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Chapter 3

The Role of Hsue-shen Tsien in the Foundation of China Academy of Space Technology*

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Abstract

The China Academy of Space Technology (CAST) was founded on February 20, 1968. The first President of CAST was Dr. Hsue-shen Tsien. He played an important role in the process of foundation for CAST. This chapter will introduce the establishment of CAST and the major works done by Dr. Hsue-shen Tsien at that period, including his decisions, thoughts, and other contributions.

I. Introduction

Dr. Hsue-shen Tsien (December 11, 1911 – October 31, 2009) is also called QIAN Xuesen in China. Dr. Qian was a famous scientist who made important contributions to the missile and space programs of China. In November 1943, Qian was one of the founders of the Jet Propulsion Laboratory. In 1949, Qian was appointed as the Director of the Jet Propulsion Laboratory. He left the United States in September of 1955 on the passenger ship SS *President Cleve-*

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land, arriving in China. His work led to the development of the Chinese space program. He was the "Father of the Chinese space program." In 1957, he was elected an academician of the Chinese Academy of Sciences. In 1979, Qian was awarded the California Institute of Technology's Distinguished Alumni Award for his achievements. In 2008, he was named *Aviation Week and Space Technology*'s Person of the Year. In 2001, Asteroid 3763 Qian Xuesen are named after him. He was also awarded the "Two Bombs and One Satellite" meritorious service medals, as well as the honorary title "National Outstanding Contributions of Scientists," from the Chinese government.

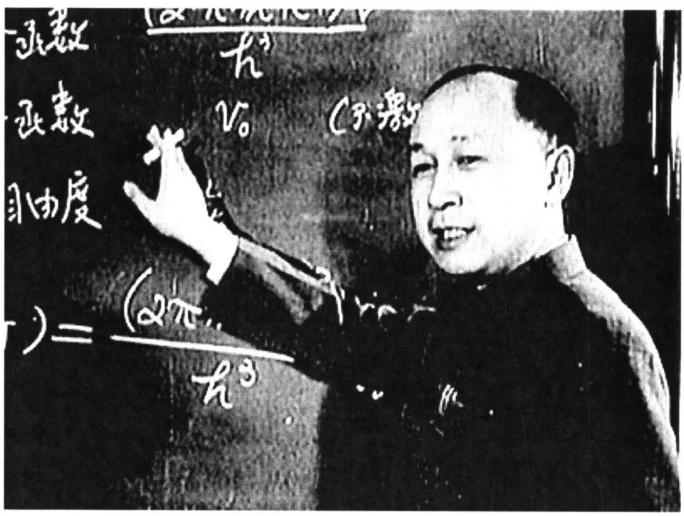

Figure 3–1: Dr. Qian Xuesen in 1960s. Credit: CAST.

Figure 3–2: Dr. Qian Xuesen with Chairman Mao (1956). Credit: CAST.

CAST was founded in 1968, currently with more than 20,000 staff members. The main business of CAST is to develop Chinese space technology and spacecraft. CAST has developed and manufactured nearly 200 spacecraft since April 24, 1970 when China's first artificial Earth satellite was successfully launched. The missions mainly include six aspects, which are: manned space flight, deep-space exploration, navigation and positioning, Earth observation, communication and broadcasting, and experiments of space science and technology. CAST also provides DC/AITC with spacecraft, satellite ground applications and customer-oriented service, such as training.

Figure 3–3: Headquarters of CAST from 1968–2000. Credit: CAST.

Figure 3–4: Current Headquarters of CAST. Credit: CAST.

II. Preparation Before the Founding of CAST

September 17, 1955: Qian and his family boarded the passenger Liner SS *President Cleveland*, and embarked on a return trip to China.

October 8, 1955: Qian finally came back to China, he said, "I have always believed I would be able to return to the motherland, and today, I finally came back."

February 17, 1956: Qian proposed the "Establishment of China's Defense Aerospace Industry" report on China's development of rockets, missiles, and space technology. It was here he made suggestions in terms of management, research, design, and production.

October 8, 1956: Chinese Defense Ministry officially announced the establishment of the fifth Research Academy, Qian was appointed as the President. This marked the foundation for Chinese missiles, space industry, and is a historic anniversary.

October 4, 1957: The Soviet Union successfully launched the world's first artificial satellite, which has opened up new areas of human activity. The Chinese scientific community spoke highly of the great pioneering work. Many prominent scientists actively promoted China's space technology.

