

**China's Space Industry and Its Strategy  
of International Cooperation**

**Lt. Col. Wang Chunyuan**

**Center for International Security  
and Arms Control**

**Stanford University**

**July 1996**

Lt. Col. Wang Chunyuan, who spent six months at the Center in 1995, serves on the senior staff of the Foreign Affairs Bureau of China's Commission on Science, Technology, and Industry for National Defense (COSTIND). Wang's research at CISAC focused on uses of missile technology for non-military space endeavors and future international space cooperation.

The Center is grateful to Carnegie Corporation of New York, the W. Alton Jones Foundation, and the John D. and Catherine T. MacArthur Foundation for supporting this project. The opinions expressed here are those of the author and do not represent positions of the Center, its supporters, or Stanford University.

The Center for International Security and Arms Control, part of Stanford University's Institute for International Studies, brings together Stanford faculty members from several scholarly disciplines with senior specialists from around the world and pre- and postdoctoral fellows for research projects, seminars and conferences, and international scholarly exchange. The Center publishes its own series of reports and papers on its work and also sponsors a series, *Studies in International Security and Arms Control*, through Stanford University Press.

Center for International Security and Arms Control  
Stanford University  
320 Galvez Street  
Stanford, California 94305-6165  
(415) 723-9625  
Megan Lauppe, reports editor

© 1996 by the Board of Trustees of the Leland Stanford Junior University  
Printed in the United States of America

## *Contents*

<i>Introduction</i>	1
<i>China's Cooperation with Other Nations</i>	2
<i>Current Missions of China's Space Industry</i>	6
<i>Existing Problems</i>	8
<i>International Challenges</i>	10
<i>Proposals for Future Cooperation</i>	15
<i>Conclusion</i>	22
<i>Notes</i>	23

## Introduction

Over the past four decades, China's space industry has pursued a unique development path and made accomplishments recognized throughout the world. China has developed a comprehensive scientific and industrial system for promoting space research and development, manufacturing, and application. For this purpose, complicated guidelines, rules and regulations, and operating procedures have been formulated, and teams of qualified space scientists and engineers trained.

To date, China has established three satellite launch complexes, one satellite control center, more than ten ground telemetry, tracking, and control (TT&C) stations on its territory, and three oceangoing instrumentation ships.<sup>1</sup> With support from these facilities, forty-three space launches have been conducted; thirty Chinese-made satellites have been projected into pre-designated orbits, including fifteen successfully recovered retrievable satellites; and five American satellites were sent into orbit by Chinese launching vehicles. Chinese space launchers were initially developed from ballistic missiles, and so far thirteen versions have been developed as space launching vehicles that can project any type of satellite into low earth orbit, geosynchronous transfer orbit, or solar synchronous orbit.

In contrast to the standards of developed countries, China's space industry grew under very poor conditions. Although China has developed a few state-of-the-art technologies, many weak areas exist. In terms of quality and reliability, China's space technology is still far behind that of developed countries, particularly in space electronics. The satellite types are inadequate to satisfy the demands of national defense and economic development; the satellite technology is characterized by a lack of sophistication, short operating life, and poor reliability. Also, the capabilities of the satellites in orbit are not fully utilized because of the lack of technological coordination. In short, China's space industry is facing the challenges of swiftly developing technology and intensely commercial competition from the outside world on the one hand, and urgent domestic needs for the technology on the other.<sup>2</sup>

How can China ensure that its space industry will continue to grow under today's circumstances at home and abroad? How can it attain its goal of reaching the advanced

---

All views expressed in this paper are the author's, and do not represent positions of COSTIND or the Chinese military.

world level in space technology in the coming decades? How can it exploit the resources of outer space by developing space technologies for the 1.2 billion Chinese people? The Chinese space community faces all these questions. Government organs, research institutes, industrial departments, and individuals have put forward various viewpoints, suggestions, and propositions. One is to further cooperation in the field of space technology with various countries of the world.

This paper reviews the activities and accomplishments of the Chinese space community in international cooperation and discusses appropriate ways of further cooperation with other nations. It is part of an effort to study how to enhance China's space industry and to share with the rest of the world the benefits of fair exploitation of outer space, which belongs to all mankind.

## I. China's Cooperation with Other Nations

### A. Three Periods of Development

To begin, a review of history is necessary. In terms of international cooperation, the development of space technology in China can be divided into three periods. In the first period, from the mid-1950s to the early 1960s, China initiated a strategic missile program in an attempt to acquire rocket technology and know-how from the Soviet Union. Under the terms of the New Defense Technical Accord, signed by the two countries on October 15, 1957, Moscow agreed to supply China with missiles and major industrial equipment related to China's missile programs. In 1958, Moscow pledged to help China build three research and development institutions and a test campaign that would focus on missile development.<sup>3</sup>

During this period, two Soviet R-1 and fourteen R-2 missiles were shipped to China, and Soviet experts came to China to demonstrate the technology and train Chinese scientists. About ten thousand Chinese students were sent to the Soviet Union to receive technical training; they would become the cornerstone of China's defense science and technology industry. Although Moscow withdrew its experts and terminated all the agreements and accords with China in 1960, when relations between the two nations were souring and "elder brother" was criticized as revisionist, it was absolutely clear that without Soviet assistance, the development of strategic missiles and space technology in China would have taken much longer.<sup>4</sup>

Isolated from the rest of the world for the nearly two decades of the second period, from the early 1960s to the late 1970s, China pursued a self-reliant policy of developing space technology without any real exchanges with outsiders. Because it was in conflict with both the "Soviet revisionist" and the "American imperialist," China could not get any help from the two superpowers. Motivated by national security and prestige, Chinese defense scientists and missileers made great efforts to develop space technology and industry, even while the political chaos of the Cultural Revolution swept the country.

During this period, a space scientific and industrial system was built, including facilities for research and development, manufacturing, testing, launching, and TT&C. China's first man-made satellite, DFH-1 (the East Is Red No. 1), was launched in 1970, and the first retrievable satellite was launched and recovered in 1975. With little knowledge of cutting-

edge technologies and a lack of technical information, China developed its space program through the traditionally initial cycles which the developed nations had conducted long ago. Therefore, the development of China's space technology was quite slow, and Chinese space products were neither practical nor reliable.

The third period extends from the late 1970s to the present day. During the Third Plenary Session of the 11th CCP Central Committee in December 1978, Beijing's leaders decided to switch their focus to economic affairs, and to designate economic development as the highest priority of the nation in the coming decades.<sup>5</sup> China has instigated reforms and an open-door policy as part of this state strategy. As part of the reform policy on defense industry, a systematic transformation of defense-oriented industries to civilian production began in 1980.

## **B. Bilateral and Multilateral Cooperation**

Several policies and guidelines have ensured the implementation of academic exchanges and collaborations between the Chinese space community and its foreign counterparts. Since the late 1970s, bilateral and multilateral cooperative activities in the space industry have been conducted. The following is a list of the activities in this period:

### *1. Signing of International and Bilateral Documents*

In 1983, China joined the Outer Space Treaty Organization to promote international cooperation in space. In December 1988, China signed the Agreement on the Rescue and Return of Astronauts and the Return of Space Objects Launched Into Outer Space, the Convention on International Liability for Damage Caused by Fallen Space Objects, and the Convention on Registration of Objects Launched Into Outer Space. In addition, China and the United States signed the following bilateral documents from late 1988 to early 1989: the Memorandum of Mutual Agreement on the Safety of Satellite Technology, the Memorandum of Mutual Agreement on the Responsibility of Satellite Launch Activities, and the Memorandum of Mutual Agreement on International Trade Issues of Commercial Launch Service.<sup>6</sup> To date, China has also signed intergovernmental accords or agreements on space issues such as communications satellites, scientific research and experimental satellites, earth resources satellites, and satellite data and images with countries including Germany, Japan, Italy, Britain, Russia, India, Pakistan, and Brazil.

### *2. Academic Exchanges and Activities*

China's space industry has also conducted various kinds of academic and technical exchanges and established extensive relations with the world academic community. China's space industry sends about two thousand scientists, engineers, and managers abroad each year to participate in international academic meetings, symposia, and activities on aerospace. Many papers have received academic awards. Several tens of Chinese space specialists have been made academicians or corresponding members of the World Institute of Space Flight, and some have been elected to leadership positions in the International Space Flight Organization as well. The Chinese space community has invited thousands of foreign experts and scholars to visit China to deliver lectures and discuss technological issues with Chinese engineers.<sup>7</sup> As Chinese space experts share experiences with their foreign counterparts through these academic activities, the level of China's space technology is enhanced.

