly promises synergies, complementarities, and economies in the manufacture of launchers and satellites. In both types of products, the organizational benefits of dual development are, at minimum, threefold. They result from economies of scale, experience effects, and modularization.

First, integrating the commercial and defense manufacture of launchers and satellites promises economies of scale and risk reductions in development and production for Chinese firms. Launcher and satellite manufacture are sensitive to volume. In general, as production volumes for a given vehicle or satellite platform rise, the cost of the average produced unit drops. Several factors account for this situation. Development costs are very high for new vehicles and platforms. Maintaining assembly, integration, and testing facilities for launcher and satellite production is costly. Retaining skilled personnel as demand for either commercial or defense products fluctuates also imposes high fixed costs. Transaction costs involved in reaching agreements with sub-system and component suppliers are high. At high volumes, these burdens are distributed over a larger number of launches or satellites. Because most launch systems carry extremely high fixed infrastructure costs, launch rates (volume/time period) have an especially profound impact on the cost of access to space.

For manufacturers facing these burdens, consolidating production of commercial and defense articles is optimal. Firms seek to capture the highest possible market for any given product, using common vehicles or platforms to carry both commercial and defense payloads where possible. Producing commercial launchers or satellite platforms for export can also increase the total production volume of a given item, further reducing its average unit cost. This cost reduction can, in turn, benefit both the commercial and defense sides of the integrated manufacturing industry.

Second, at higher production volumes, experience effects also kick in. These bring further cost reductions and other benefits. Learning effects in launch-vehicle manufacture, launch operations, and flight operations are significant. Practice is an important determinant of the success of launch vehicle programs. Even launch failures themselves provide learning opportunities. In addition, the more times a given vehicle has flown, the longer its record of reliable performance. Reliability is a priority in operators' choice of launch solutions for military and intelligence payloads, because these items are of high value, irreplaceable, and/or often uninsured. Reliability is also a concern to international commercial buyers of satellites, who are sensitive to launch insurance rates that track reliability. Using common vehicles to launch both commercial and defense payloads is a means for Chinese manufacturers to capture these benefits of experience.

Satellite platform and component makers also benefit from experience effects attained at high levels of production. For example, users of both commercial and defense satellites prefer platforms with a reliable track record of smooth operation. Once again, the higher the volume of satellites using a given platform flown, the greater this particular form of experience effect for the manufacturer. Using proven common platforms or elements for both commercial and defense projects also reduces design and development risks on these projects. Increasing the overall volume of satellite production by expanding commercial production, including for export, could benefit China's defense satellite programs.

A third set of economic and organizational benefits to result from dual commercial and defense space development has to do with modularization in launcher and satellite manufacture. Developing modular designs brings efficiencies in production and flexibility. During the past two decades, these benefits have been most accessible to China's launch-vehicle industry, but they have also existed for satellite manufacturers. By adopting modular designs, Casc has been able to serialize more of its fabrication of sub-systems and elements, bringing cost reductions and other efficiencies. According to Chinese industry experts, modular designs have also allowed more efficient assembly and testing of launch vehicle and satellite systems and sub-systems. To deliver the greatest advantages, modularization and serialization require production at a high volume. Taking advantage of commonalities in commercial and defense hardware to achieve a higher volume of production on a given satellite platform, launcher, or element allows firms to reap these economic and organizational benefits. As China's space establishment maintains launch rates approaching or even exceeding 20 launches per year, manufacturers are optimizing the modularization and serialization of various elements of launchers and satellites in this manner.

In sum, the experiences of Chinese manufacturers and research on the space industry by Chinese and international experts point to the economic and organizational benefits of pursuing an industrial strategy of civil-military integration in the space sector.

Manufacturing and operational processes applicable to defense programs

Processes in the manufacture and operation of space systems that may be common to commercial and defense programs are several. They may include system assembly, integration, and testing and the quality control of components. The commonality of commercial and defense processes in spacecraft manufacture varies by particular item and experts disagree on it overall magnitude.

Certain processes may be common to launch-vehicle and missile manufacture. Commercial launch vehicles and missiles share general features at the levels of systems and major sub-systems. Launcher technologies are not identical to missile technologies, but improvements in Casc's launcher manufacture have the potential to bring improvements to the company's missile manufacture under certain circumstances. As in other high-technology sectors, even though items of commercial and defense space hardware differ in their particular features, some defense programs can, in a general sense, benefit from improvements to processes on commercial programs.

While general commonalities make some launcher manufacturing processes applicable to missile production, differences between the two types of vehicles limit this transferability. Technical specialists explain that today's launch vehicles and missiles are designed to distinct specifications, tolerances, and performance requirements. Missiles generally use different rocket motors and launch methods than satellite launch vehicles. Their technical features also differ at the levels of smaller sub-systems and components.

Beyond manufacturing processes, certain operational processes are also common to commercial and defense space programs. These include the integration of payloads with launch vehicles and launch-site operations. These processes are similar or identical for launches of both commercial and defense satellites. Improvements' to Casc's commercial launch processes may also improve its launches of defense payloads.

