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CHINA AEROSPACE CONTROL NETWORK

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CHINA AEROSPACE CONTROL NETWORK

Yang Zhengming

Abstract The aerospace network of China consists of two general systems: carrier rocket control system, and satellite control network. There are three Chinese launch sites located in Jiuquan, Xichang and Taiyuan, which carry out different launch missions. Satellite tracking, telemetry, control and recovery, respectively, are performed at the Xi'an Satellite Control Center (XSCC), five fixed control stations, two mobile stations, a recovery station, and Yuan Wang survey vessels.

In April, 1970, China successfully launched its first satellite, which indicated that China had initially established its aerospace control system. The aerospace control system in China is composed of two major systems: carrier rocket control system and satellite control network. With this system, China has successfully launched and controlled more than 30 domestic and overseas satellites, of which the long-term operating satellites have been under proper control and supervision.

1. Carrier Rocket Control System

The three launch flight coverage control systems in China respectively provide services to three inland Launch Pads, namely Jiuquan Launch Pad, Gansu Province; Xichang Launch Pad, Sichuan

Province, and Taiyuan Launch Pad, Shanxi Province (Fig. 1).

In November, 1975, a reentry scientific exploration and technical experiment satellite was successfully launched, which showed that the Jiuquan launch flight coverage control system and near-earth satellite control network had been fully set up. This launch flight coverage control system, capable of launching and controlling large-dip satellites, was designed to launch diversified technical exploration and scientific experimental satellites.

In April, 1984, an experimental geostationary communication satellite was successfully launched in Xichang, which marked the establishment of the Xichang launch flight coverage control system and the geostationary orbital satellite control network. This system could launch and control small-dip satellites and primarily provided services in launching geostationary orbiting satellites.

In September, 1988, the Feng Yun 1 heliostationary orbiting meteorological satellite was successfully launched from the Taiyuan Launch Pad, Shanxi, which showed that the Taiyuan launch flight coverage control system had been built. This system was mainly used to launch heliostationary orbiting satellites.

As carrier rockets launched from the above-mentioned Launch Pads would fly over some medium and small cities as well as some industrial facilities, the corresponding launch flight coverage control systems had to select appropriate blastoff sites for the rockets in the event of a breakdown during their powered flight period so as to reduce or avoid damage that the disintegrating rockets might inflect on cities and industrial facilities along their course. This required that the control systems should be capable of high precision measurement of flight trajectory, real-time data processing, accurate safety judgement, and landing

site control.

In addition, the control systems also held responsibilities such as conducting orbital monitoring measurement throughout the carrier rocket flight period and providing guidance to the tracking station in the next flight coverage with data thus measured; receiving from the carrier rocket the telemetry flight data covering its entire flight period so as to complete actual monitoring of the rocket as well as post-mission analysis of its flight condition.

The carrier rocket flight domain control system installed at the Launch Pad is equipped with a launch command control center and tracking measurement stations, whose functions and composition are shown in Fig. 2, with a common measurement station located at the boundary between two flight coverage segments shared by the two coverages. Individual stations of the system have functions as follows:

Launch command control center:

This center is used to receive data sent by different stations, perform real-time processing of external measurement and telemetry data, conducting flight trajectory calculations, display, safety judgement, delivering safety control instructions, etc. Through diversified communication means, the launch command control center can exchange data with individual stations (vessels). Telemetry facilities are placed near the center and can offer an operating range covering the segment of the rocket flight coverage when the rocket might produce disastrous damage.

Photoelectric theodolite station

Its major mission is to make rocket flight trajectory

measurements during its take-off period and first-stage flight, when the rocket is approximately 60km in height.

High-precision long-baseline interferometric speed measurement location station (Jiuquan Launch Pad Area) or short-baseline interferometric speed measurement system plus monopulse radar tracking station

With the cooperation of the in-rocket transponder, this station is designed to acquire rocket speed and location information during its powered flight period, which serves as major information source for its safety control.

