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by

Yang Jiachi, Xu Fangwen, Ye Peijian

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TITLE: CHINESE SPACE TECHNOLOGY'S SPIN-OFFS AND APPLICATIONS

AUTHOR: Yang Jiachi, Xu Fangwen, Ye Peijian

SUMMARY China, in the area of space technology, has already achieved successes which are the focus of attention throughout the world. At the same time, space technology has also gone through spin-offs and applications in what we call "engineering for civilian uses" in various areas such as industry, agriculture, geology, medical science, and so on. Because of this, we have produced a good number of new products and high technologies. This has also been a very great advantage to the development of China's society and economy. The Chinese Academy of Space Technology (CAST), for many years, has consistently devoted itself to the work of taking space projects in such areas as electronics technology, measurement or surveying technology, control technology, temperature control technology, vacuum technology, and other similar fields, and turning them into engineering for civilian uses, effectively promoting spin-offs. This article introduces important points concerning a number of results which have been obtained by the Academy in question's space technology spin-offs.

KEY TERMS Space Technology, Spin-off, Application, China

I. GENERAL

As is the case with other types of learning, technology is also a kind of knowledge which can be transformed in its applications. It is capable, from its original field of application, of going through development and expansion into other fields. In the middle 1950's, China began the creation of new technology research institutes. Going through several years of development, despite the fact that they achieved a good number of results in research, their influence on China's science and technology, however, was still limited. In the early 1960's, our country began studying rockets and satellites. This work required, within quite a good number of key fields of engineering, in the different stages from design and testing to production, the study of new technology, new industrial techniques, and new equipment. Only then was it possible to finally guarantee the required product precision, reliability, life, and similar technological requirements. Because of this, in the work of test

manufacturing space flight products, they achieved advances in development and, at the same time, also promoted the technological development of numerous fields of engineering. The first manmade earth satellite was sent into predetermined orbit and completed its predetermined missions, not only verifying the correctness of the design, but, in addition, also empirically verifying the correctness of the relevent materials, technology, industrial techniques, and production processes. It was effective to handle everything as one set, and peculiarly Chinese methods of management and quality control systems were also correspondingly established. In the last ten years, space enterprises have developed without a let up. Different models of manmade earth satellites have been test manufactured one after the other for different orbits, launched and operated successfully, and, in addition, driven a large scale high technology development.

Our country's political policies encourage and support taking the achievements of high technology and applying them to other fields, letting what has already been invested bring into play even greater social and economic benefits. The work of space technology going through developmental transformations into what we call "engineering for civilian uses" in industry, agriculture, medicine, and other similar fields of application has already, in the Chinese Academy of Space Technology (CAST), achieved gratifying results, producing a batch of new products and new technologies. This article makes a simple introduction of the important points associated with the status, problems, and intentions concerning areas of spin-offs and applications of space technology.

II. DEVELOPMENT AND APPLICATIONS OF SPACE ELECTRONICS AND TELEMETRY AND CONTROL SYSTEMS

Space technologies are very numerous. However, looking from the standpoint of the actual situation, due to the special nature of the space environment, with regard to electronic components used in space, onboard computers, measurement and control systems, and so on, they raise stern requirements. Satellite engineering ground systems, in the same way, demand high reliability, stability, precision, and real

time characteristics, as well as other similar qualities. This, then, led to the development of a series of electronics technologies, automatic control technologies, measurement technologies, and computer technologies. Going through a certain redevelopment, in areas of engineering for civilian uses, they have been tied together into a number of achievements, such as, standard (STD) main line industrial control devices, medical use X-ray TV systems, satellite ground receiving stations, new models of infrared railroad thermal axle control and measurement devices, oil field and oceanic buoy data collection stations, capacitive disonance self-adjusting control systems, and computer automated measurement and control systems (CAMAC), as well as other similar equipment.