### *3. Joint Space Projects*

During this period, China's space industry did its best to cooperate with foreign space organizations in selected projects, with support from the central government. At the same time, after China implemented its open-door policy to the external world, foreign space industries realized that there would be a big market in China, and China might become a good partner. Accordingly, some international agreements were reached on space-related projects, including:<sup>8</sup>

- Representatives from the Chinese and Soviet space industries signed a space technical cooperative agreement in Moscow in May 1990 on ten cooperative projects, the first of which addressed joint efforts to develop a GLONASS/GPS (global navigation satellite system/global positioning system) compatible receiver. When the formal contract was signed two years later, the Russian side submitted a research report on the project that included background material and the principles underlying the joint effort.
- In 1992, China and the European Space Agency (ESA) decided to start a joint project that would involve a multipoint-detection satellite. A group of Chinese specialists and a delegation of scientists from Britain, France, Germany, Sweden, Austria, and other nations reached an agreement to build a multipoint satellite data center and computer network in China. This system will be used to detect fine 3-D particles in the plasmas and electromagnetic fields of earth atmospheric layers.<sup>9</sup>
- In an effort to explore opportunities to enhance TT&C capabilities in cooperation with foreign nations, China signed two key agreements on using French and Chilean satellite TT&C ground stations in 1993 and 1994, respectively. This was the first time that China was to carry out TT&C activities on the territory of other countries. It would partly remove the need to dispatch oceangoing instrumentation ships and could thus save millions of U.S. dollars.
- In order to accelerate China's preparatory research on manned space technology and reduce the related expenditure, China and Russia signed in early 1995 an agreement on training Chinese personnel and conducting relevant experiments by using Russian facilities, including space simulation stations and weightless aircraft. According to this agreement, some seventy to eighty Chinese engineers and managers would go to Russia to receive training in 1997-98.

### *4. Assistance to Developing Countries*

Since the late 1970s, China has attached increasing importance to space cooperation with developing countries. For example, Sino-Brazilian cooperation on the research, design, and production of two earth resources satellites is proceeding smoothly.<sup>10</sup> Also, China has trained more than forty space experts from Ghana, Mongolia, Laos, Malaysia, Tanzania, Pakistan, and Vietnam.<sup>11</sup>

### *5. Piggyback Services*

By 1987, China had launched and recovered eight remote sensing and scientific experimental satellites with 100 percent success. This record demonstrated that China had attained sophisticated technology to launch and recover satellites with high reliability and low cost, and attracted the attention and interest of a few foreign space organizations. China has subsequently offered space launch piggyback services:

- On August 5, 1987, while China launched the ninth retrievable satellite from the Jiuquan Satellite Launch Center, two French (Space Division of the French Matra Industry Group) micro-gravity experiment payloads were injected successfully by the Long March-2C launch vehicle.
- On August 5, 1988, a German micro-gravity experimental apparatus, developed by MBB Corporation of West Germany, was successfully launched, together with China's eleventh retrievable satellite, from the Jiuquan Satellite Launch Center by the Long March-2C launch vehicle.
- On July 16, 1990, a Pakistani digital communications satellite named Badr-A, designed and produced by the Pakistani Space and Upper Atmosphere Research Commission, was successfully launched, together with a Chinese simulation satellite, from the Xichang Satellite Launch Center by the newly developed Long March-2E rocket.
- On October 6, 1992, a Swedish experimental satellite called Freja, developed by the Swedish Space Corporation, was piggybacked on the Long March-2C rocket, which was primarily being used to launch China's fourteenth retrievable satellite. The two satellites were successfully injected into their pre-designated orbits.

#### 6. *Commercial Satellite Launch Services*

In May 1985, China announced at an international space conference in Geneva that it intended to market its Long March rocket for commercial satellite launch services. China thus signaled for the first time its interest in playing a full role in the world space community by offering commercial satellite launch services. From May to September, 1985, China also exhibited the rocket at the International Fair in Zuzhou, Japan. The U.S. Challenger mishap and European Ariane accidents in 1985 helped China's space industry emerge in the international launching market. Its technical credibility and lowest pricing are undoubtedly the main attractions for the Western world. China offered launch service at a price of around \$30-55 million per launch. This was 30-75 percent of the price of Ariane, 50 percent of Atlas, 25 percent of Titan, and 70 percent of Delta.<sup>12</sup> Several contracts have been signed since then, and most of them have been fulfilled:

- On April 7, 1990, the Asiasat-1 (the Asia Satellite Telecommunications Corporation), a communications satellite built by Hughes Aircraft, was launched by the Long March-3 booster.
- The first second-generation communications satellite of Australia, the Aussat-B1, was launched on March 22, 1992, by China's newly developed launcher Long March-2E. Unfortunately, the attempt failed due to an emergency shutdown. Five months later, on August 14, it was successfully launched.<sup>13</sup>
- The second Australian communications satellite, Aussat-B2, also built by Hughes Aircraft, was destroyed, together with the launcher Long March-2E, after forty-eight seconds of blast on December 21, 1992. The Aussat-B3, the substitute for Aussat-B2, was successfully launched on August 28, 1994.
- On July 21, 1994, another communications satellite, Apstar-1, made by Hughes Aircraft and owned by APT Satellite Company Ltd. of Hong Kong, was launched on Long March-3. The subsequent launch of Apstar-2 on January 26, 1995 failed, however.

Since the late 1970s, China's space industry has carried out a full-scale open-door policy in cooperation with its foreign counterparts. By demonstrating a willingness and capability

to cooperate with the external world, China has obtained the requisite information as well as technologies for further development of its own space programs. Most important, the Chinese have concluded that the space industry not only serves the prestige and national defense of the state, but from it enormous social and economic benefits for the development of their society can be derived as well. In 1992, the Chinese Government issued its "National Guideline for Long-Range Science and Technology Development" for the years 2000-2020. The document stressed the importance of research and development of space propulsion technology, applied satellites technology, telemetry and control technology, and manned space technology.<sup>14</sup>

## II. Current Missions of China's Space Industry

China has made considerable economic achievements since Beijing's leaders decided to carry out the reform and open-door policies in 1978. China needs space technologies, among other new high technologies, to assure continuous, rapid economic growth and to satisfy the demands of the people, whose living conditions have been enormously improved. More and more Chinese are becoming aware of the important role the space industry has played in social and economic development. Consequently, higher demands are being placed on the requirements for designing application satellites.

As a developing country, however, China possesses very limited financial resources; in the near future, the small investment in space programs will be unable to satisfy all the requirements for new application satellites. At present, the key areas for use of applied satellite technologies are the following:

### A. Education

Education is a major problem in China. There are huge numbers of illiterates in remote regions of China, not to mention few opportunities for higher education. This problem can not be solved by increasing the number of schools and teachers because of the lack of funds and the long lead time required for school construction. Providing special satellite television education programs at various levels is an effective approach. Since the early 1980s, China has worked to establish a satellite television education network. Today, there are about 15,000 television receive-only (TVRO) stations in operation, providing television coverage to 80 percent of China's territory. Currently, the satellite education network is scheduled to broadcast one channel of national education programs.<sup>15</sup> To date, these programs have provided education for more than ten million students, and have trained about one million high school and grade school teachers. Using conventional methods, it would have taken more than twenty years to train the same number of teachers.<sup>16</sup> Through many years of practice, the satellite television education network has been verified as an economical and effective approach. To further develop and support such a network, more communication and broadcast satellites are needed.

## B. Development of Transportation and Communications

It is well known that transportation in China is overcrowded. Inadequate transportation and communications has hampered China's overall economic development. The applied satellite technologies will provide an effective way to rebuild the transportation system and enhance China's transportation capability. An integrated satellite system for navigation, positioning, and communication will greatly facilitate real-time coordination and dispatch of various transportation systems, thereby improving their efficiency. Many economic activities in today's China can be performed without travel, by telephone, facsimile, and other telecommunications equipment. This will relieve the overloaded transportation system by reducing the passenger amount by one-third, which translates into an annual savings of RMB 10 billion yuan. Meanwhile, the total amount of funds being transferred through the financial community reaches RMB 50 to 60 billion per year, and the average transit time is six days. A 20 percent increase in transmission speed corresponds to RMB 10 billion yuan of additional funds in circulation.

Post and telecommunications is another transportation-related problem. China's communications capability is apparently unable to satisfy the demands of economic growth and a higher standard of living for the Chinese people. In the 1970s, the ownership of a telephone at home was a symbol of a person's social position. In 1978, the total number of telephones in China was equal to those in a large Western city. After rapid development in the past years, China has greatly improved telecommunications, with annual growth rates of 30 percent in 1991, 40 percent in 1992, and 58.9 percent in 1993. The number of telephone switchboards increased six times, from 5.7 million in 1978 to 37 million in 1994.<sup>17</sup>

Telecommunications construction in China has involved many advanced technologies such as microwave transmission, optical fiber transmission, and satellite communications. Through the research of the past few years, the relevant Chinese government departments, research institutes, and engineers are aware that satellite communications is the most fitting technology for China's telecommunications system because of the nation's huge population and complex terrain. Although much progress has been made, the supply of telecommunications services still lags far behind the demand.<sup>18</sup> For example, applicants for telephone service have to wait three to six months in most cities for approval to use telephones at home. A recent report from the Ministry of Post and Telecommunications indicates that China needs sixty to seventy satellite communication transponders by the end of 1995, and two hundred transponders in total by the year 2000. However, the total number of operating satellite transponders is less than twenty, and 80 percent of them are leased from foreign firms. There is still much room for the rapid development of applied satellite technologies.

