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The Rapid Progress of China's Space Development

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1 Introduction

In October 2003, China successfully launched and recovered a manned spacecraft, becoming the third country, subsequently to the United States and Russia, to do so. Underlying the feat are not only technical achievements steadily accumulated over 40 years of aiming towards space, but also rapid transformation of social systems, including reforms in science and technology systems. Under policies for sustainable economic growth, ambitious research and development and operation of manned space flights can be expected to continue into the future. This article will analyze the organizational systems behind China's thriving space development, its past achievements, and its future prospects. In addition, this article will look at a journal published by a major Chinese space technology research institution and examine the spread of themes and the regional distribution of authors in order to uncover a cross-section of trends in China's space technology research.

2 China's space development systems and research organizations

China's space development system formerly centered on the Ministry of Aerospace Industry, but in June 1993 the China National Space Administration (CNSA) was established directly under the State Council. In addition, the implementation sector for space activities was separated from the government and transferred to the state-owned enterprise China Aerospace Corporation. Following further reorganization and name changes, CNSA ceased to be under the State Council and was placed under the Committee on Science and Technology Industry for National Defense (COSTIND), as shown in Figure 1. The China Aerospace Corporation was divided into the China Aerospace Corporation (CASC) and the China Aerospace Science and Industry Corporation (CASIC).

CASC became a special enterprise assuming all responsibility for research and development and manufacture of the spacecrafts that are at the center of China's space activities, including manned spacecrafts and geosynchronous satellites. Under its umbrella are heavy industrial manufacturers such as China Great Wall Industry Company (CGWIC) and research organs such as the Chinese Academy of Space Technology (CAST) and the China Academy of Launch Vehicle Technology (CALT). CAST publishes the journal that this article examines.

The organization in charge of launching satellites into orbit by launch vehicles is the China Satellite Launch and Tracking Control General (CLTC), which is under the umbrella of the General Equipment Department of the People's Liberation Army, which in turn is directly under the National Central Military Commission. It has three launch bases in Xichang, Jiuquan, and Taiyuan and tracking control centers in Xi'an.

Other research organs related to space include the Institute of Remote Sensing Applications (IRSA), which is under the umbrella of the Chinese Academy of Sciences (CAS) directly under the State Council, and the National Remote Sensing Center under the Ministry of Science and Technology (MOST).

3 Overview of achievements in Chinese space development

3-1 Chinese satellite launches

Table 1 shows the situation of Chinese satellites launches, most of which utilized Changzheng (Long March) launch vehicles, from the first (1970) through the most recent (April 2004). China has successfully placed 60 satellites in orbit during this period.

From Table 1, we can see that the types of missions have greatly increased since 2000. In addition, China also has satellites except for those shown in the Table 1. They include commercial communications satellites owned by Hong Kong corporations launched via Changzheng or foreign launch vehicles (US Atlas, etc.) and a small satellite launched by Russian Cosmos launch vehicle.

Turning next to the number of Changzheng launches by launch site, in Table 2 we see that Xichang, which launches geosynchronous satellites has launched 36; Taiyuan, which launches polar-orbit satellites, has launched 15; and Jiuquan, which launches low-altitude orbit

