Status Quo and Assumption of China's Space Satellite Monitoring

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ABSTRACT

Satellite's frequency and orbit resource are limited natural resources shared by the whole humankind, which utilization and occupation represent the nation's radical rights and interests. The purpose of space satellite monitoring is to properly use and manage the satellite's frequency and orbit resource, and enable them to exert the best benefits in terms of national economic construction and security. The paper elaborates the development and assumption of China's satellite monitoring based on satellite's orbit, frequency and characteristics of coverage.

Key word: Satellite monitoring, stationary satellite, non-stationary satellite, satellite's frequency and orbit resource, satellite's interference and position

Since the launching of the first artificial earth satellite by the Soviet Union in 1957, the satellite application industry has witnessed a skyrocketing development over half century. At present, there are over 1100 spaceflight corporates from about 60 countries and regions around the world participating in the R&D, manufacture, deployment and operation of various military and civilian satellite systems, and the nation and region with satellite applications for communication, navigation, meteorology and remote sensing spread all over the world. With extension to almost every sector of common people's daily life as well as economy, society and military affairs, the satellite application industry has a huge and far-reaching affect and penetrating power to economy, society and national security, fundamentally changing people's thinking, production and living style, boosting the development of productive forces, and making in-depth changes on the whole society and bringing human a new visage. The satellite application industry especially the satellite communication industry has been rapidly developed in U.S., Europe and Japan etc., and gradually extended and penetrated to some developing countries in Asia, Middle East and South America, and become an important impetus for economic growth and social progress.

Through many years of painstaking efforts and struggle hard by scientific and technical workers, China's satellite cause has gradually formed a satellite system including observation to ground, navigation, communication and scientific experiment etc. And satellite application is playing a more and more important role in the construction of China's

economy and national defense. In the meantime, the state's departments concerned also attaches importance to the application of satellite technology, each industrial sector rebuilds the traditional industry by using satellite technology and strives for making breakthrough in technology, and government leads the social demand actively to enlarge the breadth and depth of application, so as to drive the development of satellite industry. In 1996, the gross output value of China's satellite application industry reached nearly 3 billion RMB, and increased to 10 billion RMB by 2000, accounting 2.1% of the global satellite application industry with annual growth rate of 35%, about 24% higher than that of total industrial output value in the same period, and 12 percentage point higher than that of China's high-tech industry. The development of China's satellite application has formed a new growth point of national economy, and driving the development of related industries as well.

I. NECESSITY AND IMPORTANCE OF SPACE SATELLITE MONITORING

Satellite's frequency and orbit resource are limited natural resources shared by the whole humankind, which utilization and occupation represent the nation's radical rights and interests. As the transmission of radio frequency has the feature of wide coverage and without national boundary limitation, therefore, satellite communication is playing an important role to economic development and national security. One of key responsibilities undertaken by radio managing department is to properly use and manage space satellite frequency and orbit resources, and enable them to exert the best benefits in terms of national economic construction and security.

According to Article 16 of Radio Regulation, International Telecommunication Association, the monitoring organization which has undertaken the implementation of domestic laws and regulations and engaged in the international monitoring shall be generally required to participate in the monitoring of emission signal by space station.

With the continuous increase of cosmic space satellites, and emergence of various satellite businesses, the competition for satellite orbit resource is becoming fiercer. And mutual interference between satellites, satellite's interference to ground and ground's interference to satellite happens occasionally, which seriously affect the healthy development of the satellite communication cause. To reasonably use, plan and coordinate the limited frequency and orbit resources, some relevant technical means must be applied. On the other hand, the breaching-rules activities in different degrees existed in satellite operators and users' usage and operation, and breakdown of users' devices, all of these, will also result in the reduced quality of satellite communication signal and emergence of various interferences. The solution, except for enhancing radio administrative means, must conduct regular supervision through technical means to operators and users.

As 2008 Beijing Olympic Games to be held in China, Beijing Organizing Committee for the Games will build up large-scaled communication system, including all kinds of emergency communication devices such as emergency satellite communication vehicles to transmit live matches, and on-site command and dispatch. To ensure the reliable communication and dispatch for the Games, it is also very necessary to make pertinent perfection of the satellite signal monitoring system.