## C. Environmental Protection

Because of its complex geography, China repeatedly suffers natural disasters. Fires, floods, hurricanes, tidal waves, earthquakes, and hailstorms occur frequently, causing huge losses of property and life and enormous economic damage. Statistics show that natural disasters annually cause the loss of RMB tens of billion of yuan (for example, the loss was RMB 50 billion yuan in 1990). In 1988, a group of space scientists pointed out in a proposal submitted to the Chinese Government the necessity and feasibility of setting up a satellite disaster prevention and rescue system. In 1991, the National Remote Sensing Center under the State Science and Technology Commission built a satellite remote sensing system. Many more earth remote sensing images both from foreign satellites and domestic solar-orbit

meteorological satellites are now used for monitoring natural disasters and weather forecasts.<sup>19</sup>

A satellite monitoring system can not only provide real-time disaster forecasting capability, but can also reduce the severity of the losses from disasters by organizing efficient rescue means after disasters have taken place. Indeed, reliable information provided by meteorological satellites has significantly lessened the losses caused by wind, flood, and fire in recent years. Accordingly, the development of a satellite disaster prevention and rescue system has become one of China's most urgent needs.

The rapid development of industry has severely polluted the atmosphere and water resources of the nation in recent years. Constant monitoring of pollution throughout China is necessary in order to control environmental pollution. This mission can only be effectively carried out by a satellite monitoring system.

#### **D. Making Effective Use of Natural Resources**

The strain that overpopulation has placed on the nation's natural resources is one more challenge for China's social development. China has 22 percent of the earth's population but only 7 percent of its arable land. The cultivable land, forests, fresh water, and mineral resources of the country are much lower than the world's average. Considerable misuse and waste of valuable resources resulting from the lack of scientific approaches to development, application, and management is a serious problem. China has begun to develop both underground and underwater resources for making maximum use of the available natural resources, and has concentrated on developing earth resources satellites for this reason.<sup>20</sup>

China is currently in the process of developing different types of meteorological and earth resources satellites. The meteorological satellites include those in sun-synchronous orbits and in geosynchronous orbits. The earth resources satellites, named CBERS, are under development by a joint venture between China and Brazil. The first China-Brazil Earth Resources Satellite, CBERS-1, is expected to be built and launched in mid-1997, and CBERS-2 is scheduled to be launched before the end of 1999. Studies are also under way to provide better capability for monitoring the atmosphere, the land, and the ocean by improving the resolution, expanding the spectrum for remote sensing, and extending the operating life of the satellites.

### **III. Existing Problems**

China faces challenges at home and abroad as it develops space technologies. Without proper solutions to the existing problems, China can not make breakthroughs in its space industry. Let us first review the domestic aspect of the problems that obstruct the further development of China's space industry.

#### **A. Inadequate Satellite Capabilities**

China's space technology is not as advanced as that of developed countries. The satellite R&D cycle in China, usually seven to eight years, is too long; satellites' operating lives, less than four years, are short; the resolution of the remote onboard sensors is low; and the

capacity and power of communications satellites are imperfect, with no more than four transponders on each satellite. The technical specifications of China's operating stationary communications satellites and of retrievable remote sensing satellites are equivalent to those of developed countries in the 1970s. For example, the IntelSat-6 communications satellite of the International Satellite Communication Organization, launched in 1988, was equivalent to twenty of the Chinese DFH-2a communications satellite, which was put into operation at the same time. China has played a marginal role in the international commercial launching market in recent years with its rocket technology, which, although still behind advanced nations, is relatively sophisticated. Its payload is only one-third of some advanced countries' launch vehicles with the same lift-off thrust.

### **B. Small Production Scale and Low Efficiency**

Applied space technology in China is characterized by a small production scale and low efficiency. China has only five types of satellites: communications satellites, retrievable remote sensing satellites, photographic positioning satellites, polar-orbit meteorology satellites, and space technical experimental satellites. Of these five types, only communications and broadcast satellites have been initially established in an operating system. Because of inadequate funding and insufficient assignments, only about one-third of space research organizations and engineering and technical personnel are actually involved in advanced studies, design selection studies, and engineering management of space systems. Many research institutes are working at about half-capacity only. Every year, only three to four satellites are manufactured at the main satellite assembly center; only a few booster rockets are built at the booster rocket assembly plant; only three to four launches are conducted at the three large-scale space launch bases; and the telemetry and tracking systems are used only a few times. It is obvious that the cost-effectiveness ratio is poor and the tempo of upgrading personnel and technologies is too slow.<sup>21</sup>

### **C. Decentralized Leadership and Planning**

One of the urgent tasks for China's space industry is to spur unified leadership and planning by giving definite job divisions to the government agencies concerned with space programs, primarily the Commission on Science, Technology, and Industry for National Defense (COSTIND), the China Aerospace Industry Corporation, the State Science and Technology Commission, the Chinese Academy of Sciences, the Ministry of Post and Telecommunications, and the China Meteorology Bureau. Because the functions and responsibilities of these agencies are not clearly delineated, and because their points of view are usually different and occasionally even contradictory, there has been inadequate coordination between them. This has resulted in difficulties in working out plans for short- and medium-term space programs and carrying out these programs. The inefficient decision-making process affects scientific design and manufacturing quality. Following the commercialization of the space industry in recent years and the reform of government organizations, contradictory points of view between government agencies have intensified.

Lack of coordination exists also between the development of the space segment and the ground segment in the application of space technologies. For example, the transponders and effective onboard bandwidth of the communications satellites are not fully utilized, and therefore are being wasted because of the poor system planning.

#### D. Tight Budgets and Inadequate Financial Support

The greatest hindrance to the development of space technology in China is tight budgets and inadequate financial support. As a developing country, China's investment in space technologies is inadequate compared with developed countries that generously provide greater financial support, both in absolute and relative terms. In absolute terms, China's state investment in the space industry is now approximately \$100 million, which is about two orders of magnitude lower than that of the United States and the Commonwealth of Independent States, and one order of magnitude lower than that of Western Europe and Japan.<sup>22</sup> In relative terms, China's budget was only 0.035 percent of GNP in 1987, compared with the United States (0.52 percent), former USSR (1.5 percent), France (0.11 percent), Germany (0.04 percent), Japan (0.04 percent), and India (0.14 percent).<sup>23</sup> It was the smallest investment among the world's spacefaring countries, which places Chinese space programs at a disadvantage.

With the problems and disadvantages mentioned above, China's space industry is faced today with unprecedented domestic pressure as the centrally planned economy converts into a market-oriented economy. Because China's space industry cannot completely meet the requirements of various government agencies, industrial and commercial departments, and individuals, and because some people do not have confidence in indigenous products, more and more space-related products are imported. Each year, China spends tens of millions of U.S. dollars on purchasing electronic units, components, and materials for satellites, rockets, and ground equipment, satellite data and images, transponders of communications satellites, and even whole satellites. Shrinking assignments and orders for domestic space products have discouraged the further development of Chinese space technologies, and if this trend continues China will in the end be forced to withdraw from the international space club.

### IV. International Challenges

In the post-Cold War era, the economic benefit from space programs and activities has replaced military competition in the space sector in most countries. Because of this, space competition is more intense than ever before. China's space industry, as a latecomer, is facing a narrow opening and a tough path in its efforts to enter the crowded international commercial satellite launch market. Its missions to launch Aussat and Asiasat are good examples of the difficulties it faces in attempting to enter the world market. In the course of the negotiations for these launches, from signing contracts and agreements to the final launch arrangements, the Chinese not only learned the procedures of international negotiations, but also came to understand the difficulties they face and how the Western world views them.

#### A. Western Constraints on China's Space Industry

The decision to launch Aussat and Asiasat on Chinese rockets was met with considerable opposition from Western launch suppliers and the U.S. defense community. This opposition inspired the U.S. and Chinese governments to reach several agreements. From 1986 to 1989, three principal agreements on technical security, competition, and third-party liability were negotiated and signed.<sup>24</sup> In terms of competition and related issues, Chinese launch services

Controls (CoCom). This was an informal group of representatives of the main NATO countries, plus Japan and Australia. CoCom set guidelines for controls by members on their respective exports of strategically sensitive technology. CoCom was dissolved in 1994 and replaced with a new arms control forum, the Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies.

## B. Agreements on Satellite Technology Safeguards

The prospect of the Aussat and Asiasat missions drove the U.S. government to conclude with China in December 1988 the Memorandum of Agreement on Satellite Technology Safeguards, in order to "preclude the unauthorized transfer of sensitive technology associated with the possible launching of the U.S.-manufactured Asiasat and Aussat from the People's Republic of China." This agreement essentially confines the transfer of technical data to only that which is needed for the Chinese to perform their duties as a launch services provider. It also details constraints on access by Chinese citizens to the spacecraft processing at the Xichang launch site, as well as the transportation of the spacecraft within China and the procedures to be followed in repatriating spacecraft debris in the case of a launch failure.