Figure 1 : The organization of Chinese space development

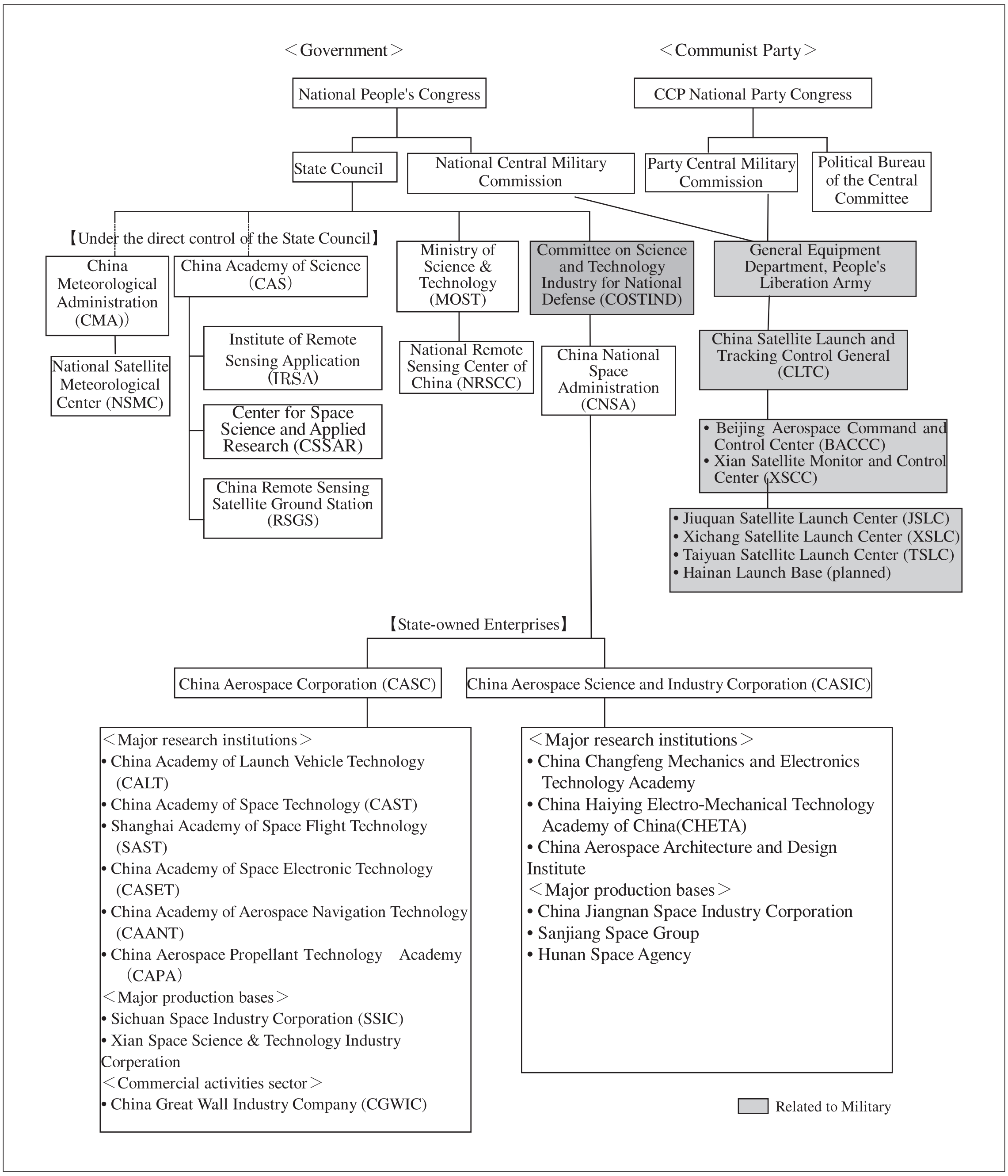


Table 1 : Number of satellites launched by China by 5-year period

Period	Satellites launched (number failing to achieve orbit)	Names of successful satellites (number)
1970-74	2	Dongfanghong 1 Shijian 1
1975-79	3	Fanhuishi (3)
1980-84	8 (1)	Dongfanghong 2, Fanhuishi (3), Shijian 2 (3)
1985-89	9	Dongfanghong 2A (3), Fengyun 1A, Fanhuishi (5)
1990-94	11 (1)	Dongfanghong2A, Dongfanghong3, Fengyun1B, Shijian 4, Fanhuishi (5), Atmosphere(2)
1995-99	10 (1)	Dongfanghong 3, Fengyun 1C, Fengyun2A, Fanhuishi, Shijian 5, Ziyuan1 (CBERS1), Shenzhou, Communications satellites (2)
2000-04 (through April)	20	Shenzhou(4), Fengyun1D, Fengyun2B, Beidou (3), Sino Star (2), Fanhuishi, CBERS2, Ziyuan 2 (2), Haiyang 1, Chuangxin 1, Tance 1, Shiyan 1, Naxing 1
Total	63 (3)	

Table 2: China's rocket launches (launch sites)

Period	Xichang	Taiyuan	Jiuquan	Total launches
1970-74			3 (1)	3(1)
1975-79			3	3
1980-84	3(1)		2	5(1)
1985-89	3	1	5	9
1990-94	10 (3*)	1	5	16 (3)
1995-99	12 (3)	9	2	23 (3)
04 (through April)	8	4	5	17
Total	36 (7)	15	25 (1)	76 (8)

Parentheses ( ) represent failed launches.
* In July 1990, one of two satellites in a payload failed.

satellites, has launched 25. There have been 8 failed launches (including a partial failure), giving the Changzheng a success rate of 89.5 percent (In case count 7.5 failures for a success rate of 90 percent). Through April 2004, there have been 34 consecutive successful launches since the last failure, in August 1996.