In summary, it is very necessary to build up the national space satellite monitoring system. Through the monitoring to space satellites, we can know in time the frequency occupation of our orbited satellites and availability factor of frequency spectrum, know the frequency spectrum and orbit of passing foreign satellite such as military satellite (including declared and undeclared) over our country, and use, plan and coordinate more reasonably the limited frequency and orbit resources. In the meantime, we can search and eliminate all kinds of harmful satellite interference, so as to effectively safeguard our space satellite communication resource, protect and supervise the operators' benefits. On the other hand, enhancing satellite monitoring can prevent illegal organizations from interference and damage to satellite communication, so as to maintain the nation's political and economic stability.

II. STATUS QUO OF SPACE SATELLITE MONITORING

China's space satellite monitoring is started up later. The establishment of project is initiated during the Ninth Five Plan period, and construction of space satellite monitoring station is commenced in 2000. At present, the Beijing Satellite Monitoring Station has been set up and put into operation, and Shenzhen Satellite Monitoring Station is under construction. The two stations after being linked with each other can sufficiently monitor the launching parameters of various satellites and their operating orbits over China's territory and the surrounding areas.

The Beijing Satellite Monitoring Station can monitor the downlink parameter of C-Band and Ku-Band satellite with Geostationary Earth Orbit (GEO) within the scope of 50E-180E (East Longitude), and have the capability of positing the satellite's uplink launching source. The station has integrated functions such as radio monitoring, signal measurement, automatic identification, and position of interference etc., and having leading technology compared with the same-typed monitoring system in home and abroad in terms of antenna efficiency (amplification), tracking accuracy, measuring bandwidth, automatic identification of signal type, parallel operation of dual systems, transmission of radio frequency, ground interference and position, and reference of launching source network etc.

The successful operation of Beijing Satellite Monitoring Station has provided our country with a platform of joining in the International Space Satellite Monitoring System of ITU: In 2004, the delegation organized by Radio Administration Bureau of MII, and National Radio Monitoring Center attended the 7th International Space Radio Monitoring Conference in Paris, introduced our satellite monitoring system to all participants, and received positive assessment unanimously from foreign experts and counterparts. In 2005, the National Radio Monitoring Center successfully developed the Interchange Format of Satellite Monitoring Data jointly with South Korea and Japan, and completed relevant tests and experiments. The Interchange Format of Satellite Monitoring Data, which has been revised and perfected, is planned to be submitted to ITU this year, as the criterion of satellite monitoring data interchange across borders and international cooperation.

By using this system and implementing regular monitoring work actively, we have monitored most of the C-Band and Ku-Band satellites with Geostationary Earth Orbit (GEO) over our territory, verified their orbits of operation, and obtained the basic information about repeaters of the C-Band and Ku-Band satellites with Geostationary Earth Orbit (GEO) over our territory, and providing powerful technical supports for coordinating satellite orbit and planning frequency. Meanwhile, by using the position of satellite interference source, we have found out many significant satellite interference incidents, removed dozens of frequency points which are embezzled and interfering our communication satellite frequency band for a long time, and protected the legal rights and interests of satellite operators and users, and won acclaim from the governing departments and satellite operators.

III. ASSUMPTION OF SPACE SATELLITE MONITORING

Based on space satellite's characteristics, three aspects should be taken into consideration when building our space satellite monitoring system: First, the type of satellite orbit (GEO and Non-GEO); secondly, the frequency band of satellite (downlink frequency is mainly distributed in L-Band, S-Band, C-Band, X-Band, Ku-Band and Ka-Band); thirdly, the covering features of satellites' repeaters over our territory. At present, we are capable of monitoring the GEO satellites with C-Band and Ku-Band, but have limited capability to monitor the GEO satellites with other bands, and even have no capability to monitor Non-GEO satellites. Next is a brief introduction about assumption of building our space satellite monitoring system:

3.1 Monitoring of GEO satellite

GEO satellite refers to the geosynchronous satellite about 36000km over the equator, which are mainly applied in field of telecommunication, broadcast and meteorology etc., with frequency band of L, S, C, X, Ku, Ka. Due to its advantage of covering the whole globe with only 3 to 4 satellites, therefore, the control of constellation is simple, and remote telecommunication can be completed without tracking satellite and inter-satellite link. The deficiency is the shortage of frequency and orbit resources, unable of covering the polar areas; especially because of the longer distance between satellite and ground, it results in more link load and longer propagation delay time (larger than 250ms), and causing the increased volume and costs of satellite and users' terminal, and unsuitable for application of mobile communications business.