Dual-use space hardware and related knowledge

Particular items of commercial space hardware can be repurposed for defense applications with only minor modifications. These items include entire systems, such as launch vehicles, which can launch both civil-commercial and defense payloads. They also include sub-systems, such as sensors and robotic arms on spacecraft, which can in some measure be applied or adapted to intelligence or counterspace missions. Finally, dual-use technologies also include many smaller components, such as radiation-hardened electronic elements.

These dual applications are apparent to Chinese experts and policymakers, who advocate using commercial technology to modernize and develop the defense industries. While stressing autonomous development, sectoral policies and directives guide Casc and Casic to resort to commercial solutions available on world markets when indigenous defense technologies are not available.

Limitations on civil-military integration efforts

Several factors, both domestic and international, still hinder the pursuit of civil-military integration in China's space sector. These factors are discussed in recent reports on China's military modernization and defense industries submitted to the Commission. In addition to organizational and institutional obstacles to integration, U.S. export controls and other restrictions on trade in space items with China limit opportunities for Chinese firms to use commercial solutions to meet defense needs.

Foreign sources of China’s space technology

With few exceptions, it is difficult to state with any confidence when and how international actors have supplied China’s space industry with space technology items. While characterizing these transfers is challenging, observing the course of China’s space development nevertheless reveals changing conditions that affect the likelihood of Chinese actors seeking and using foreign inputs today and in the future.

Since at least 1999, the main thrust of China’s space development has been national and relied in large part on technology developed by domestic actors. Chinese space experts explain that, given the sector’s strategic role, their country must assure its independent access to and utilization of the space environment. The goal of sectoral policy, it follows, has been building a comprehensive industrial base within China, so as to ensure national control over critical processes in satellite and launcher manufacture. At the same time, this approach has allowed the selective pursuit of international trade and cooperation projects, where these bring significant benefits, but carry few risks. In this approach, foreign partners’ inputs can supplement, but should not substitute for or interfere with, homegrown capabilities.

Having pursued this strategy for many years, China’s space industry is by now so advanced in many areas that it may in fact seek or need fewer foreign inputs than in the past. As Chinese experts explain, major programs avoid importing entire foreign systems or sub-systems. Instead, they prefer to seek out partnerships with foreign firms that have special competencies to co-produce or co-develop major systems or sub-systems. For example, the China Manned Spaceflight Engineering Office has sought an international partner to develop in-space robotics for the space station program. China’s space industry is now more likely to seek out foreign inputs of specialized sub-systems, instruments, or components than foreign-made platforms or complete systems.

Moreover, as a result of its advances, China’s space establishment today is at least as likely to be a supplier of technology to newer entrants into the sector as an importer. For example, through their role in the Asia-Pacific Space Cooperation Organization, Chinese space organs provide opportunities for training and access to data to member states that have relatively modest space capabilities. China’s space industry has also concluded a string of agreements to export satellites and/or launch services to developing countries that theretofore had no significant space assets.

Impacts of U.S. export controls

The impact of U.S. export controls on China’s pursuit of space capabilities today is difficult to assess. Some observations suggest that its effects are mixed and declining.

Much of China’s success in space owes to structural factors and Chinese policy choices that lie beyond U.S. influence. As discussed above, among these factors are China’s enormous internal market for space goods and services, large and stable budgets for space activities, and strong political commitment to success in space endeavors.

Some Chinese specialists interpret the 1999 tightening of U.S. export controls on space items as part of a U.S. strategy to suppress China’s peaceful rise. In this view, the 1999 controls are not merely a denial of trade opportunities, but one facet of a larger U.S. effort to block China’s national rejuvenation: a “space containment policy” targeting China’s core development and security interests. In this view, the embargo constrains China’s economic advance by excluding it from world markets for high-technology goods and stifles its defense modernization. These interpretations of U.S. export controls underpin and rationalize policies to rapidly and autonomously develop capabilities in civil, commercial, military, and intelligence space.

Whether or not U.S. policy has in fact had the containing or hindering effects identified by Chinese experts, China has achieved an impressive record of national firsts in space technology while U.S. export controls have been in place. Further complicating the assessment is the fact that China's high-technology industries have made significant advances both in areas that are tightly export-controlled, such as space technology, and in areas that are more loosely controlled, such as aeronautic technology.

Conclusion

In sum, the environment of policies and processes in which Chinese space activities occur continues to evolve. However, the setting within which space programs are designed, adopted, and implemented today is more institutionalized and stable than in the past.

Overall, the Chinese space establishment has made remarkable technical achievements, producing a string of important national firsts since 1999. In particular, China is only the third country to develop advanced capabilities in human spaceflight and among only a handful to be building a global satellite navigation system. Now possessing core space capabilities in every major area, China's space establishment is poised to contemplate achieving global firsts in space science and engineering.