Figure 2 presents the successful launch rates of major launch vehicles so that we can compare China's launch vehicle with those of other countries. So that they can be compared under the same conditions, the launch vehicles are compared every 10 launches. We can see that like US's and European launch vehicles, China's launch vehicle has overcome some early failures and raised its success rate.

3-2 Overview of missions to date

(1) Recoverable satellites

China launched 18 Fanhuishi (recoverable) satellites from 1975 through November 2003. Their missions were photography (film recovered) and microgravity experiments (materials science and life science samples recovered). China carried out not only their own microgravity experiments but also French and German experiments. The method of firing retro engines at orbital separation to reduce speed and descending by parachute is the same used by the Russian Soyuz manned spacecraft. No doubt the achievement of the Chinese manned spacecraft Shenzhou(Magic Vessel) owed much to China's experience with recoverable satellites.

Advances in technology have lengthened the mission duration of recoverable satellites from their original 3 days to 15 days. Because recoverable satellites do not have solar batteries, that was achieved through increases in primary battery capacity.

Of the 18 recoverable satellites, 1 was not recovered. Launched in 1993, the 15th recoverable satellite, the Jianbing, entered an uncontrollable orbit farther from the earth when the retro engine fired to deorbit for reentry. The world was faced with the crisis of being unable to predict where a spacecraft that would not completely burn up in the atmosphere would fall to the Earth. Finally, it landed in the Southern Pacific and caused no damage.

(2) Earth observation

China has launched four Fengyun (Wind and Cloud) 1 meteorological satellites and two Fengyun 2 geosynchronous satellites. In addition, recently China has launched a succession of Earth observation satellites such as the Ziyuan(Resources) and the Haiyang(Ocean) developed from the joint China-Brazil Earth Resources Satellite (CBERS). Those satellites are relatively small, but are loaded with multiple observation instruments such as multiband CCD cameras.

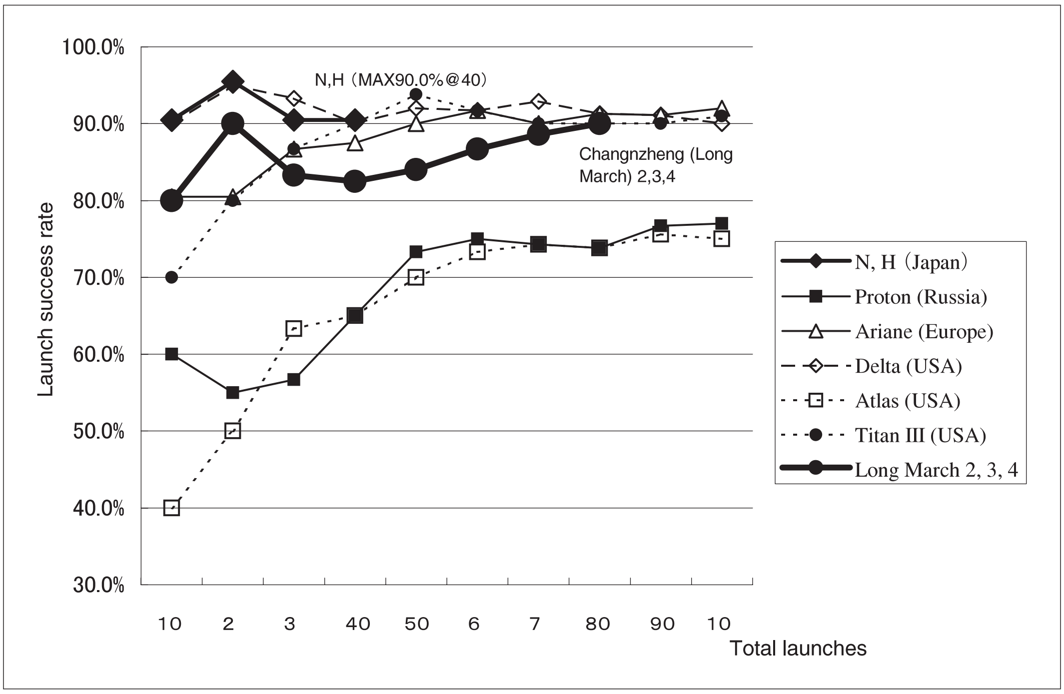
In December 2003, China launched the environmental observation satellite Tance (Probe) 1 that it jointly developed with the European Space Agency (ESA) into equatorial orbit. Together with Tance 2 in polar orbit, the project is called Shuangxing (Double Star)[1]. In April 2004, the Ministry of Science and Technology and the ESA held a symposium to open the Dragon Program, which utilizes data provided by the ESA's ENVISAT environmental observation satellite to study water and air pollution, and forest, marine, and water resources, and so on[2].