May 17, 1958: Chairman Mao Zedong put forward the grand vision, "We will also develop satellites," reflecting the Chinese people's determination to develop space technology and the ardent desire to further explore the universe.

August 1958: Qian was appointed as the head of the leading group responsible for planning satellite development. Chinese Academy of Sciences set up three academies responsible for system design of the satellite and launch vehicle development, satellite instruments, and satellite control.

November 1958: The academy for satellites and launch vehicles development moved from Beijing to Shanghai, and its name changed to Shanghai Mechanical and Electrical Academy.

January 1959: Chinese Academy of Sciences put forward a sounding rocket as the start, with high-altitude physical exploration as the foundation, thus continuing to explore the development of satellite technology.

February 19, 1960: Shanghai Electrical and Mechanical Academy launched the first practical sounding rockets: T-7M.

1961 to 1963: Qian, Zhao Jiuzhang, and other space pioneers, began to organize a forum to discuss ways to develop China's space technology, and encourage the exchange of academic views.

1963: The Committee of Space Flight was set up by the Chinese Academy of Sciences, led by Qian, Zhao Jiuzhang, and other pioneers. They were respon-

sible for planning the development of space technology and arranging some R&D activities, which laid a solid foundation for talent and technology preparation.

January 8, 1965: Qian proposed a plan to the National Defense Science and Technology Commission, entitled "Some Ideas About the Development of Satellites," suggesting the early formulation of China's satellite development program. Zhao Jiuzhang from the Institute of Geophysics also made similar suggestions.

1965 was a year of great significance as a turning point for Chinese space activities. During that year, China's space enterprise transitioned from years of academic preparation, into a well-planned, step-by-step engineering development period.

September 1965: Chinese Academy of Sciences set up an Institute of Satellite Design, which began the system design of the satellite, with Qian Ji as president. In the end of November 1965, the overall design of China's first artificial satellite had been reviewed, the subsystems technical design, manufacture, and tests started. Meanwhile, under the leadership of the chief engineer, Wang Xiji (who was inducted into the IAF Hall of Fame in 2016), the overall design of the launch vehicle and recoverable (FSW-0) satellite were also in progress at the Shanghai Mechanical and Electrical Academy.

Due to historical reasons, the resources of China's first artificial satellite and other spacecraft development is dispersed in the Chinese Academy of Sciences, Seventh Mechanical Industry Ministry, and some other sectors, which has brought many difficulties in management. Therefore, solving organizational problems has become a key issue in the development of the early stage. In early 1967, Vice Premier Nie presented the report, which proposed the formation of the Academy of Space Technology, and in August, the Preparatory Office was established. In November 1967, the National Defense Science and Technology Commission approved the proposed program made by the Preparatory Office led by Qian. Chang Yong determined the direction, mission, tasks, and constituent units of the new Academy, resulting in CAST.

III. Activities After the Founding of CAST

February 20, 1968: Qian was appointed as the first President of CAST. Institutes from the Chinese Academy of Sciences, like the Institute of Satellite Design, the Institute of Automation, the Southwest Electronics Research Institute, the Lanzhou Institute of Physics, the Beijing Scientific Instrument Factory, the Shanghai Scientific Instrument Factory, etc., served as the basis. These institutes worked in conjunction with the Shanghai Electrical and Mechanical Academy

and other related units, to formally establish the Chinese Academy of Space Technology. The direction of the academy was to gradually become the center, or core, of national space enterprise. The academy is responsible for national space technology research, the development of national space planning, and the organization, implementation, and coordination of space technology research. This included spacecraft design, prototyping, test, production, and space application.

May 1968: Qian worked to develop "Satellites, Spacecraft Development Planning for the Next Decade (draft)." Qian noted that satellite development should focus on providing services for the national economy, taking into account space exploration, so the development of application satellites is very important. In the blueprint planning, he suggested the development of scientific and technological experiment satellites, recoverable satellites, meteorological satellites, communication satellites, navigation and positioning satellites, manned spacecraft, etc. He proposed a three-step technology development strategy: "first go to LEO, to come back second, third to GEO." Under his promotion, China formulated the "Three satellites planning." The process called for the successful launch of the *Dongfanghong-1* satellite (the east is red, also called *DFH-1*), followed by the key development of a return satellite, then to develop GEO orbit communications satellites. This Technology Roadmap helped China's satellite enterprise take a huge step forward, in a short period of time, and laid a solid foundation for the future development, especially in manned space development.