As China's space development forges ahead, its leaders stress the benefits of pursuing civil-commercial and defense space activities in a simultaneous and coordinated fashion. These benefits are systemic and institutional. They include organizational efficiencies, improvements to processes, and the dual applicability of hardware. Still, domestic and international factors continue to hinder the pursuit of civil-military integration.

While it is difficult to assess the contribution that specific foreign-origin technologies have made to China's space efforts, its advancing programs are geared toward the domestic sourcing of inputs and the development of independent national capacities. This situation suggests that the Chinese space industry's need for foreign inputs may be narrowing in scope. Similarly, the impacts of U.S. export controls on China's pursuit of space capabilities today remain difficult to assess. Some observations suggest that their effects are mixed.

Please accept my sincere thanks for the opportunity to share with you the results of my research. I would be pleased to answer any questions at the hearing or in writing.

Appendix: Leading institutions in China's space establishment

China's space policies and programs consist in the implementation of long-term technology development strategies. Numerous state organs are involved in space activities. These range from units that formulate and oversee policies and programs to those that produce and operate space hardware. In this system, major programs have dedicated program offices. They coexist with large organizations, such as the ones listed below, whose reach extends across multiple programs.

China Aerospace Science and Technology Corporation (Casc) and China Aerospace Science and Industry Corporation (Casic)

Casc and Casic are the two large state-owned defense industrial groups that build virtually all the hardware for Chinese space missions and projects. They are sometimes regarded as the most influential actors in the space sector. These conglomerates' major clients are the government organs that run the space program. Both the civil and military space budgets flow into these two companies.

Casc and Casic each subsume vast and diverse facilities and organizations performing the research, development, and production of space systems. Their main facilities are clustered around Beijing and Shanghai. Each of these industrial groups comprises system integrators, sub-system integrators, and component makers.

The larger of the two conglomerates, Casc, focuses on more powerful launch vehicles and larger satellites. Casc subsidiary China Great Wall Industry Corporation is responsible for marketing Chinese launch services and satellites abroad. The smaller Casic focuses on missiles and smaller satellites. Casc and Casic both develop and manufacture civil, commercial, and defense space technology and both are also involved in industries other than space. Each has undergone profound reforms and several rounds of restructuring since 1998.

In addition to these two major players, many small and medium-sized enterprises have emerged as users and processers of space-derived data and space-based services over the past two decades.

State Council of the People's Republic of China

The main body at the helm of state administration, the State Council is made up of the heads of major ministries and equivalent organs. This body formally decides and adopts top-level long-term policies and strategies for science and technology. In 2006, the State Council issued the national *Medium- and Long-Term Plan for the Development of Science and Technology*. This strategy for the 2006-2020 period updated and accelerated the pursuit of goals set out in the *State High-Technology Development Plan* of 1986 (also known as Program 863), which set China's major space programs on their current course. The *Medium- and Long-Term Plan* identifies and funds technology mega-projects, including large projects in space exploration, human spaceflight, and satellite navigation.

State Administration for Science, Technology, and Industry for National Defense (Sastind)

In 2008, Sastind succeeded the Commission for Science, Technology, and Industry for National Defense (Costind). Unlike its more autonomous predecessor, Sastind is a unit within the Ministry for Industry and Information Technology, designated a 'super-ministry' because it subsumes units of formerly ministerial level. Costind and Sastind have been the main state entities involved in space policy and technology development programs. Guided by the long-term strategies discussed in the preceding entry, Sastind formulates and coordinates the implementation of policies and programs between the large state-owned enterprises in the sector, military and other government end-users, research facilities, and concerned ministries.

State-owned Assets Supervision and Administration Commission of the State Council (Sasac).

Sasac oversees and guides reforms of China's large state-owned enterprises. Among these are the ten defense-industrial groups, which include Casic and Casc. Among other corporate and industrial restructuring goals, these reforms aim at improving the efficiency and business viability of the defense manufacturers and their capacity to supply domestic end-users and, in some cases, compete in export markets.

China National Space Administration (CNSA)

This small bureaucracy conducts relations with external parties on non-commercial space matters. As part of this function, it concludes international space cooperation agreements and represents China's space establishment at international meetings. The CNSA also plays a formal role in policy coordination. The CNSA Administrator is an influential figure concurrently appointed to positions in Sastind and key program offices.

National Space Science Center (NSSC) of the Chinese Academy of Sciences

Formerly the Center for Space Science and Applied Research, the NSSC participates in and coordinates scientific missions. The Center also researches, develops, and produces certain scientific instruments and payloads for space missions.

General Armaments Department (GAD) of the PLA

Critical space infrastructure, including launch facilities, and the day-to-day management of civil and military space operations, are the responsibility of PLA organs. Within the PLA, the GAD plays the most important role in space activities. The GAD, in cooperation with dedicated program offices, leads China's major space technology development programs. In civil space, the GAD acts mainly in and through the China Manned Space Engineering Office, the entity responsible for the human spaceflight program.