1) Coverage of GEO satellite with each frequency band

The GEO satellite covering our territory has the major frequency bands of L, S, C, X, Ku, and Ka. The following is the introduction of each frequency band excluding C and Ku-Band.

L-Band:

In the division of radio frequency by ITU, L-Band frequency is allocated to mobile business of landsat satellite, maritime satellite and aeronautical satellite etc., with downlink frequency scope of 1525MHz~1559MHz, and 1613.8MHz~1626.5MHz. The EIRP of GEO satellite with L-Band is about 30～40dBw, while losses of free space is about 188dB(1600MHz).

Along with changes of people's life and working style, the demand for mobile communications is increasingly higher, and the rapid development of "Personal Communications" even fuels up the construction of global seamless communication network, and all of these can't be realized without satellite mobile communications system. Therefore, many countries across the world are accelerating the development of L-Band GEO satellite mobile communications system in recent years, and causing more frequent tasks of coordinating L-Band satellite orbits.

S-Band:

In the division of radio frequency by ITU, S-Band satellite business includes fixed-satellite service, landsat mobile business and broadcasting satellite business, with downlink frequency scope of 2120MHz~2300MHz and 2500MHz~2690MHz. The EIRP of GEO satellite with S-Band is about 30～40dBw, while losses of free space is about 192dB(2500MHz).

At present, many countries are actively developing mobile business and broadcasting satellite business of S-Band GEO satellite, for instance, Japan's ETS system. And our satellite navigation and positioning system named "Beidou No.1" has been put into operation, and the system G2 is under research and development at a speeding pace. In the meantime, the coordinating task of S-Band satellite frequency across borders is increasingly heavy and frequent.

X-Band:

In the division of radio frequency by ITU, X-Band satellite business includes fixed-satellite service, landsat mobile business, earth exploration-satellite service, space research, meteorological-satellite service, and satellites with military affairs purposes, and frequency scope of 6700MHz~7075MHz, 7250MHz~7850MHz, and 7900MHz~8500MHz. And EIRP of repeater is mostly above 45dBw.

Ka-Band:

In the division of radio frequency by ITU, Ka-Band satellite business includes fixed-satellite service, satellite mobile business, broadcasting-satellite service, and radio astronomy etc., with frequency scope of 173000MHz~313000MHz. According to SRS CDROM documents released by ITU-R, the EIRP of GEO satellite with Ka-Band (17.7GHz~21.2GHz) over equator of our territory (50E ~180E) is mostly around 60dBW.

2) Monitoring of GEO satellite

Based on GEO satellite's characteristics, the assumption and method of monitoring GEO satellite is as follows:

(1) Fixed monitoring of GEO satellite

Fixed monitoring means to set up fixed satellite

monitoring station through selecting reasonable monitoring place according to satellite's covering features and our geographical circumstance, and monitor the GEO satellites over our territory. Through monitoring satellites' parameters, we can know the application of satellite's frequency spectrum resource covering our territory, and effectively allocate and manage our frequency spectrum, and providing technical basis for coordinating satellite orbit and frequency. Considering the covering characteristics of satellite frequency band, we set up the satellite monitoring by division of frequency band, and the monitoring of each frequency band is as follows (excluding C-Band and Ku-Band):

L-Band and S-Band:

As L-Band and S-Band satellite is mostly adopting global beam to cover service areas, therefore, only one station for each band needs to be set up to monitor all the L-Band and S-Band satellites over our territory. The monitoring station is recommended to be built in Beijing.

X-Band:

As there are few X-Band GEO satellites, and most of them are military satellites, therefore, the demand for monitoring the X-Band satellites is not very urgent. It is recommended to set up one station to monitor the X-Band satellites over our territory first, and then determine the further perfection of the monitoring devices according to the future demands.

Ka-Band:

Due to its higher frequency, the downlink signal of Ka-Band GEO satellite is mainly adopting spot beam to cover the globe. Therefore, one monitoring station built in our vast territory can only capture the appearance of a few Ka-Band repeaters in the region covered by the station.