(3) Communications and broadcasting

As for its own geosynchronous communications satellites, since 1984 China has launched the Dongfanghong(East is Red) 2, Dongfanghong 2A, and Dongfanghong 3. Within China, they are held to have contributed to the development of China's spacecraft technology and satellite communications utilization technology. The Dongfanghong 3 is a full-scale geosynchronous communications satellite utilizing triaxial attitude control and carrying 24 transponders. Although operation of the first one, launched in 1994, was abandoned due to a fuel leak in the following year, the second one, launched in 1997, has already been operating for seven years. Its planned life is eight years.

Communications demand in China is growing rapidly. For eample, 5 million new mobile phone subscribers being added every month. For satellite communications, China does not rely solely on satellites it launches itself, but actively pursues a full satellite lineup by purchasing new foreign made satellites, leasing them from foreign corporations, and purchasing ownership rights to satellites already in orbit.

Figure 2 : Success rates for rockets from various countries at every 10 launches



(4) Navigation satellites

The satellites currently utilized for the Global Positioning System (GPS) are the US NAVSTAR and the Russian GLONASS. In addition, Europe is working on the Galileo program. China has launched three Beidou (Dipper) geosynchronous satellites as its own navigation satellites. China has not made public detailed information about the satellites, but they are positioned at 80°, 110°, and 140° east longitude and are used for navigation work in road, railway and marine traffic. In contrast to orbiting satellites, there is no need to send positioning data to geosynchronous satellites, so their systems are quite different. It is also thought that those satellites are unable to carry out positioning alone.

(5) Manned spacecraft

China launched the first experimental Shenzhou spacecraft in 1999 and completed preparations for a manned mission with three more launches through 2002. In October 2003, China successfully launched and recovered a manned spacecraft. China's first astronaut was Yang LiWei, a 38-year-old lieutenant colonel in the Astronaut Team of the People's Liberation Army.

The Shenzhou 5 comprised of four modules, an orbital module, a reentry capsule, a propulsion module, and additional parts. The orbital module remained in orbit after separating from the reentry capsule, and spent the next approximately six months carrying out experiments in space environment measurement, completing them in March 2004[3].

(6) Engineering test satellites

The Naxing(Nanosat) satellite launched in April 2004 is a 25-kilogram microsatellite developed at Tsinghua University. It utilizes a CMOS camera for topographical scanning, testing the creation of high-resolution topographical maps[4]. Other engineering test satellites include the Chuangxin(Innovation) and the Shiyan(Test).

4 Future prospects for space development

Xu FuXiang of the Chinese Academy of Space Technology believes that space technology and space applications will be industrialized and marketized and that the development and use of space resources will meet broad demands in economic growth, national security, and science and technology development in the long-term outlook for space development [5]. China's goal is to combine various functions and orbits in diverse systems to create a complete space infrastructure and build a network system that integrates space and Earth. With that sort of outlook, several missions and the development of satellite technologies can be expected to move forward in the near future.

4-1 Development goals by mission

Looking at media such as the People's Daily, Beijing Review, and China News, various mission plans are enthusiastically reported.

(1) Earth observation satellites

Launch of the Tance 2 global environmental observation satellite jointly developed with the European Space Agency (ESA) is planned for the end of July[6]. Launch of the third and fourth CBERS resource monitoring satellites jointly developed with Brazil is also planned in order to bring them into constant use[7]. In the future, China can be expected to work towards stable monitoring centered on the National Remote Sensing Center under the Ministry of Science and Technology and utilizing data from various types of Earth observation satellites.