CAST is the product of Chinese space activities developed to a certain stage. The establishment of the academy was an important step for the development of China's space projects. After its establishment, the academy gradually formed a relatively complete system of spacecraft research and development, and the main objective of "Satellites, Spacecraft Development Planning for the Next Decade," was achieved in 1976.

Considering the planned launch of China's first artificial satellite in 1970 or 1971, and the ten-year plan ratified by the government, Qian decided the first important mission for the academy was to make sure that China's first artificial satellite, *DFH-1*, would be completed on schedule. With the process developed by this satellite, his team better understood the laws and rules in technology and management. This helped to establish the necessary conditions for development, and laid a more solid foundation for the subsequent development of satellites in the plan.

Development of *DFH-1* began in 1965, and made great progress before the switch to the Chinese Academy of Space Technology. Before and after the academy was founded, its design had been further revised and improved by Sun Jiadong and other experts. Sun Jiadong was engaged in launch vehicle develop-

ment before 1967, and with the recommendation of Qian, he moved from his original unit to CAST. Jiadong was responsible for system design and development of *DFH-1* and later became President of CAST in the 1980s. Critical technology, like the "East is Red" music simulation instrument, short-wave antenna deployment, the satellite thermal vacuum test method, and other key technologies have undergone tenacious struggles to be deployed on schedule. The system test was also completed on time.

The development and launch of *DFH-1* satellite attracted attention from all over the country. The program got strong support from many people in China, ranging from national leaders to ordinary people. Premier Zhou Enlai chaired the *DFH-1* satellite development situation report many times, which was a strong impetus to the development process of other satellites. In March of 1970, the academy successfully completed the two-flight model final assembly, integration, and testing (with the backup model still preserved in CAST). On April 24, 1970, the *DFH-1* satellite was successfully launched by Long March-1. The perigee height of the satellite was 439 km, and apogee height was 2,384 km. The inclination was 68.5 degrees. The satellite weighs 173 kilograms, with a frequency of 20.009 MHz for broadcasting "The East is Red" music. China's *DFH-1* not only weighed more than the original design of 100 kg but it exceeded the total weight of the first satellite of the Soviet Union, the United States, France and Japan. The mission success of *DFH-1* satellite made a breakthrough for China's participation in space exploration, making China the world's fifth country to independently develop space technology. This was of great significance in the history of China's space developments.

In 1970, Qian was appointed as the Deputy Director of the National Defense Science and Technology Commission, no longer serving as President of CAST. Since then, the Chinese Academy of Space Technology has achieved:

March 3, 1971: China launched a scientific experimental satellite *Practice-1*, with eight years working time in orbit.

November 26, 1975: China's first recoverable satellite was successfully launched, making China the third country after the United States and the Soviet Union to master recoverable satellite technology.

April 8, 1984: China's first experimental communications satellite—*DFH-2* was successfully launched, establishing China as the world's fifth country to have geostationary satellites.

September 7, 1988: China launched an experimental meteorological satellite—*FY-1*.

October 31, 2000: The first navigation and position satellite, *Beidou-1A*, was successfully launched, making China the third country after the United States and the Soviet Union to master space navigation and position technology.

October 15, 2003: The first manned *Shenzhou-5* spacecraft carried the first Taikonaut, Yang Liwei, into space, making China the third country after the United States and the Soviet Union to master manned mission technology.

At this point, Qian's blueprint, "Satellites, Spacecraft Development Planning for Next Decade," drafted in 1968, was fully realized.

July 1973: The State Council decided that CAST would be officially merged into Seventh Mechanical Industry Ministry. Since then, the ministry has established a fully complete system for spacecraft and launch vehicles process of development.

March 8, 1982: The Seventh Mechanical Industry Ministry renamed the Ministry of Space Industry; CAST was still in this ministry.

April 9, 1988: The State Council decided to merge the Ministry of Space Industry and the Ministry of Aviation Industry together and renamed it the Ministry of Aerospace Industry. CAST belonged to this new ministry.

July 1, 1999: The State Council approved the establishment of the China Aerospace Science and Technology Corporation (CASC); CAST then became a part of this Corporation.