At present, we haven't Ka-Band satellite (which might be launched 2 or 3 years later), and on-orbit Ka-Band satellites are fewer. There are no manufacturers in China to produce Ka-Band satellite receiving antenna system, and the monitoring of Ka-Band is under planning.

(2) Mobile monitoring of GEO satellite

China has a vast territory and long boundary line, and fixed satellite monitoring can only basic satellite parameter and partial EIRP. When needing detailed covering parameter in specific region, the fixed satellite monitoring is obviously incapable of meeting the requirements.

In addition, for international satellite coordination, many parameters of satellite, such as satellite orbit, frequency of repeater, covering scope, transmitting power, satellite G/T, and polarization etc., need to be coordinated. And International Telecommunication Association has strict rules and regulations on satellite launching coverage in these parameters. In fact, every country attaches great importance to the monitoring of satellite launching power flux density especially in the border areas. In addition, in order to maintain our political stability, we don't hope any satellite broadcasting television business with any political motives covering our territory. Meanwhile, we also don't hope any foreign satellite signals affecting our other normal businesses. One of the means to avoid these incidents occurring is to monitor the satellite's values such as EIRP etc. in border areas.

In summary, it is very necessary to set up mobile satellite monitoring station, which should be equipped with the features of strong flexibility and wide monitoring of frequency band (including L-Band, S-Band, C-Band, X-Band, Ku-Band, and Ka-Band). Through mobile monitoring, we can know the information about the coverage of foreign satellite on our border or in specific region and time. When the radiation parameters of satellite in one region need to be coordinated, it will be done by assigning the mobile monitoring station to the region.

3.2 Monitoring of None-GEO satellite

1) Characteristics of Non-GEO satellite

The Non-GEO satellite refers to other satellites except for GEO satellite, and most of which orbit height is 500km to 10000km (medium and low-orbit satellite), with rich orbit resource, less path attenuation, short propagation delay time, small volume of satellite and user's terminal (low costs), and

easy realization of global personal mobile communications etc. Due to its lower orbit position, the satellite's service life is shorter. This type of satellite is also playing a very important role in military field, and the United Sates has launched scores of Non-GEO military satellites especially used in the Gulf War and Iraqi warfare in recent years. There are some ITU materials only partially reflecting Non-GEO satellite applications, which deviate a lot from the actual situation. The following is a brief introduction about satellite with various orbits:

(1) The low-orbit satellite mobile communications system (orbital height of 500km to 5000km), also named as inverted cellular system, has its infrastructure built in space. The cell position is switched relatively to the earth, and mobile user can be regarded as still while its mobility compared with satellite's moving speed. By adopting many moonlets in low-orbit to compose constellation, the system is integrated with many advantages from low-orbit satellite like power-saving, easy launching, less link load, and short propagation delay time etc. In addition, it retains the advantages from GEO satellite like large coverage, and providing real-time and continuous communications (The constellation composed by scores of moonlets is equivalent to a super-large satellite. At least one moonlet can be watched in any corner of the world, and the regional or global communications can be realized by connection of the watched moonlet with the others). Another large elliptical inclined orbit satellite can solve the communications in the region of high latitudes, but with deficiencies like more required satellites, complicated control, increased all-in costs, greater technical difficulty, and higher risks.

(2) The medium-orbit satellite (orbital height of 5000km to 10000km), which is generally composed by 12 to 15 moonlets, has the characteristics of both high-orbit and low-orbit satellite. By adopting technologies of conventional satellite and ground communications, the satellite has the advantages like less risks, low costs, and high visual angle (The high visual angle can avoid the signal screen caused by trees, buildings and topography).

(3) Apart from commercial applications, the medium and low-orbit satellites are mostly applied in the military field.