Several monopulse precision tracking radar stations

In cooperation with the transponder in the rocket, a measurement chain was formed to measure carrier rocket outer trajectory throughout its powered flight period. Within the flight coverage, fixed radar facilities are generally provided for land use. Specifically, vehicle-borne mobile radar stations included in the satellite control network as well as the Yuan Wang survey vessels equipped with monopulse precision tracking radars, respectively, are deployed on land and at sea for greater tracking measurement coverage. While the telemetry equipment can receive telemetry data from a carrier rocket throughout its flight.

Under the precondition of satisfying technical requirements, various control facilities are relatively concentrated in deployment, which is convenient for construction, supervision, and command. In the Xichang flight coverage, measurements are intended to be made over a flight distance more than 7000km from rocket take-off through satellite-rocket staging by five measurement stations on land and two Yuan Wang survey vessels at sea, and one of the vessels is positioned at satellite orbital point near the equator. In the Jiuquan and Taiyuan launch flight

coverages, measurements are made over a rocket flight of less than 3000km by three major measurement stations but, if these flight coverages are continuously expanding, it may be needed to position survey vessels at sea and mobile stations on islands.

2. China Satellite Control Network

1) Formation of China Satellite Control Network

The China satellite control network, divided into near-earth satellite control network (satellite at heights below 5000km) and geostationary orbiting satellite launch control and fixed-point support network, mainly consists of the Xi'an Satellite Control Center, five fixed stations, two mobile stations, a mobile recovery station, and two measurement vessels, as well as simple telemetry vessels.

Xi'an Satellite Control Center

The Xi'an Satellite Control Center can automatically work out in real time plans and execute control over several (six) satellites simultaneously. Similarly, it also has the capability of post-mission analysis and software development.

Central Computer System

This system is made up of three NC12780 computers and two VAX8700 computers, which are connected with Ethernet via the Xin Xing He Qi [rocket-shape-together-device]. Equipped with multiple satellite control system software, the system enjoys high reliability and powerful processing capability.

Monitoring Display System

It provides command and operating staff with orbital flight

information and major spacecraft engineering parameters, which are displayed in tables and images to ensure interactive operation.

Tracking and Control Software System

The Xi'an Satellite Control Center developed an overall flight tracking and control software system, which can be roughly divided into two categories that depend on satellite missions:

(1) Near-earth satellite tracking and control software (including satellite recovery)
(2) Geostationary satellite tracking and control software

The overall flight tracking and control software covers divisions such as telemetry processing; instruction generation and checking; orbital measurement data processing; orbital determination and prediction; attitude data processing and attitude determination; orbital mobility and attitude mobility; satellite recovery control and monitoring; overall-system simulation maneuvers, and other auxiliary software.

Many years of practice proved that the Xi'an Satellite Control Center and Tracking Software System, with its extremely high effectiveness, can satisfy different satellite control requirements in both functions and performance.

Five Fixed Near-Earth Satellite Control Stations

These stations are deployed in the eastern part, central part and western part of China, designated as the Changchun Station, the Xiamen Station, the Nanning Station, the Weinan Station, and the Kash Station (see Fig. 1). They are designed to perform, through cooperation, daily tracking and control over medium- and low-orbiting satellites. In addition, the Weinan and

Xiamen stations also undertake missions of geostationary orbital satellite launches and daily control, while the Nanning and Xiamen stations are also responsible for carrier rocket flight coverage tracking measurement during geostationary satellite launches as well as perigee control missions during near-earth orbital satellite launches.

Two Mobile Stations

Their major tasks are to complete an accurate control over reentry satellites and their reentry trajectory tracking so as to provide an information source for accurate prediction of the reentry compartment landing site. This can compensate for the inadequate coverage by the fixed control stations in carrier rocket flight coverage, as well as for inadequate perigee coverage of fixed control stations for certain satellites.

Mobile Recovery Station

Its function is to search for and find the reentry compartments of reentry satellites. Equipped with helicopters, this station can discover, hoist, and transport reentry compartments in a short time.