Meanwhile, the United States effectively controls the export of any Western spacecraft, and U.S. requirements for export controls need to be taken into account by all Western satellite users. This is because most Western spacecraft use a significant number of U.S.-source units, components, or materials. The United States therefore effectively holds the right of veto over their ultimate destination. As a matter of fact, apart from the primary agreements, the U.S. government requires five licenses covering the items on the MC list, and a number of other licenses are required by the Department of Commerce. Each license for an item on the MC list carries many provisos. The main points of the memorandum were essentially as follows:

- The Chinese should be given only data directly related to the form, fit, and function of the interfaces between the spacecraft and launch vehicles and launch site.
- What could not be transferred to the Chinese was governed by the principle that the spacecraft and its launch program could not be used as a tool to assist China in the design, development, or enhancement of its satellites and launch vehicles.
- In a more subtle vein, the governing principles behind the licenses also prohibit the transfer of substantive information about how a program is executed in a typical Western space company. Specifically, test philosophies, organizational rationale, industrial relationships, and other procedural issues were not permitted to be transferred to China.
- Finally, the U.S. government required that its representatives have full access to the spacecraft to launch vehicle integration program. U.S. government representatives attended all the interface meetings and have the right to observe all technical exchanges with China.

The Chinese drew some useful lessons from the practical experiences of the Aussat and Asiasat missions, and came to the conclusion that the improvement of the political and diplomatic relationship between China and the Western countries, in particular the United States, could make it feasible for the Chinese space community to increase its cooperation in international ventures in space development and markets. Otherwise, China would never become a major member of the international space club.

Mishaps in recent years have caused foreign clients to reconsider the maturity of Chinese technology and to suspect its reliability. Because of this, these mishaps actually are severe setbacks for China as it attempts to accelerate its progress in international activities. China has experienced several commercial space launch failures:

- When China launched the Aussat-B1 with its newly developed Long March-2E cluster high-capacity carrier rocket on March 22, 1992, at the Xichang Satellite Launch Center, the ignition failure of one of the eight main engines of the first stage caused an automatic program emergency shutoff after three minutes, and the rocket shook slightly. Aussat-B1, the first Australian second-generation communications satellite with twenty-four transponders, built by Hughes Aircraft as the first satellite of the company's HS601 series, fortunately was undamaged. It was later launched successfully on August 14 of the same year by the same kind of rocket.
- The second Australian communications satellite, Aussat-B2, was ejected from the Xichang center on December 21, 1992 by the Long March-2E rocket. This time ignition occurred without a hitch, and the launch vehicle took off successfully with the Aussat-B2 on board. After forty-eight seconds of flight, however, the aircraft was exploded from inside of the Chinese-made cowling. Miraculously, the rocket flew continuously along the predestined trajectory and sent signals back down to the ground TT&C stations of separations of strap-on boosters, first stage and second stage, and all the technical parameters received from the rocket met the requirements of the original satellite/rocket interface control documents (ICD).<sup>28</sup> Subsequently, failure analysis was conducted by both sides, but no mistake was found. They agreed to manufacture a satellite and a rocket and to launch them again as compensation for Australia. As a replacement for Aussat-B2, the Aussat-B3 satellite was successfully launched one year and eight months later, on August 28, 1994.
- The failure of the Apstar-2 satellite launch is considered by the majority of Chinese to be the most tragic failure in the history of the Chinese space program. Because the televised live relay of the launch had been announced in advance, hundreds of millions of Chinese watched on January 26, 1995 as a giant fireball of exploding rocket and satellite appeared on their screens seconds after lift-off—the first experiment in their lives to end in such an accident. As another Hughes-built HS601 model satellite, the Apstar-2 was the second communications satellite of the Hong Kong-based Asian-Pacific Telecommunication Satellite Company Ltd. It was launched by the same Chinese Long March-2E launch vehicle as the Aussat; coincidentally, the timing of the explosion was almost as same as that of the Aussat B-2 launch, but this time the rocket was destroyed together with the satellite. The long-awaited results of the six-month investigation were released on July 25 by the U.S. Hughes Aircraft Company, the satellite manufacturer, and the China Great Wall Industry Corporation, the launch vehicle vendor. In a joint statement, Hughes and Great Wall said that separate investigations concluded that high winds aloft and wind shear led to the January 26 explosion that destroyed the HS601 satellite and the Chinese Long March-2E rocket. But the two firms differed over whose equipment collapsed under the weather-related stress.<sup>29</sup>

### C. The Impact of Launch Failure on China's Space Industry

Together with these failures of foreign space projects, the accidental explosion in 1994 of the Chinese-made geostationary meteorology satellite FY-2A during its final technical test and the malfunction of its most advanced telecommunications satellite with twenty-four transponders, DFH-3, created unprecedented difficulties for China's space industry. Top leaders of both the State Council and the Central Military Commission paid great attention to these disasters and problems. COSTIND and the China Aerospace Industry Corporation, two key players in China's space industry, received investigative reports and analyses of these failures, and corrective steps were immediately taken at different levels of management, design, manufacturing, and operations.

After the Aussat-B2 launch failure, the Chinese space community formed a failure analysis group headed by Wang Dechen, chief designer of the Long March vehicle. The group analyzed and evaluated the Aussat explosion from four different angles. They double-checked more than four hundred remote sensing parameters and weather data during the launch of the Aussat-B2 and compared these with the same data from the launch of the Aussat-B1. A failure analysis center rechecked the design and test data of the rocket, especially data related to the fairing. They analyzed and compared the data to wind tunnel test results, aerodynamic coupling analysis, trajectory, load, and thermal coupling analysis, structure design, ground static tests, and whole rocket vibration analysis. They also traced the manufacturing, testing, and inspection data for the fairing. After months of investigation and analysis, they announced that all the results showed that the various systems worked normally.<sup>30</sup>

After the failure of the Apstar-2 launch, more detailed analyses and investigations were conducted by representatives of the Long March launch vehicle design and manufacturing groups, and by professionals from outside the China Aerospace Industry Corporation such as COSTIND and the Chinese Academy of Sciences. Through these subsequent evaluations, Chinese experts found some minor problems that needed correction, but they strongly believed that the Long March vehicle and its cowlings were not the cause of the explosions. On the other hand, Hughes Aircraft concluded that there was nothing wrong with its satellites. In order to preserve the prestige of both sides, the joint statement attributed the failure to natural weather conditions.

It is inevitable for foreign space industries, especially satellite manufacturers, to hesitate to use Chinese launch vehicles or to cooperate with China's space industry. Some Western space companies set forth additional requirements for their Chinese counterparts. For example, the Asia Satellite Telecommunications Corporation of Hong Kong and the EchoStar Communications Corporation of the United States, whose satellites were launched by Chinese Long March rockets in late 1995, asked the China Great Wall Industry Corporation, their launch provider, to strengthen the rockets' fairing and to exercise more caution in certain weather conditions. Other steps were requested as well. In short, for whatever reasons, these failures cast a pall over the Chinese space community and slowed to some extent China's entry into the world space market.

Judging from the history of Chinese space development, its accomplishments in international cooperation, and the rising status of China's space industry in the international space community, the Chinese have reached the conclusion that carrying out international cooperation with other countries in space exploration and technology development remains the only feasible way for China to maintain the pace of space technology development in the foreseeable future. China can save both money and time by pursuing cooperation with

outsiders rather than closed-door development. Now, however, a new issue confronts the nation: Should China intensify cooperation with the international space community while its space technology shifts from the experimental to the applied phase under intense international competition?

## V. Proposals for Future Cooperation

The success of Beijing's goal of promoting international cooperative space projects and activities involves comprehensive efforts at many levels and among many departments. Only when the top leadership has firmly resolved to work in this direction can China's space industry make progress in the international arena.

### A. Defining Chinese Space Policies

First, China must clearly define its policies on space technology if it wishes to encourage its space industry in cooperative ventures with Western countries. After more than ten years of carrying out reforms and the open-door policy in China, many Chinese officials still consider it unnecessary and impossible for China's space industry to substantially cooperate with foreign countries because of the great differences in social and political systems, values, and infrastructure between China and Western countries. They believe that China has developed space technology on its own for decades, and has made great achievements without foreign aid.

Although Beijing gives priority to China's space industry, cooperative space projects with foreign countries are obstructed by other organs, because the assignments of many government agencies usually overlap in complex projects that cover many fields. It is time for the different levels of the Chinese space community to reach a common understanding regarding international cooperation by formulating definite policies to guide and regularize its activities in international cooperation, including multilateral and bilateral joint projects.

Government agencies and space industrial facilities should prepare analyses and estimates in accordance with the practical experiences gained from international cooperative projects and activities over the past years, and then submit a joint detailed proposal covering all aspects of international space cooperation to the Space Leading Group. After comprehensive studies of the proposal and vetting of the various suggestions from different sources, the top leadership should dictate a national strategy on international cooperative space projects. The strategy would consist of principles for urging China's space industry to engage in certain international cooperative space projects closely related to the nation's space development goals and overall economic development program.

As concrete measures in accord with the new situation, specific regulations should also be formulated in addition to the macroscopic policies. Specifically, management procedures, rules, and regulations with regard to the application, approval, and management of funds; the management of import and export activities; and the management of each stage of research, manufacturing, testing, and TT&C must be clearly established or adjusted.

## B. Unified Leadership

After clearly defining its policies regarding space technology, Beijing must exercise unified leadership over international cooperative space projects. Established in 1989 and placed under the State Council, the Space Leading Group currently is responsible for policymaking and coordinating assignments among ministries and industrial enterprises. Its first priority is to coordinate all space activities in China. The group is composed of six members: the premier, the director of COSTIND, the deputy director of the State Science and Technology Commission, the vice minister of foreign affairs, the deputy director of the State Planning Commission, and the president of the China Aerospace Industry Corporation. At the group's twice-yearly meetings, members discuss how to resolve the existing problems in space programs.