(2) Communications and broadcast satellites

China is currently developing the Dongfanghong 4 for launch in 2005. It is projected to carry 38 C-band (telephone use) and 16 Ku-band (television broadcast use) transmission devices, a large increase over the Dongfanghong 3. Its expected mission life is to be 15 years, double that of the Dongfanghong 3[8].

(3) Satellite positioning systems

In addition to its own Beidou geostationary satellites, China has begun cooperating with the European Galileo project. With the USA and Europe reaching an agreement in June 2004 to cooperate on navigation satellites, worldwide use of navigation satellites, including by China, is expected to accelerate.

(4) Manned space flight and microgravity experiments

China plans a manned space flight with a two-person crew lasting several days in 2005. China's goal is a three-person flight lasting several days in about 2006. Currently 14 astronaut candidates are training[9]. On future manned flights, scientific experiments in space materials science and life science carried out on unmanned flights are expected to be carried out with the support of astronauts.

(5) Space environment monitoring

In June 2004, the Chinese Academy of Sciences announced a plan to place three solar wind observation satellites in differing orbits at altitudes of 700, 50,000, and 150,000 kilometers with a single launch by 2011. It would study solar winds and other aspects of the space environment in conjunction with the joint US-Russian-European-Japanese International Solar-Terrestrial Physics (ISTP).

(6) Deep space exploration

In February 2004, the Committee on Science and Technology Industry for National Defense announced a planned December 2006 launch for the ChangE(name of goddess ascended to the moon) 1 lunar surface probe[10]. It said that the plan for the first probe is entirely produced in China, without foreign cooperation, and that manufacture and testing of measuring instruments are already complete. It is considering joint development with foreign countries from the second probe onwards. The Committee said that China will land a lunar rover by about 2010, and by 2020 it will reach the stage of returning. In the future, China plans to harvest useful resources such as helium-3 and use them as energy sources. The United States and Europe are showing interest in Chinese lunar exploration from the second probe on.

Deep space exploration missions farther than the Moon are still a matter for the future, but China has indicated it will launch a Mars probe by 2020. For the long-term, China's goals are to stake out a relatively weighty position in the world's space science field and to develop its own characteristic research.

4-2 Technical goals for satellite development

China has following technical development goals in mind common to satellite missions[5].

(1) Prioritize development of technologies for satellite onboard mission equipments.
(2) Develop commonized platforms for satellites. By choosing from several types of platforms for satellite series such as geosynchronous satellites, polar-orbit satellites and recoverable satellites, time required for satellite development could be reduced, costs lowered, and reliability improved.
(3) Optimal design for the satellite as a whole, precision attitude control, new solar battery technology, space microelectronics technology, space data safety technology, autonomous satellite flight, space lightweight structures and mechanisms, large deployable and multiband antennas, advanced freezers for use in space, etc.
(4) Strengthen research and development in space application technologies such as GPS and communications and broadcasting.

4-3 Provision of data obtained by satellites to Asia-Pacific countries

At the 60th meeting of the Economic and Social Commission for Asia and the Pacific (ESCAP) in April 2004, Luan EnJie, the head of the China National Space Administration indicated China's intention to provide observation data to developing nations in the Asia-Pacific region from its constellation of small Earth observation satellites in order to lessen damage from disasters and so on. China states that in 2003 alone, 200 million people were victims of natural disasters that did over 180 billion yuan in damage[11]. China is attempting to actively use data obtained through satellite technology to lessen such damage. Having already become a "possessing country" through the rapid development of its space development activities, China is attempting to spread those blessings not only to its own disaster policies, but also to its neighbors in the Asia Pacific region.

5 Analysis of papers on space development

We need to know what kind of technical research underlies China's achievements and future prospects as described above. Below are the results of an examination of that aspect.

5-1 Overview by technical sector

The journal of China Space Science and Technology (published by the China Academy of Space Technology) is the medium for the most advanced space-related articles in China in terms of content. Published since 1981, it appeared bimonthly last year, with six issues. By examining at it, we can see a sample of the research being carried out around China.

There were 71 articles published in the six issues that appeared in 2003. Table 3 shows their distribution by field.

Below I also introduce some of the interesting research found in individual articles.