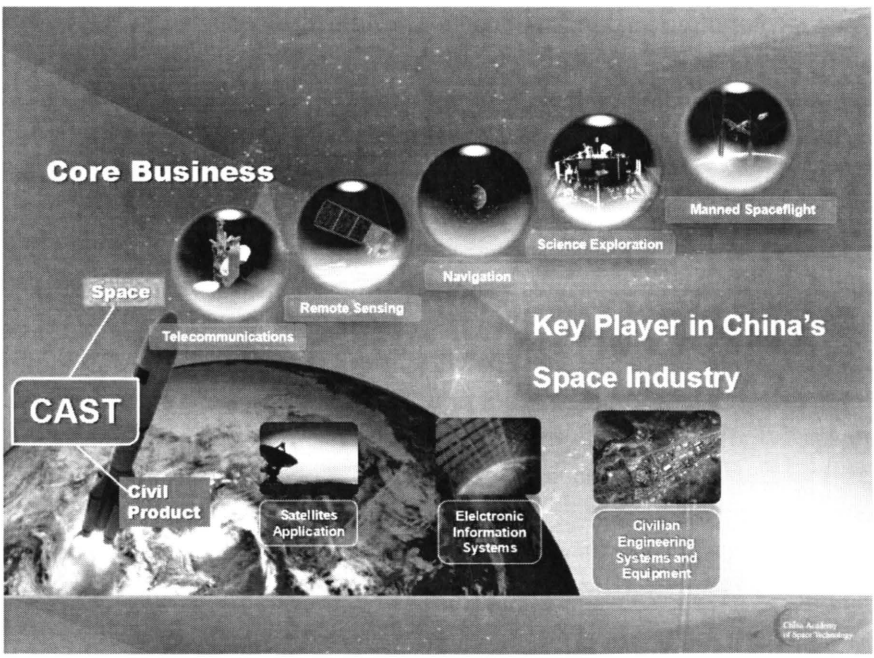

Figure 3–5: CAST's present businesses. Credit: CAST.

IV. Other Main Contributions

Systems Engineering Theory

Qian is the founder of systems engineering theory and methods in China. His experience in aerospace, as well as his knowledge and ideas on the development of China's aerospace systems, had a profound impact on this area. From the early 1970s to 1990s, China's aerospace engineering management systems continued to improve. China Systems Engineering gradually formed a complete theoretical system. In 1978, Qian published a paper, titled: "Management Technology for Organization—Systems Engineering." This article was identified as a milestone in the systems engineering development in China. In 1979, Qian proposed the establishment of systematics. In 1980, the China Systems Engineering Society was established, marking the popularization and application of systems engineering as a new stage. Two years later, he published the book, *On System Engineering*, the same year the Systems Engineering Theory and Application Research Institute was set up as a result of his suggestion.

System Design Department

Under the guidance of Qian, CAST formed the research and production organization system, with the System Design Department as a basis, supporting different missions. It strengthened the authority of the System Design Department in the whole process, overall planning, and comprehensive system-wide integration of technology, logistics, coordination, and management mechanisms. The System Design Department was the lead in the program, and was established in accordance with the feature of the mission. The System Design Department had "three functions, two properties." The three functions were: design, planning studies, and R&D projects. The two properties entailed technical decisions, organizational coordination, and management. The System Design Department was not only responsible for overall technical development, but also for organizational management. This system ensured the success of the space mission for many years in CAST.

Technology Condition and Infrastructure

At the beginning of CAST, the foundation was weak, and research conditions were very primitive. Qian led his colleagues to overcome difficulties one after another, made significant progress, especially in the system design, recoverable technology, control technology and other areas, thereby creating and nurturing a high technical level of the spacecraft development team. Management sys-

tems with corresponding effective rules and regulations, and a set of scientific management methods, were formed. Most of the units of CAST were from the Chinese Academy of Sciences, which was well practiced in fundamental theory, but not yet adapted to engineering. Spacecraft design, production, and testing were in need of further development, since there were only a few instrument and test facilities. At that time, import and purchase from foreign countries was impossible. The development of ground equipment and facilities became the responsibility of the new program and the relevant units in the country under strong domestic collaboration. Under the leadership of Qian, his colleagues overcame technological difficulties, developed a variety of technical equipment, and established a number of laboratories, dedicated workshops, precision turntables, large thermal vacuum chambers, etc. Much of the equipment and facilities were up to the national advanced level. To fill some gaps in the country, some projects reached the international advanced level, which created the necessary conditions for development of various space vehicles and technical research.