While not as powerful as the famous CCP Central Special Commission, which played a unique role in China's space development, especially in the 1960s and 1970s, the Space Leading Group must keep an eye on China's space development strategy for the medium and long term and coordinate with the departments and industrial enterprises concerned. In particular, the group should take full responsibility for promoting international cooperation in the market-oriented economy so that space technology will better serve the modernization drive. The CCP Politburo, the CCP Central Military Commission, and the State Council should grant the group the leadership role and overall planning authority to ensure that China's space industry is capable of carrying out its assignments in the joint projects.

As in other countries, the development of the space industry in China has depended on close coordination between various government agencies. To cope with the swiftly changing market-oriented economy for contract-based business, the central government should devise new rules, regulations, and procedures for further defining the responsibilities and relationships between government agencies and users and research, industrial, and testing facilities. During each stage of development of space technologies, the government should formulate and enforce policies that ensure strict adherence to the overall plan.

## C. Upgrading Space Technologies

International joint projects will be most fair and mutually beneficial if the cooperating parties have similar levels of space technologies. From this perspective, China's space industry faces yet another challenge as it works to upgrade its space technologies. As mentioned earlier, there is still a wide gap between the space technologies of China and those of developed countries. The Chinese space community should concentrate its efforts on making breakthroughs in these key space technologies by the year 2000:

- In the area of rocket propulsion technology, Chinese specialists should focus their efforts on the research and development of low-cost, non-toxic, high-thrust hydrocarbon engines, large hydrogen-oxygen engines, high-performance orbit-transfer engines, high-energy solid propellants, and space shuttle propulsion systems.
- In the area of special satellite technologies, the efforts of the Chinese should be devoted to the study of high-precision ultraviolet, infrared, visible-light, CCD microwave remote-sensing and processing techniques; high-efficiency onboard power supplies; lightweight deployable solar arrays, large reliable antenna arrays; antenna beam-shaping and thermal control techniques; and onboard payloads which include K, S, and L-band equip-

ment and transponders, as well as payloads for studying microgravity, biology, solar, and geophysics and astronomy.

- In the area of tracking and control technologies, efforts should be devoted to the study of large-capacity, high-speed data transmission; satellite data relay; satellite-to-ground and satellite-to-satellite acquisition and tracking; multiple-target tracking and monitoring; precision orbit determination; miniaturization of sensors and onboard equipment; and adaptive, computer-controlled telemetry.
- In the area of applied satellite technologies, priority should be given to the development of digital communications, mobile communications, and techniques for receiving, processing, interpreting, and utilizing remote sensing data.
- In the area of launch and recovery technologies, priority should be given to the development of automated systems for testing and inspecting launch vehicles and space vehicles; automated command, control, and communications systems; vertical testing and smoke-exhaust management techniques; and large parachutes, as well as recovery and safety processing, cooling, cleaning, emergency, and rescue procedures.

#### **D. Increasing Investment in the Space Industry**

The state should increase investment in the space industry, and explore new sources of financial support. As is known, the amount of state investment in the space industry has been controversial. It is quite clear that Beijing's leaders have assigned the highest priority to economic development, and would not support many loss-incurring economic activities. China has expressed this point of view through its defense reform policy. Some officials argue that the nation's investment in space industry should be shrunk, and the space industry left to develop on its own via commercialization. Further implementation of this policy would mean cutting funds to the space industry and pressuring it to become more entrepreneurial. If the commercialized space industry did not become a net generator of revenue, it might even be abandoned.

Others argue that the government should increase investment in the space industry. In a broad sense, some kind of governmental intervention is inevitable for spacefaring countries, and all spacefaring countries, they hold, subsidize their space services. In addition, the existing commercial market for space industry is not perfect, and other sectors of the economy, such as the banking, insurance, and financial investment sectors, are reluctant to support space programs and cooperative international projects because of the risks involved and the long-term payback. Furthermore, faced with the pressures of international competition, other countries with free-market systems have responded by subsidizing domestic producers. In the United States, for example, NASA has played the role of customer, developer of the technology, provider of assistance, and general focal point for commercialization efforts.<sup>31</sup>

They also argue that it is unrealistic to expect China's space industry to follow market-oriented principles within the existing structure of a centrally planned economy. History shows that there has been active government intervention in economic affairs in China since as early as 1848. Since the founding of the People's Republic of China in 1949, the dominant mode of production and distribution has been through state-owned industries. In such an environment, it is difficult to determine what portion of goods and services belongs to the state and what to private individuals. This fundamental difference between China and

Western countries is a source of continual controversy in connection with the issue of subsidization of space commercialization.

No matter what the result of the arguments, China's space industry will be continuously supported by government investment in R&D in the near future. More and more people are aware that an investment of 0.035 percent of GNP in space programs is hardly sufficient to keep China in the international club of space powers. In order to maintain and develop space capabilities that can match those of advanced countries, the government is considering an increase in the space budget. This point of view was explicitly expressed by Minister Ding Henggao (COSTIND) in his speech at the Forum on Aerospace Technology Developing Plan in April 1994 in Beijing.<sup>32</sup>

However, as an economically underdeveloped country, China can not change the situation overnight. The government investment in space technology will continue to be very limited in contrast with advanced countries because other economic sectors like transportation, energy resources, and communications are more closely related to the overall development of the national economy. Accordingly, China's space industry must search for other sources of financial support besides state investment.

At the beginning of each space project, the space industry could first raise funds from those government agencies that would benefit from the specific space program. For example, the Ministry of Post and Telecommunications uses communications satellites as one of its communications business services; the State Bureau of Meteorology uses the photographs and remote sensing data from meteorology satellites for weather forecasting and monitoring of natural disasters; the Ministry of Agriculture and Forests can mitigate the losses caused by natural disasters and increase the productivity of the fishing industry by 13 percent with the aid of earth observation satellites.<sup>33</sup> Other government agencies also reap economic benefits from applied space technology. Therefore, with support from the central government the space industry could raise development funds from many agencies.

For commercial space projects, the space industry could also take loans from central banks and specialized banks such as the Agriculture Bank of China, the Industrial and Commercial Bank of China (ICBC), and the Communications Bank of China. The space industry has accumulated rich experiences in this regard. For example, the ICBC Shanghai Branch gave full support to the manufacturing of the Long March-3 carrier rocket in 1992, when the branch agreed to loan RMB 31 million yuan (\$5.6 million) to the Shanghai Aeronautical Bureau, a local research facility affiliated with the China Aerospace Industry Corporation and assigned to manufacture many parts of the rocket. In 1991 and 1992, the ICBC Shanghai Branch had already provided some RMB 54.5 million yuan (\$9.9 million) in low-interest loans for the manufacture of the Long March-3 rocket.<sup>34</sup>

Also, in 1995, the China Import and Export Bank functioned as a guarantor for a credit of \$100 million taken by the Asian-Pacific Satellite Telecommunication Ltd. (APT), which had applied for a \$230 million loan from a French bank. The loan will be used for launching the Apstar-1A and Apstar-2R satellites in late 1995 and early 1997, respectively. In view of the fact that the Chinese side has provided 48 percent of the total investment in these projects, the China Import and Export Bank was willing to provide such a credit guarantee.<sup>35</sup> These examples have proved that taking bank loans is a practical and efficient way for China's space industry to raise funds as a supplement to insufficient state investment. And, bank loans encourage the development of space technology in an efficient manner.

## E. Making Use of GATT/WTO Membership

Next, China could continue negotiations on its membership in the General Agreement on Tariffs and Trade/World Trade Organization (GATT/WTO). As one of the world's largest international economic organizations, GATT/WTO's purpose is to promote just and fair free trade and economic growth in the world. China has negotiated for membership in GATT/WTO for more than nine years. Although many problems are yet to be resolved, the Chinese Government is still working hard to reach this goal. In view of the expectation that China is likely to return to the organization no later than 1996, China's space industry should evaluate the impact of China's entry into GATT/WTO on its international activities, and adopt appropriate measures to fully enjoy its proper rights and undertake the tasks ahead.

Without GATT/WTO membership, China's space industry has been unable to participate fairly in competitions for international activities. After China returns to GATT/WTO, however, this will no longer be the case. China would considerably enhance the quality and level of its science, technology, and industry after returning to GATT/WTO. China's space industry can make direct use of the favorable conditions of GATT/WTO to bring in more advanced foreign components, technologies, equipment, and even prototypes. This will certainly result in a significant reduction in development expenses, in shortened periods of development, and in upgraded space technologies. Consequently, the technological level of China's space industry could be greatly enhanced.<sup>36</sup>

Entry into GATT/WTO presents both opportunities and challenges for China's space industry. It is a good opportunity, however, because the advantages outweigh the disadvantages. As a member of the organization, China could establish better relations with the international space community and develop its own space technologies more rapidly.