(1) Finding optimal parameters for engines for Single Stage To Orbit (SSTO) systems

Single Stage To Orbit systems utilize a single-stage rocket to place satellites in orbit, with the rocket recovered on the ground keeping its figure. In research performed at Northwestern Polytechnical University (Xi'an City, Shaanxi Province) Tan SongLin (age 37) and collaborators are considering Vertical Ttakeoff/Horizontal Landing (VTHL). It requires main wings and so on for horizontal landing. With a weight of 1,007 tons, propulsion comes from seven tripropellant engines utilizing two types of propellants, a petroleum-based one and liquid hydrogen, and liquid oxygen as oxidant, with 200 tons of thrust each. A US corporation invented tripropellant engines. Near the ground, where the atmosphere is thicker, they utilize petroleum-based fuel, while in the upper atmosphere they switch to hydrogen in order to efficiently obtain thrust. Utilizing the mass of the body, tank, and other parts, thrust, combustion time, fuel changeover timing, and so on as variables, the researchers carried out optimal design, finding the possible parameters for placing a 15-ton satellite in Low Earth Orbit (LEO)[12].

(2) Manned spacecraft rendezvous

China has not yet actually performed a space rendezvous in which two or more spacecraft approach each other. However, it is possible that in the future it will have its own space station to which it will send manned spacecraft and resupply vehicle that will require rendezvous and docking. Zhu RenZhang (age 62) of Beijing University of Aeronautics and Astronautics and collaborators carried out research on acceleration and deceleration during approach for manned spacecraft rendezvous. They are unique in studying the use of engine firing to reduce the astronaut's field angle (equivalent to the angle of attack as an aircraft lands) as the chaser satellite draw near the target satellite[13].

(3) Analysis of human errors in manned spacecraft

With Chinese manned space activities soon to become longer in duration, Zhou QianXiang (age 34) of Shanghai JiaoTong(Transportation) University and collaborators analyzed human errors in US Apollo and Soviet Soyuz spacecrafts. They suggest that measures against human errors should be taken in spacecraft design[14].

First, they introduced case studies of human errors in space activities and statistics concerning their timing. Next, they evaluated the process of human awareness and ability of attention. They are studying topics such as the sharing of works between human and machine, response times for display, as means to prevent human errors. While it is inevitable that astronauts must perform some work, the authors believe that the roles of robots and artificial intelligence as "helpers" should be optimized, leaving astronauts as much as possible to make only high-level decisions.

A point worthy of notice is their study of personal spatial separation aboard spacecraft for stranger who is not known by astronauts. That is a suggestion useful less for the case of the three astronauts not only Chinese army colleagues but also ordinary people joining missions for some purpose.

There is nothing technically new in the article, but the research is related to improving reliability in China's manned space flights beyond minimum necessity.

(4) Wavelet transform

In recent years, wavelet transform that can simultaneously analyze time data and frequency data is being used in various applications. Zhong Ping (age 24) of the National University of Defense Technology (Changsha City, Hunan Province) and colleagues carried out research on applying wavelet transform to find meaningful outlines in image data with much noise. They were able to obtain more detailed outlines than with conventional analysis methods such as Sobel filters[15].

Even though it is a graduate student article, it seems unusual for a military-related research institute to publish research on image analysis that it directly applicable to reconnaissance.

5-2 Distribution of author affiliations

The top five affiliated institutions for authors are shown in Table 4.

The top five institutions account for about 60 percent of the articles. The institution accounting for the most articles is the National University of Defense Technology, which is under the People's

Table 3 : Fields and major keywords of articles appearing in China Space Science and Technology during 2003

Field			No. of articles	Major keywords
Overall	1	Overall plans	1	◎ Achievements and prospects (authored by Xu FuXiang)
Mission-critical systems	19	Manned flight	1	◎ Human error
		Propulsion	3	◎ Single stage to orbit (SSTO) ◎ Tripropellant engines ◎ Liquid oxygen, Liquid hydrogen Microdetonation thrusters
		Parachutes	2	Rigid models Expansion simulation
		Reentry vehicles	9	Reentry vehicles
		Tracking control	4	Orbit-determining algorithms
Systems utilized in space	18	Satellite design	2	Fuzzy logic
		Space experimentation	3	Mutants
		Earth observation	3	◎ Wavelet transform
		Communications	3	Column-array despun antennas
		Orbital design	7	Formation flight, Genetic algorithms
Technical research	33	Reliability	1	Neural networks
		Sensors	1	Synthetic aperture radar
		Electricity	1	Solar battery panels
		Space environment	2	Atomic oxygen, Space debris
		Structure	2	Modal cost analysis
		Information processing	2	Asynchronous transfer models (ATM)
		Heat control	3	Heat contact resistance, Coatings
		Attitude control	4	Secondary nonlinear filters, Kalman filters
		Mechanisms	4	Flywheels, Pulse tube freezers
		Guidance and control	13	◎ Space rendezvous ◎ Chaser satellite, Target satellite

◎ :described in text.