Two Survey Vessels

These vessels carry out missions such as reentry measurement in the event when a carrier rocket is supposed to drop into the sea during its full flight experiment; trajectory tracking, measurement and telemetry data reception during the over-sea flight period of the third stage of the geostationary orbital satellite-launching carrier rocket; monitoring of trajectory characteristic points; monitoring measurements during secondary ignition of the third rocket stage, satellite-rocket staging and satellite orbit transfer. The simple telemetry vessel can

receive telemetry data from the carrier rocket to compensate for the flight path not covered by the measurement vessels.

2) Principal Facilities of Near-earth Satellite Control Station

(1) The VHF/UHF control system contains two systems: dispersed carrier-wave system and unified carrier-wave system. The dispersed system, by using a double-frequency velocimeter to measure the distance-variation ratio coupled with a telemetry demodulation terminal, can receive satellite telemetry signals modulated on two beacon frequencies. The independent remote control equipment can carry out various ground system-to-satellite instruction control and data insertion. The unified carrier-wave system uses one antenna for both transmission and reception and has an additional function in distance and angle measurement.

(2) A C-band monopulse precision tracking radar is installed at several control stations. This radar is suitable for measurement of the satellite perigee period and its reentry orbit owing to its large number of measurement elements and high measurement precision, as well as its high ability of locating orbits with data.

(3) Station computers and monitoring display facilities. These integrated facilities can complete preprocessing of orbit measurement data; realize digital guidance and acquisition for station control equipment; deliver remote control instructions and data and conduct data exchange with the Xi'an Control Center so as to save communication voice channels.

(4) The time unified service facilities, command, dispatch and communication facilities are all service facilities.

Geostationary Orbital Satellite Control Network

The geostationary orbital satellite launch and control network consists of the Xi'an Control Center (shared with near-earth satellite control network), the Xiamen Control Station, the Weinan Control Station, and a survey vessel that is deployed near the perigee. The Xiamen Control Station, the Weinan Control Station, and a survey vessel are equipped with unified C-band carrier wave control systems, which, with the cooperation of the in-satellite transponder, can perform tracking orbit measurements, telemetry, and remote control over high-orbiting satellites within 40,000km in height. Its tracking orbital measurement function covers distance, azimuth, and pitch angle measurement; its telemetry function includes coding telemetry and simulation telemetry, while its remote control function includes instruction control and synchronous control.

The Xiamen and Weinan control stations, respectively, are equipped with two computers, which, exercising a duplex operation, can complete missions such as control station data processing, data exchange with satellite control center, as well as attitude control, orbit control during long-term control, and supervision over geostationary orbital satellites. Apart from these, when control stations need to carry out satellite-to-earth reentry route simulating maneuver test in mission preparation period, one computer can be used for satellite powered simulation, while the other--as an actual combat computer.

During the launch of a geostationary satellite, one survey vessel is deployed at the perigee near the equator and, when the satellite enters its orbit, the unified C-band system in the vessel starts to conduct tracking orbital measurement, telemetry and instruction control. In the same time, the C-band precision monopulse tracking radar that is installed in the vessel can

measure the glide-path orbit during the carrier rocket short-arc period, while the UHF telemetry equipment can receive telemetry data from the rocket. In this way, both can respectively locate the initial orbit of the rocket. Incidentally, these methods were used to calculate orbital root numbers during the launch of Asia 1 Satellite. The above-mentioned survey vessel can also receive satellite telemetry data over a few orbital-arc periods after the satellite reaches the first-round apogee following orbital transfer. So far, this control network has successfully completed control missions over five geostationary communication satellites launched together with their daily supervision.

3. Communication Network

The communication network is designed to integrate different centers, different control stations (vessels), and different facilities to form the China Aerospace Control Network. The communication network can carry out dispatching, command communications, data transmission, and other service communications. This network consists of three parts:

1) Local Communication Network

This network, containing an internal telephone network, call communication facilities, and closed-circuit television, serves as an internal communication system for centers, control stations and survey vessels.

2) Long-distance Communication Network

With wire, wireless, and dedicated communication satellite lines, this network can ensure long-distance command communications, data transmission, and other service communications between launch command control center and its subsidiary control stations (vessels), as well as between the

Beijing Command Center under the National Defense Scientific and Engineering Committee and the launch command control center and the satellite control center.