## F. Setting Priorities

China should establish a set of goals and priorities for its space programs in line with its limited financial resources. Based on the key technical breakthroughs that China's space industry has made, these goals and priorities should take into account advanced technologies and the most urgent commercial demand at home and abroad. China's space industry should strengthen its efforts in basic research while tracking the latest technical developments of developed countries. To reach these goals, China's space industry should make the following efforts before the year 2000: first, continue to improve the launch, control, and telemetry capabilities of the Long March family as launch vehicles; second, develop new-type application satellites with higher reliability and longer operating lives; third, promote high-capacity communications satellites, weather satellites, and multifunctional earth resources satellites; fourth, develop advanced ground systems; and fifth, develop manned space flight technology to reach the goal of building an unmanned spacecraft.<sup>37</sup>

By setting circumscribed goals, China's space industry could focus its limited funds on the techniques and products in urgent need of upgrading, and push forward the programs that are critical for the development of the national economy in the near future. Of course, extended international exchanges are helpful for setting limited goals. After reaching these goals, China could participate in international space programs in cooperation with developed countries on an equal basis.

## G. Selective Goals in International Cooperation

China's space industry should diversify the types of international exchange it participates in, with a focus on quality improvement. China is now pursuing a strategy of exchanging selective technologies in international cooperation. Space exploration and development are arduous tasks that require the joint efforts of several countries over several decades. Along with the advancement of space technologies, steadily increasing amounts of investment are required in order to achieve major breakthroughs in key technologies. China recognizes this trend, and is making an attempt to play an active role in promoting cooperation in international space activities. However, international space technical exchange is politically sensitive, because developed countries will not easily transfer such high technologies to other countries.

Over the past fifteen years, China has made much progress in international space cooperation. Judging from practical experience, especially under present-day conditions, China should make a great effort to improve the quality of international technical exchange in order to diversify cooperative programs with foreign countries. The following activities are considered to be appropriate for international cooperation:

1. Governmental agreements or accords are the fundamental element of all kinds of space cooperation and technical exchange. China has already signed intergovernmental accords or agreements on space issues with several countries. China should continue to work with the governments of selected countries to reach bilateral and multilateral agreements for promoting the development of Sino-foreign joint space programs and technical exchanges at different levels. The Chinese Government should continue to encourage key government agencies and industrial sectors to maintain extensive contacts with their counterparts in most of the developed and developing nations, and to exchange information and views on bilaterally interesting space projects. Both sides should sign an intergovernmental accord once they have reached a mutual understanding on space development or certain space issues. These intergovernmental agreements could easily dictate all kinds of space technical exchanges, and therefore facilitate smooth cooperation at all levels.
2. Providing commercial satellite launch services is a good way for China's space industry to enter the international space market. Since 1990, China has successfully conducted five launches of foreign-made satellites, at low cost and with considerable reliability. These satellite launch services have further trained Chinese space engineers, enhanced China's international prestige, and brought financial benefit to the nation. Recent failures, however, have greatly hampered the efforts of the Chinese to enter into the international market. It is time to reconsider the reliability and compatibility of the Chinese-made space products with foreign satellites. If permitted by the Agreement on Satellite Technology Safeguards and the Interface Control document, the Chinese side as a supplier of launch services should provide the flight sequence and data of the rockets and acquire as much data as possible on satellites, especially the vibration frequencies. Before each launch, a joint evaluation and failure analysis group should be established, and its findings should be accepted by both the Chinese side and satellite manufacturers.

China can offer launch services to foreign customers at competitive prices because Chinese rockets are made primarily of domestic materials and components that are much cheaper than those sold on the international market; also, China's labor cost is much lower than that of Western countries.<sup>38</sup> Low pricing, which has been the most important reason for China's share of the international satellite launch market until now, will continue to attract

foreign customers in the future. To maintain this momentum, China is planning to generalize, standardize, and serialize its space products, including subsystems and components of satellites and launch vehicles. If so, the Chinese can further reduce the cost and increase the reliability of Chinese rockets.

Another favorable method of improving China's satellite launch services in international cooperative programs is to establish a space launch joint venture with foreign companies. For example, China's space industry can draw lessons from the newly created Lockheed-Khrunichev-Energia International (LKEI), a joint venture formed to market the Russian Proton rocket. In a related development, Lockheed Martin unveiled plans in June 1995 to market the Atlas and Proton rockets together in package deals. Packaging Atlas with Proton could also give Lockheed Martin a competitive advantage by giving customers added flexibility, and could provide customers an alternative in case one rocket is grounded by failure. In 1994 alone, LKEI signed up several customers for an undisclosed number of Proton launches for the Russian side.<sup>39</sup> LKEI has four launches scheduled for 1996, beginning with the Astra 1F direct broadcast satellite for Société Européenne des Satellites of Luxembourg. This launch will be followed by the Tempo direct broadcast satellite for Space Systems/Loral of Palo Alto, California in the second quarter of 1996. Next will be a satellite for the International Mobile Satellite Organization (Inmarsat) of London, and then for PanAmSat of Greenwich, Connecticut.<sup>40</sup>

Based on LKEI's successful experiences, China's space industry could single out a few Western space companies with good credit, and establish a joint venture. With a focus on the Asian-Pacific region, the venture could offer launch services for Western satellites. According to a Sino-American accord concluded in March 1995, China is allowed to launch eleven satellites to geostationary transfer orbit over the next seven years, in addition to another four already under contract. This quota is good for China. In the coming years, China will also launch twelve Globalstar satellites by one Long March-2E rocket, and twenty-two Iridium system satellites by eleven Long March-2C rockets to low Earth orbit in accord with the ongoing negotiations with Space Systems/Loral and the contract with Motorola. Therefore, the number of commercial launches will total twenty-seven in the next seven years, about four launches per year. Because it will be difficult for China to acquire such orders in fierce competition with Russian Proton and Ukrainian Zenit rockets at the same modest price, a Sino-foreign joint venture should be established in the near future.

3. As an Asian country, China is in a competitive position in the crowded international space launch market because many developing countries in Asia are not capable of developing and launching satellites. Furthermore, the demand for ground systems will grow as result of the increasing number of satellites being launched into orbit. For example, there has been increased demand for C-band communication earth stations from Southeast Asian countries such as Pakistan, Thailand, Myanmar, and the Philippines after the launch of the Asiasat-1 broadcast and communication satellite.

There are many signs that the satellite launch service market in the Asian-Pacific region will grow rapidly in the coming years. The delivery of satellite television programs to cable systems and broadcast stations or directly to residences is the fastest growing satellite service in the region. The satellite television market in Asia is expected to grow from nine million in 1994 to about twenty-two million in 2004. By the end of 1995, there will be more than forty satellites serving the region, with more than one thousand transponders in total; and, according to conservative estimates, the total number of transponders in the Asian-Pacific

region will be doubled by the end of 2000. Simultaneously, the demand for corresponding ground systems will also greatly increase.<sup>41</sup>

Because it possesses workable space technologies, China is in a favorable position among countries in the Asian-Pacific region with regard to international space competition, and should set up regional space technology joint ventures with countries in the region. Recognizing that the satellite communications market was crowded, China in 1993 began discussions with Singapore, Malaysia, Thailand, and U.S. Hughes Space and Communications International Inc. to establish the Asia Pacific Mobile Telecommunications Satellite Pte. Ltd. (APMT) in Singapore. To date, the partners have signed a primary contract and reached most of the operating agreements. The total investment of the company is approximately \$1 billion, and the Chinese side will hold 75 percent of the shares. COSTIND, the Ministry of Electronics Industry, and the China Aerospace Industry Corporation participated in the joint venture as partners. The company plans to procure a geostationary communications satellite to provide broadcasting and telephone services to all Asian countries. The company has not yet chosen a manufacturer for the satellite, which is expected to be launched in late 1997.<sup>42</sup>

4. In developing countries, environmental problems caused by industrial development are worsening, and natural disasters cause huge losses every year. The governments of various countries have started to attach greater importance to these problems, and plan to spend more money on using space technology to solve them. Most of the countries of the world are increasingly making use of weather information and environmental monitoring. Accordingly, there is room for international space cooperation in the field of earth observation and remote sensing. China will have three or four stationary meteorology satellites and earth resources satellites in sun synchronous and geosynchronous orbits by the end of 1997, enhancing its satellite remote sensing capability. Providing and exchanging remote sensing data and satellite photographs with other countries, especially the Asian countries, will benefit China and its partners.

## Conclusion

Facing unprecedented competition in the international space launch market, the central authorities in Beijing should support the efforts of China's space industry to break a new path in cooperation with world space powers. The top leadership should dictate a national strategy on international cooperative space projects, based on a thorough analysis by government agencies and space industrial facilities of China's past international collaboration in space. The strategy should consist of principles for urging China's space industry to engage in certain international cooperative space projects closely related to the nation's space development goals and overall economic development program.

Beijing must exercise unified leadership over international cooperative space projects, and must take solid measures to make the Space Leading Group as powerful as the famous CCP Central Special Commission. The group must be granted the authority to exercise concerted leadership and provide overall direction to ensure that China's space industry is capable of carrying out its assignments in the joint projects.