1. STD Main Line Industrial Control Devices

STD main lines are just in the process of becoming one type of key industrial control device main line. Going through 5 years of effort, CAST has already successfully developed the STD5000 series industrial control devices. At the present time, they opt for 8088, Z80, MCZ-51, and MCS-96CPU. Over 60 types of modules have already been produced, satisfying many types of functions. At the same time, over ten types of software packages have been developed. They have already been widely applied in different systems, for example, pharmaceutical plants, sugar refineries, railroads, and digitally controled machine tools, with applications in temperature and pressure control, data collection, and process control, as well as other similar areas. Following the needs of the marketplace, 16 position control devices are also being paid serious attention to by people more and more every day.

2. Medical Use X-Ray TV Systems

As far as applied data processing technology and electronics technology are concerned, test manufacturing was done of medical use X-ray TV systems. In these, among the space applications that were also borrowed for use, choices have already been made to utilize high resolution graphics technology and phototube or pickup tube

technology. It is compatible with different X-ray producing devices and is capable of being used in the areas of medical diagnosis and treatment. This type of system has very little radiation damage, very high resolution, unusual stability, reliability, and other similar advantages. It is unusually suitable for use in clinical diagnosis. It is capable of carrying out position determinations on the locations of pathological changes, and it is not necessary to work in a darkroom. Because of this, the applications are extremely wide.

3. Satellite Surface Reception Stations

The principal mission of CAST is to develop applied satellites and, at the same time, adequately advance the applications of satellites. This has made us master relatively well satellite information reception and processing technologies. In the area of satellite data reception, we developed a good number of new technologies and new products. Through strenuous efforts, we also, very quickly, in the civilian area, developed a series of products associated with television ground single reception stations. These all had very great significance for the improvement of our country's television broadcasting quality and coverage area.

4. Infrared Railroad Thermal Axle Probe or Sounding Device

One of the biggest accidents in railroad operations is nothing else than the cutting off or severing of gudgeons due to the heat generated. Making use of satellite infrared level instrument technology, we developed a type of infrared railroad thermal axle probe device. It is capable of adaptation to a range of changes from low to high speed in trains, and is capable of adjusting to different types of engines, passenger cars, and freight cars. With the participation of computer intelligence technology, it is possible to automatically determine axle type, carry out calculation of vehicles, calculation of axles, and measurements of temperature. Through the network, it is possible to carry out supervision and control within a wide scope without human beings. Because of this, it is capable of reaching very high malfunction prediction rates and has already achieved broad applications in the Railroads Department.

5. Oil Field and Oceanic Buoy Data Collection Stations

Remote sensing, telemetry, remote control, as well as communication technologies, in satellite engineering, and, in particular, in satellite-ground systems, are four basic technological areas. As far as adequately making use of the superiority of these technologies is concerned, CAST developed fully automatic, unmanned, low power consumption, high reliability data collection systems. The typical applications are the carrying out of data collection in far flung oil fields and broad expanses of ocean. The systems in question are generally composed of two parts: the central control station and the on-site stations. On-site stations include industrial control devices, signal modulator and demodulator systems, and signal receiving and sending systems used in data collection. They are capable of supplying multiple circuit analog and on-off measurements. They are very clear. Central stations, besides signal modulation and demodulation, receiving, and sending systems, mainly also have information processing systems.

6. Capacative Dissonance Self-Adjusting Control Systems

The special requirement for satellite onboard computers is high reliability. Because of this, one opts for the use of capacitive dissonance self-adjusting technologies. These technologies successfully, in onboard satellite computer and control systems, have made their applications felt. Three years ago, this technology was successfully transfered to the Tianjin Oil Refinery's three machine capacitive dissonance control systems. When the occurence of external interference reached 20% over the normal state, the systems in question are capable of very rapidly restoring the normal state. The system composed of three machines guarantees, in situations with three machines, two machines, and one machine, normal system operations. This even extends to periods when all three machines are malfunctioning. It is possible, from the three machines, to reorganize a new system connecting them. This guarantees system operation. This system has very high control precision and very long average operating periods without malfunction, guaranteeing the possibility of off-line maintenance. As far as opting for this system

is concerned, the Tianjin Oil Refinery's product quality went up 0.66%. Product stability went up 1.59%. These increases have brought with them perceptible economic benefits for the plant in question.