3) International Communications

International satellite communication ground stations have been established in Beijing, Xi'an and Xichang, which can be directly connected to the INTELSAT network to provide user-leased circuits. The Xichang International Ground Station was used in launching the Asia 1 Satellite.

4. Future Development of Control Network

With advances in aerospace, some facilities in service for the China Aerospace Control Network are expected to be renewed, upgraded and gradually perfected.

1) Establishing additional unified S-band carrier wave systems, which will provide service in future launches of resource satellites and will cooperate with international S-band network.

2) In the long run, attention needs to be paid to setting up a space-based control system which conforms to conditions in China and can undertake satellite data retransmission.

At present, the aerospace control system in China can provide services in launching overseas satellites and it can offer support to overseas satellites or connect to overseas satellite control networks. As cooperation on a global scale grows, the China Aerospace Control Network is likely to be upgraded by importing some sophisticated technologies from other countries.

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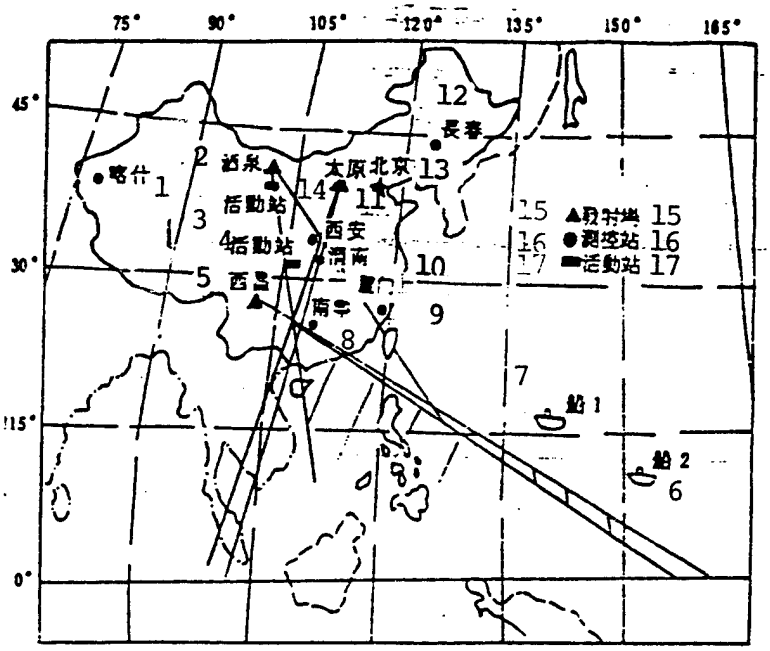

Fig. 1. Distribution Map of Aerospace Launch Flight Coverage Areas and Control Networks in China

(1) Kash (2) Jiuquan (3) Mobile station
(4) Mobile station (5) Xichang (6) Vessel 2
(7) Vessel 1 (8) Nanning (9) Xiamen
(10) Weinan (11) Xi'an (12) Changchun
(13) Beijing (14) Taiyuan

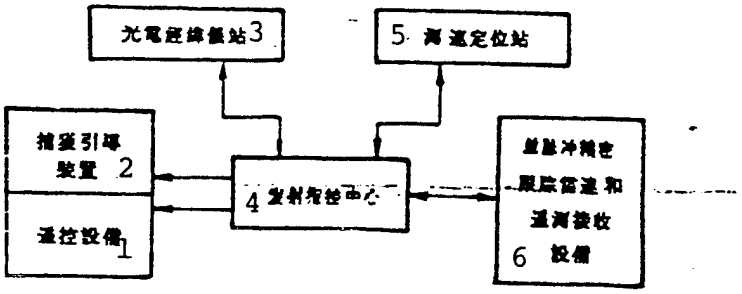

Fig. 2. Flight Coverage Carrier Rocket Control System Based in Launch Pad

(1) Remote control facilities (2) Acquisition and guidance device (3) Photoelectric theodolite (4) Launch command control center (5) Speed measurement location station (6) Monopulse precision tracking radar and telemetry receivers