In order to fill the gap between the space technologies of China and those of developed countries, China's space industry should focus its limited funds on upgrading the most needed techniques and products and pushing forward the programs most critical for the

development of the national economy in the near future. Specifically, efforts should be focused on making breakthroughs in key space technologies.

In order to maintain and develop space capabilities that can match those of advanced countries, the state should increase investment in space industry and explore new financial sources. An investment of 0.035 percent of GNP in space programs is insufficient to keep China in the international club of space powers. One strategy is for the space industry to first raise funds from those government agencies that would benefit from the specific space program under development, and then to pursue bank loans that would encourage the development of space technology in an efficient way. As a member of GATT/WTO, China could establish better relations with the international space community and develop its own space technologies more rapidly.

Finally, China should improve the quality of technical exchange in international cooperation in an attempt to diversify cooperative programs with foreign countries. In view of the fact that governmental agreements or accords are the fundamental element of all kinds of space cooperation and technical exchange, China should continue to work with the governments of selected countries to reach bilateral and multilateral agreements for promoting the development of Sino-foreign joint space programs and technical exchanges at different levels. For example, China could set up regional joint ventures in space technology with countries in the Asian-Pacific region. The Chinese Government should continue to encourage key government agencies and industrial sectors to maintain extensive contacts with their counterparts in most of the developed and developing nations, and to exchange information and views on bilaterally interesting space projects. Providing and exchanging remote sensing data and satellite photographs with other countries, especially the Asian countries, will benefit China and its partners. Although many difficulties remain to be overcome, there is room yet for China to further develop its space industry through extensive international cooperation.

## Notes

<sup>1</sup> Xie Guang et al., *China Today: Defence Science and Technology* (Beijing, 1992), pp. 368–469.

<sup>2</sup> JPRS-CST-93-002, China Report, "Spaceflight Development Strategy; Medium, Long-Term Program for S&T Development," 27 January 1993, p. 7.

<sup>3</sup> Zhang Jun, chief editor, *Dangdai Zhongguo de Hangtian Shiye* [Contemporary China's Space Cause] (Beijing, 1986), p. 106.

<sup>4</sup> John W. Lewis and Hua Di, "China's Ballistic Missile Programs," *International Security* 17, no. 2 (Fall 1992): 5–8.

<sup>5</sup> Yanping Chen, "China's Space Commercialization Effort—Organization, Policy and Strategies," *Space Policy* (February 1993): 48–49.

<sup>6</sup> JPRS-CST-94-004, China Report, "Vice Administrator of CNSA Analyzes Space Activities in China," article by Wang Liheng, p. 4.

<sup>7</sup> FBIS-CHI-94-104, "Space Industry Expands Worldwide Cooperation," 31 May 1994, p. 36.

<sup>8</sup> Unless otherwise cited, the information in this section is from interviews with Chinese space specialists, 1995.

- <sup>9</sup> JPRS-CST-92-013, "China, ESA Cooperate on Multipoint-Detection Satellite Project," 29 June 1992, p. 42.
- <sup>10</sup> JPRS-CST-92-004, "PRC Delegation Discusses Joint Space Project in Brasilia," 20 February 1992, p. 1.
- <sup>11</sup> FBIS-CHI-94-167, "News Analysis on Future of Space Industry," 29 August 1994, pp. 46-47.
- <sup>12</sup> Yanping Chen, "China's Space Commercialization Effort," p. 50.
- <sup>13</sup> FBIS-CHI-92-239, "Article Views Launching of Australian Satellite," 11 December 1992, pp. 20-25.
- <sup>14</sup> Wang Liheng, "An Analysis of China's Space Activities," *Zhongguo Hangtian* [Aerospace China] (Beijing), no. 10 (1993): 4-6.
- <sup>15</sup> Ding Henggao, "Accelerating the Development of Space Technology to Meet the Challenge from the New Decade," *Weixing Yingyong* [Satellite Applications] (Beijing), no. 3 (1994): 1.
- <sup>16</sup> JPRS-CST-91-001, China Report, "Head of Space Technologies Research Institute Outlines Future Satellite Applications," January 4, 1991, p. 4.
- <sup>17</sup> The information in this and the next paragraph is from Ding Henggao, "Accelerating the Development of Space Technology," p. 2.
- <sup>18</sup> Chen Daoming, "A Review of China's Broadcast Communications Satellites," *Dianxin Kuaibao* [Telecommunications Information] (Shanghai), no. 5 (1989): 2-7.
- <sup>19</sup> The information in this and the next two paragraphs is from FBIS-CHI-94-169, "Beijing 'Widely Using' Remote Sensing Research," 31 August 1994, p. 20.
- <sup>20</sup> JPRS-CST-90-007, "Prospect for Chinese Applications Satellites Reviewed," 6 March 1990, p. 24.
- <sup>21</sup> JPRS-CST-94-019, China Report, "Prospects for Development of China's Space Technologies Reviewed," 5 December 1994, p. 24-25.
- <sup>22</sup> JPRS-CST-91-009, China Report, "Overview of Technological Development and Applications of Communications Satellites," 8 May 1991, p. 1.
- <sup>23</sup> Yanping Chen, "China's Space Commercialization Effort," p. 49.
- <sup>24</sup> Gordon Pike, "Chinese Launch Services—A User's Guide," *Space Policy* (May 1991): 110.
- <sup>25</sup> "Fact Sheet on the Memorandum of Agreement Between the U.S. and PRC regarding International Trade in Commercial Launch Services," U.S. Department of State, Washington, D.C., 1989.
- <sup>26</sup> David J. Jefferson, "Rocket to Reality," *Wall Street Journal*, 9 November 1990.
- <sup>27</sup> Deng Shuchu, "China's Satellite Applications—Current Status, Problems and Suggestions," *Weixing Yingyong*, no. 2 (1994): 5.
- <sup>28</sup> JPRS-CST-93-012, "Chinese Say AUSSAT-B2 Failure Not Fault of Long March Launch Vehicle," 29 June 1993, p. 11.
- <sup>29</sup> Patrick Seitz, "Hughes, Chinese at Impasse On Cause of Rocket Failure," *Space News*, July 31-August 6, 1995, p. 1 and p. 20.
- <sup>30</sup> JPRS-CST-93-021, China Report, "Chinese Say AUSSAT-B2 Failure Not Fault of Long March Launch Vehicle," 29 June 1993, p. 11.
- <sup>31</sup> Barbara A. Stone, "Space Commerce: Preparing for the Next Century," paper delivered at the 42nd Congress of the International Astronautics Federation (IAF), Montreal, Canada, IAA-91-643, October 5-11, 1991.
- <sup>32</sup> Ding Henggao, "Accelerating the Development of Space Technology," p. 5.

- <sup>33</sup> JPRS-CST-93-015, China Report, "The Strategic Position and Role of Space Activity in China," 15 September 1993.
- <sup>34</sup> JPRS-CST-92-012, China Report, "Bank Gives Full Financial Support to Space Industry," 18 June 1992, p. 47.
- <sup>35</sup> Geng Zhizhong, "Import and Export Bank Providing Credit Guarantee for APT," *Renmin Ribao* [People's Daily], overseas ed., 19 September 1995, p. 2.
- <sup>36</sup> JPRS-CST-93-015, China Report, "Impact of GATT on Nation's Space Industry Analyzed," 15 September 1993, p. 22.
- <sup>37</sup> Based on Liu Jiyuan, "The Strategic Position and Role of Space Activity in China," *Aerospace China* (Beijing), no. 5 (1993): 4. As president of the China Aerospace Industry Corporation, Liu is in charge of China's space industry.
- <sup>38</sup> JPRS-CST-90-019, China Report, "Aerospace Vice Minister on Launch Services Policy," 23 July 1990, p. 17.
- <sup>39</sup> Warren Ferster, "U.S. Firms Lock Horns Over Launch Quotas," *Space News*, June 12-18, 1995, p. 1.
- <sup>40</sup> Warren Ferster, "Rocket Makers Plan Upgrades To Bolster Market Share," *Space News*, May 15-21, 1995, p. 19.
- <sup>41</sup> Patrick Seitz, "Analysis Predicts Temporary Satellite Surplus for Asia," *Space News*, May 29-June 4, 1995, p. 8.
- <sup>42</sup> Patrick Seitz, "Cutting-Edge Technology Reaches New Markets," *Space News*, August 7-13, 1995, p. 8.

## Center for International Security and Arms Control Stanford University

Please send orders to: Publications, 320 Galvez Street, Stanford, California 94305-6165. Enclose check payable to Stanford University. Add \$2.00 postage and handling for first item ordered (\$5.00 for overseas delivery), \$1.00 for each additional item. Foreign orders must be in U.S. dollars and drawn on a financial institution with branches in the United States. California residents, add appropriate sales tax.