2) Radio monitoring of Non-GEO satellite

To strengthen the monitoring of our space electromagnetic environment, it is very necessary to monitor the downlink parameters of the Non-GEO satellites passing our territory. The major frequency bands of the Non-GEO satellites covering our territory include L-Band, S-Band, C-Band, X-Band, Ku-Band, and Ka-Band. And their included angles between orbital plane and equatorial plane are mostly larger than 60 degrees. According to our topographic distribution characteristics and Non-GEO satellite

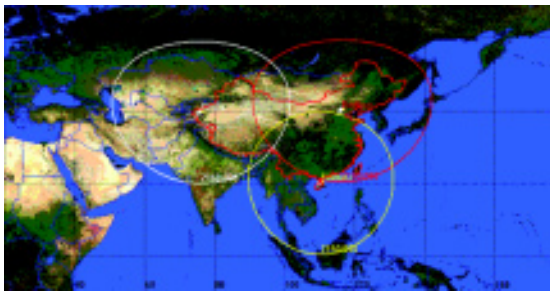

Fig.1 Covering graph of orbital height of 500km

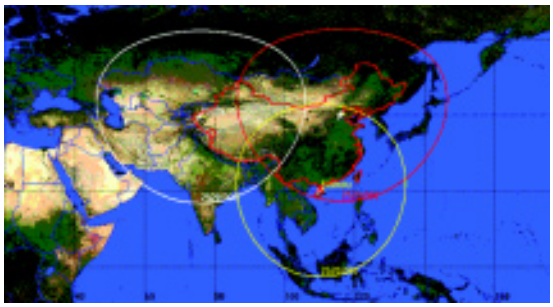

Fig.2 Covering graph of orbital height of 800km

running features, three monitoring points built in our country can monitor all the Non-GEO satellites passing our territory, and their layout is shown in the Figures below after being calculated:

From above Figures, we see that building one Non-GEO satellite monitoring system in Beijing can monitor most of Non-GEO satellites passing our territory, and enabling us to grasp some basic information about Non-GEO satellite, and laying a solid foundation for the future managing frequency in the field.

3) Optical monitoring of Non-GEO satellite

The study shows that the radio signal's emission of some running Non-GEO satellites is random; therefore, it is difficult to monitor their existence by radio monitoring method, and incapable to predict their businesses and affects on our frequency resource and national security either.

The satellite optical monitoring is one technical means to monitor satellite's shape and orbit position by using optical telescope. To be used together with radio frequency spectrum, it can make the monitoring system perfect. By using the optical monitoring system, we can observe the moving track of Non-GEO satellites, conduct statistical analysis on their running rules, and figure out satellite ephemeris, and then input it into the satellite tracking system for tracking and monitoring satellite. In this case, we can intercept the satellite data as long as the watched satellite sends off radio signals, analyze their business types, and make assessment on their affects to our national security and economic development.

According to above statements, building optical monitoring system of Non-GEO satellite is an important supplement to radio monitoring method. By using the optical monitoring system, we can accomplish the monitoring tasks which can't be done by radio monitoring system, and improving our country's satellite monitoring ability and technical level.

To sum up, although our country's satellite monitoring starts up late, it is of higher starting point in technology. The monitoring system of GEO-satellite with C-Band and Ku-Band, which are put into operation recently, has already exerted huge economic and social benefits. With rapid development of national economy, we will continuously improve our satellite monitoring system, and make it perfect. It is predicted that satellite monitoring will play a very important role in terms of safeguarding satellite communications and national security, as well as boosting social progress in the future.

BIOGRAPHIES

***Zhou Hongshun**, Senior Engineer of State Radio Monitoring Center (SRMC), is graduated from Beijing University of Technology in 1970, and has engaged in the field of broadcast and communications over 20 years.*

Since taking over the Director of Monitoring Division, SRMC, in 1991, Zhou Hongshun has been in charge of planning and implementing the construction of radio monitoring devices across the country. He has published many papers in relevant academic journals and magazines, organized the compilation of Technical Searching Method and Experiences of Radio Disturbance, the translation and edit of Monitoring Frequency Spectrum Manual by ITU. In 2000, he took charge the construction of National Space Satellite Monitoring System, which was awarded the first prize of China Institute of Communications in 2005.

***Liu Wubing**, Senior Engineer of State Radio Monitoring Center (SRMC), is graduated from the PLA Information Engineering University in 1982, and has engaged in the satellite communications and monitoring many years. He has published many papers in relevant academic journals and magazines. In 2000, he participated in the construction of National Space Satellite Monitoring System, which was awarded the first prize of China Institute of Communications in 2005.*