7. CAMAC Systems

CAMAC systems are a universally used international computer automated measurement and control connection standard. Due to the requirements of satellite detection and measuring systems, several years ago, CAST cooperated with a good number of units within our country to develop CAMAC systems. At the present time, there are already approximately 108 CAMAC function modules in use. Examples are: telemetry modules, AC/DC modules, clock modules, connection or port driven control devices, and other similar modules. 5
Simultaneously with the developing of CAMAC systems, development was also done on two types of FORTH and BASIC language tools and they were used on CAMAC measurement systems. These measurement systems are capable of being used in carrying out analog, digital, and time duration measurments. Besides this, CAMAC is also capable of providing different control signals. Because of this, there are very broad future prospects for operational uses integrated by them. They have already become one of the key pieces of equipment in automated systems. For example, in electric generating stations, due to the fact that measurement and control of electrode and electric device networks possess a certain dangerous nature, CAMAC are then capable of acting as a measurement and control system that has good capabilities, high reliability, good stability, and good real time characteristics. Moreover, it has effectively made its effects felt.

III. OTHER SPACE TECHNOLOGY SPIN-OFFS AND APPLICATIONS

Besides the several items discussed above, CAST, in the last several years, in the area of spin-offs and applications of space technology, has also obtained the several main results below.

1. Information Processing

CAST made use of large amounts of photographs which it was holding and obtained from earth observation satellites. They also had the advantage of being equipped with good information processing equipment, strengthening the processing and applications of these photographs. This caused them to be socially and economically advantageous to the work of making a general investigation or survey of resources in our national territory in many such areas as geological conditions, general terrain surveys, hydrologic adjustments and research, forest resources, vegetation cover, and so on. This has strongly supported the development of the national economy.

2. Gyroscopic Platforms

The technology of gyroscopes and their platforms is traditionally one of CAST's most advanced technologies. They have already been utilized to advantage in numerous areas. One completely typical application is in the Railroad Department. Making use of this, it is possible to very quickly and accurately measure the degree of uneveness of rails.

3. Heat Tube Technology

Heat tube technology, in 1976, began to be used in satellite engineering. Heat tubes are a new type of system model which possesses fine heat conductivity. It is unusually well suited for large heat flows with small temperature differentials and heat transfers associated with non-moving parts. It possesses good reliability, good temperature regularity or consistency, a variety of structural types, broad temperatures of application, and other similar advantages. Besides this, heat tubes possess the special characteristics of temperature controlability and unidirectional heat transfer. Because of this, their uses are very broad. In 1980, we began taking these items of technology and transfering them to ground applications. Presently, we have already manufactured quite a number of good quality products, for example, heat tube thermostats. They

are used in the small heat tubes of plastic modules and electronic components, heat tube solar energy collection devices, as well as heat tube regulated energy boilers, and other similar devices. At the present time, heat tubes are in the midst of broad applications in electronics, instruments, textiles, chemical industry casting or foundry work, boilers, and other similar uses in various industrial departments and every day life.

4. Ion Beam Corrosion

Ion beam corrosion technology is a type of superprecision processing technology which has developed along with the processing of space materials. When the surfaces of solid objects are bombarded making use of ion beams, spattering effects are created in order to strip off and process or machine any geometrical figure on solid pieces of work. Due to the fact that the figures which they corrode or etch possess extremely high definition or resolution, the depth of the grooves and the angle of slant of the groove walls can be controlled, the lack of bore etching phenomena, as well as small surface stresses, and other similar advantages, this technology has already come to be a powerful means for research on and manufacture of large scale integrated circuits, acoustic surface wave devices, magnetic bubble devices, microwave devices, integrated optical circuits, superconducting devices, as well as infrared devices, and other similar apparatuses.