### *Center reports, working papers, and reprints*

- Assessing Ballistic Missile Proliferation and Its Control*. 1991 (181 pages, \$14.00; summary \$3.00).
- Andrei Baev, Matthew J. Von Bencke, David Bernstein, Jeffrey Lehrer, and Elaine Naugle. *American Ventures in Russia*. Report of a Workshop on March 20-21, 1995, at Stanford University. 1995 (24 pages, \$7.00).
- David Bernstein. *Software Projects in Russia: A Workshop Report*. 1996 (28 pages, \$7.00).
- David Bernstein, editor. *Defense Industry Restructuring in Russia: Case Studies and Analysis*. 1994 (244 pages, \$14.00).
- George Bunn and Wolfgang K. H. Panofsky. *Arms Control, Compliance, and the Law* (working paper). 1988 (26 pages, \$5.00).
- George Bunn. *Does the NPT require its non-nuclear-weapon members to permit inspection by the IAEA of nuclear activities that have not been reported to the IAEA?* 1992 (12 pages, \$4.00).
- General George L. Butler, Major General Anatoli V. Bolyatko, and Scott D. Sagan. *Reducing the Risk of Dangerous Military Activity* 1991 (39 pages, \$6.00).
- Charles T. Call. *From "Partisan Cleansing" to Power-Sharing? Lessons for Security from Colombia's National Front*. 1995 (60 pages, \$7.00).
- Cooperative Security in Northeast Asia* (text in English and Russian) 1993 (17 pages, \$4.00).
- David Dessler. *Talking Across Disciplines in the Study of Peace and Security: Epistemology and Pragmatics as Sources of Division in the Social Sciences*. 1996 (40 pages, \$7.00).
- Sidney D. Drell and Thomas H. Johnson. *Technical Trends and Strategic Policy*. 1988 (41 pages, \$9.00).
- Lynn Eden and Daniel Pollak. *Ethnopolitics and Conflict Resolution*. 1995 (21 pages, \$5.00).
- Anthony Fainberg. *Strengthening IAEA Safeguards: Lessons from Iraq*. 1993 (64 pages, \$6.00).
- Alexander L. George, David M. Bernstein, Gregory S. Parnell, and J. Philip Rogers. *Inadvertent War in Europe: Crisis Simulation*. 1985 (80 pages, \$10.00).
- Seymour Goodman et al. *Building on the Basics: An Examination of High-Performance Computing Export Control Policy in the 1990s*. 1995 (85 pages, \$14.00).
- Seymour Goodman. *The Information Technologies and Defense: A Demand-Pull Assessment*. 1996 (48 pages, \$9.00).
- John R. Harvey, Cameron Binkley, Adam Block, and Rick Burke. *A Common-Sense Approach to High-Technology Export Controls*. 1995 (110 pages, \$15.00).
- John Harvey and Stefan Michalowski. *Nuclear Weapons Safety and Trident*. 1993 (104 pages, \$12.00; summary \$2.00).
- Ji, Guoxing. *Maritime Security Mechanisms for the Asian-Pacific Region*. 1994 (25 pages, \$5.00).
- Leonid Kistersky. *New Dimensions of the International Security System after the Cold War*. 1996. (34 pages, \$8.00)
- Allan S. Krass. *The Costs, Risks, and Benefits of Arms Control*. 1996 (85 pages, \$8.00).
- Gail Lapidus and Renée de Nevers, eds. *Nationalism, Ethnic Identity, and Conflict Management in Russia Today*. 1995 (106 pages, \$12.00).
- John Lewis and Coit D. Blacker, editors. *Next Steps in the Creation of an Accidental Nuclear War Prevention Center*. 1983 (45 pages, \$8.00).
- Liu, Huaqiu. *China and the Neutron Bomb*. 1988 (49 pages, \$9.00).
- John J. Maresca. *The End of the Cold War Is Also Over*. With commentaries by Norman M. Naimark, Michael May, David Holloway, Arthur Khachikian, Daniel Sneider, and Renée de Nevers. 1995 (60 pages, \$8.00).
- Michael May. *Rivalries Between Nuclear Power Projectors: Why the Lines Will Be Drawn Again*. 1996. (20 pages, \$7.00)
- Michael May and Roger Speed. *The Role of U.S. Nuclear Weapons in Regional Conflicts*. 1994 (24 pages, \$5.00).
- Michael McFaul, ed. *Can the Russian Military-Industrial Complex Be Privatized?* 1993 (60 pages, \$6.00).
- Robert F. Mozley. *Uranium Enrichment and Other Technical Problems Relating to Nuclear Weapons Proliferation*. 1994 (64 pages, \$9.00)

- John M. Owen. *Liberalism and War Decisions: Great Britain and the U.S. Civil War*. 1996 (22 pages, \$5.00).
- Wolfgang K. H. Panofsky. *Do We Need Arms Control If Peace Breaks Out?* (lecture). 1990 (9 pages, \$4.00).
- William J. Perry. *Defense Investment: A Strategy for the 1990s*. 1989 (43 pages, \$9.00).
- Theodore A. Postol. *Possible Fatalities from Superfires Following Nuclear Attacks in or near Urban Areas* (reprint). 1986 (57 pages, \$3.00).
- Scott D. Sagan, ed. *Civil-Military Relations and Nuclear Weapons*. 1994 (163 pages, \$12.00).
- Scott D. Sagan and Benjamin A. Valentino. *Nuclear Weapons Safety after the Cold War: Technical and Organizational Opportunities for Improvement* (text in English and Russian). 1994 (25 pages, \$5.00).
- Judith Sedaitis, ed. *Commercializing High Technology: East and West*. 1996 (336 pages, \$18.00).
- Capt. Alexander Skaridov, Cmdr. Daniel Thompson, and Lieut. Cmdr. Yang Zhiqun. *Asian-Pacific Maritime Security: New Possibilities for Naval Cooperation?* 1994 (28 pages, \$5.00).
- Song, Jiuguang. *START and China's Policy on Nuclear Weapons and Disarmament in the 1990s*. 1991 (29 pages, \$5.00).
- Konstantin Sorokin. *Russia's Security in a Rapidly Changing World*. 1994 (95 pages, \$10.00).
- Roger D. Speed. *The International Control of Nuclear Weapons*. 1994 (59 pages, \$11.00).
- Terence Taylor. *Escaping the Prison of the Past: Rethinking Arms Control and Non-Proliferation Measures*. 1996 (65 pages, \$10.00).
- Terence Taylor and L. Celeste Johnson. *The Biotechnology Industry of the United States. A Census of Facilities*. 1995 (20 pages, \$7.00).
- The Transformation of the Asian-Pacific Region: Prospects for the 1990s* (conference report) 1991 (191 pages, \$15.00).

#### *Selected books available from other publishers*

- Herbert L. Abrams. *The President Has Been Shot: Confusion, Disability, and the 25th Amendment in the Aftermath of the Assassination Attempt on Ronald Reagan*. New York: W.W. Norton, 1992.
- Coit D. Blacker. *Hostage to Revolution: Gorbachev and Soviet Security Policy*. New York: Council on Foreign Relations, 1993.
- Coit D. Blacker and Gloria Duffy, editors. *International Arms Control: Issues and Agreements*. Second edition. Studies in International Security and Arms Control. Stanford: Stanford University Press, 1984.
- George Bunn. *Arms Control by Committee: Managing Negotiations with the Russians*. Studies in International Security and Arms Control. Stanford: Stanford University Press, 1992.
- Gordon H. Chang. *Friends and Enemies: The United States, China, and the Soviet Union, 1948-1972*. Stanford: Stanford University Press, 1990.
- Sidney D. Drell. *Facing the Threat of Nuclear Weapons*. Revised edition. Seattle: University of Washington Press, 1989.
- Sergei Goncharov, John W. Lewis, and Xue Litai. *Uncertain Partners: Stalin, Mao, and the Korean War*. Stanford: Stanford University Press, 1993.
- Robert Hamerton-Kelly. *The Gospel and the Sacred: The Poetics of Violence in the Gospel of Mark*. Fortress Press, 1994.
- David Holloway and Norman Naimark, editors. *Reexamining the Soviet Experience: Essays in Honor of Alexander Dallin*. Boulder, CO: Westview Press, 1996.
- David Holloway. *Stalin and the Bomb: The Soviet Union and Atomic Energy, 1939-1956*. New Haven: Yale University Press, 1994.
- John Wilson Lewis and Xue Litai. *China Builds the Bomb*. Studies in International Security and Arms Control. Stanford: Stanford University Press, 1988.
- John Wilson Lewis and Xue Litai. *China's Strategic Seapower: The Politics of Force Modernization in the Nuclear Age*. Studies in International Security and Arms Control. Stanford: Stanford University Press, 1994.
- Michael McFaul. *Post-Communist Politics: Democratic Prospects in Russia and Eastern Europe*. Washington, D.C.: CSIS, 1993.
- Michael McFaul and Sergei Markov. *The Troubled Birth of Russian Democracy: Parties, Personalities, and Programs*. Stanford: Hoover Press, 1993.
- Norman M. Naimark. *The Russians in Germany: A History of the Soviet Zone of Occupation*. Cambridge: Belknap/Harvard University Press, 1995.
- Scott D. Sagan and Kenneth N. Waltz. *The Spread of Nuclear Weapons: A Debate*. New York: W W. Norton, 1995.
- Scott D. Sagan. *The Limits of Safety: Organizations, Accidents, and Nuclear Weapons*. Princeton: Princeton University Press, 1993.
- Condoleezza Rice and Philip Zelikow. *Germany Unified and Europe Transformed: A Study in Statecraft*. Cambridge: Harvard University Press, 1995.

July 1996