Table 4 : Number of the 71 articles published in 2003 by institution (top 5)

National University of Defense Technology (Hunan Province)	15
Chinese Academy of Space Technology (Beijing)	10
Beihang University (Beijing)	9
Harbin Institute of Technology (Heilongjiang Province)	7
Nanjing University of Aeronautics and Astronautics (Jiangsu Province)	6

Liberation Army. The journal's publisher, the Chinese Academy of Space Technology (CAST) is second. It is notable that the three universities ranking third through fifth are all affiliated with the Committee on Science and Technology Industry for National Defense. Most of the universities ranked sixth and below, such as Beijing University, are affiliated with the Ministry of Education.

Although it may seem as if CAST is not a military organization, one can see that its actual research involves close industry-academia-military cooperation beyond dual use.

Looking at the research of the military-related universities, they engage in an extremely wide range including not only guidance control and information processing related launche vehicles, but also Earth observation technology and satellite mechanisms related to early warning satellites.

5-3 Analysis of works cited

Result of cited reports divided into types in the 71 articles is shown in Table 5.

The number of Chinese domestic reports cited is approximately 200, with the number of domestic journal articles and books and other publications cited about the same.

Of the foreign articles cited, particularly common were those of the Institute of Electrical and Electronics Engineers (IEEE) with 52 citations and the American Institute of Aeronautics and Astronautics (AIAA) with 30, as well as 7 from NASA reports. No citations of reports with Japanese authors were found.

In the past it appeared that China obtained much of its space technology from the Soviet Union, but recently with many students returning from study abroad like the USA and engage research works in home country, it seems that they have great interest in the latest information from Europe and US where technological innovation is so remarkable.

Table 5 : Number of cited reports divided into types

Chinese domestic journals	102
Chinese domestic publications	103
Foreign articles	191
Foreign publications	30
Conference proceedings	21

6 Social changes underlying the rapid progress of space development

China is undertaking to reform its science and technology systems, improve its antiquated customs in state-run enterprises, achieve sustainable economic development. Furthermore, it is actively working to upgrade its trade control systems. We must not overlook the fact that underlying the rapid progress of China's space development are rapid changes in social systems. Below I will introduce some of those trends.

(1) Reformation of science and technology policies

In August 2003, Shen Hua of the Bureau of Science and Technology Policies, China Academy of Sciences, gave an address in Tokyo regarding China's aim to reform its science and technology systems[16]. In her address, she spoke of China's drive for all-out reform to optimize national research institutes by 2010 and the goal of upgrading about 80 research bases. Along with those reforms, China will implement policies to attract outstanding human resources. In its personnel systems it will carry out evaluation systems designed to bring out the positiveness of human resources such as compensation based on results and competitive selection.

(2) Improvement of antiquated customs in state-run enterprises

In China they refer to the vested interests of the state-run enterprises that are harming national economic development as the "three irons". The "three irons" are the "iron rice bowl" (no bankruptcies), the "iron wage" (guaranteed wages), and the "iron armchair" (lifetime employment). In the past China's state-owned enterprises in the space sector also suffered those ills. Since we hear of the outcry of those losing their vested interests even in Japan, we can be sure that reform is actually taking place.

(3) Sustainable economic development

Regarding China's rapidly developing domestic economy, there is concern both at home and abroad that constraints on resources such as energy, water, and food will limit growth. With large numbers of the rural population moving to cities, energy and other major problems are expected to become even more serious. In response, the Chinese government has made sustainable economic growth a national strategy and is providing political guidance wherever possible. Utilization of space technologies such as Earth observation and positioning will become even more important.

(4) New trade control systems

Beginning January 1, 2004, the Ministry of Commerce and the Customs General Administration jointly implemented a "sensitive commodities and technology export permit control register" based on the Foreign Trade Law. That was a necessary revision of domestic law allowing China to join the Nuclear Suppliers Group (NSG) and the Missile Technology Control Regime (MTCR). At the NSG meeting in Sweden in May, China became a member. In June, China formally declared its intention to join to the MTCR. Once membership is achieved, even technology that can be directly applied to the manufacture of missiles and reentry vehicles can be exported from Japan to China or from China to Japan with permits.