5. Magnetic Force Coupling and Power Transmission

Space flight is located in a type of high vacuum space environment. Because of this, magnetic force coupling and power transmission technologies have been developed. Rare earth boring type magnetic bodies are a new type of permanent magnetic material developed in recent years. Its magnetic energy accumulates to high levels, coercive or holding forces are great, magnetic forces are maintained for long periods of time and do not disappear, and it is possible to use multiple types of magnetic force shaft couplings, magnetic force coupling devices, and magnetic force power transmission

devices. They all possess advantageous points. For example, magnetic force coupling devices are capable of being used in the transmission of power in vacuum and high pressure containers, guaranteeing good sealing characteristics, eliminating leaks, and transmitting torque moderately. Also, if one is conerned with a magnetic force straight line power transmission device, it is possible to use it in vacuum or medium and high pressure vessels in reciprocating straight line motion or material tranport structures. At the present time, magnetic couplings and power transmissions are being applied in all such departments as oil fields, chemical industries, nuclear energy, hospitals, food, and so on. Moreover, the comprehensive benefits are obvious.

6. Weather Satellite Cloud Map Receiving Systems

Weather satellite observations have already become an indispensable means for weather forecasting activities and research in atmospheric science. Moreover, they are capable of providing services in such areas as industrial and agricultural production, aviation, maritime navigation, fishing, forestry, water conservancy, as well as military security, and so on. Making use of the signal reception, information processing, and computer technologies which were developed in satellite engineering, CAST test manufactured weather satellite cloud map receiving systems which are capable of tracking and receiving high resolution cloud map information sent by polar orbiting weather satellites and geosynchronous weather satellites. They are capable of separately transmitting analog and digital cloud maps, providing transmission displays of actual cloud map photographs, and providing computers for information storage and analytic processing.

7. Others

Besides the results of space technology spin-offs, which have already been presented above, several technologies which were formed in response to the development requirements of space projects, such as, low temperature technologies, industrial processes for materials,

industrial processes for processing or machining technolgies, semiconductor technologies, control technologies, recovery or retrieval technologies, optical technologies, radio technlogies, systems engineering technologies, large scale experimental technologies, microwave technologies, and so on, have also all, already, achieved redevelopment and reutilization in the realm of engineering for civilian uses. The scope in which applications are carried out and their geographical distribution are also extremely broad. A number of items have already entered the international marketplace.

IV. PROBLEMS AND CONCLUSIONS

From what has been said above, it is possible to see that CAST has already done a good deal of work with the spin-offs of space technology, and it has achieved many results. However, there still exist a number of problems. These problems block an even more effective technological transfer from space to civilian uses. The key questions are in the several areas below. Number 1. Technological transfer is not uniform. Some technologies transfer very well and have broad applications. But, there are quite a few technologies which still only exlusively serve in space research. Number 2. There are a number of items of technological transfer which have transfer periods that are excessively long and development costs which are excessively great. As a result of this, benefits are not large, even to the extent of being counterproductive. Number 3. A number of technological transfers do not have clear operational objectives. They are relatively blind in nature. Finally, in the process of transfering space technology to civilian uses, cooperation and mutual coordination within the Academy and outside was not adequately close. At times, this even created duplication of work. Because of this, earnest study and resolution of the problems discussed above is an important operation which should be put on the agenda. Only when this is done will it be possible, in the work of transfering technology, to use the smallest cost to achieve the greatest benefit.

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CAST functions as a unit for China's high technology research. It takes on the responsibility of exhausting its own efforts to help the development of industry for civilian uses and to seeing that they make use, to the greatest extent possible, of the results of space technology spin-offs. In order to realize this desire, CAST will continuously implement the current policy direction, opening up a step further the field of view. Moreover, it will exert its efforts to take a good grasp on the three items of work below. Number 1. Nurture even more men of talent who are happy exerting their efforts in the work of transfering space technology. Number 2. Strengthen the leadership power and organization of work in the development of products for civilian use. Number 3. Coodinate even better the utilization of various types of technology between development units. We believe that, in various areas of common effort and cooperation, the work of applying spin-offs from China's space technology must be taken a step forward in development, achieving even more numerous and gratifying results.

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* Xu Fangwen and Ye Peijian are Senior Engineers at CAST.

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