7 Conclusion

In this article, I have outlined the achievements of approximately 40 years of Chinese space development, current organizational systems, current and future goals, and the background of social change. As exemplified by the impressive achievement of manned space flight, in recent years in particular space development and space utilization have begun exhibiting results amidst China's rapidly growing economy.

Types of satellite missions are increasing rapidly, with new projects in previously untested fields such as lunar probes and space environment monitoring making swift progress. In space transportation, the continuous successes of the Changzheng (Long March) launch vehicle are expected to bring its successful launch rate above 90 percent.

In the field of international cooperation, China has already jointly manufactured and launched an Earth observation satellite with Brazil. In the future, its cooperation with the European Union (EU) will also be noteworthy. From the perspective of contributing to the international community, how to allow the nations of the Asia-Pacific region to utilize the results of China's space technologies will be an issue for China as a "possessing country". Already China has made clear its intention to provide information to Asia-Pacific countries from its constellation of small satellites to reduce the impact of disasters.

In addition, through research papers on space development, China is carrying out broad research on its own space development and utilization that ranks with that of the United States, Russia, Europe, and Japan. In the field of manned space flight in particular, one receives the impression that China is carrying out its research more ambitiously than other countries. If innovative space transportation systems such as SSTO begin to be realized, the impact on the world's space development will be great.

China's progress in the field of space development cannot be explained solely through increased technical prowess. Underlying that progress are reforms in personnel systems in science and technology, maintenance of the nation as a whole on the path of sustained economic growth, revision of trade control systems, and other changes in social systems that make China remarkably different from how it was in the end of 20th century.

Rather than merely observing the rapid progress of China's space development as it has been doing for the past several years, Japan should be asking what it can learn from Chinese research and development trends and changes in social systems.

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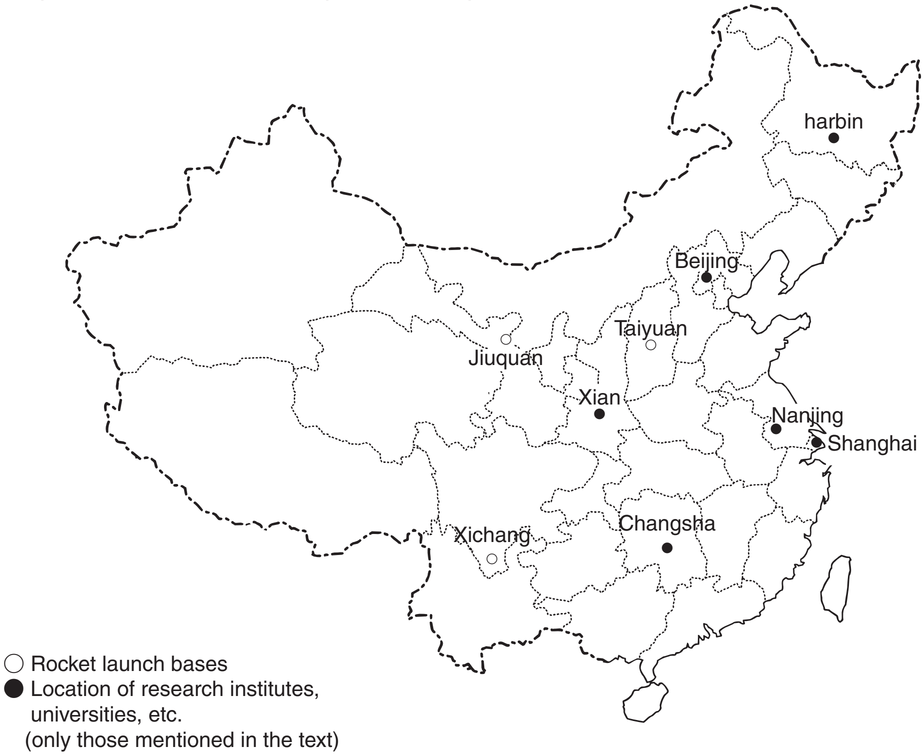
Map of centers of China's space development activities



(Original Japanese version: published in July 2004)