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THE DEVELOPMENT OF SPACE DATA
SYSTEMS AND TECHNOLOGY

by

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THE DEVELOPMENT OF SPACE DATA SYSTEMS AND TECHNOLOGY

Chen Fangyun Yang Zhaode

I. INTRODUCTION

Today, the world confronts a comprehensive struggle associated with concentrated knowledge, concentrated technology, high quality, and high efficiency. Data technology is one of the livliest productive forces in the modern world commercial economy. Applying information technology in order to improve the benefits and competitive power associated with industry and service enterprises, promoting the conversion of management and policy making into scientific processes in order to facilitate the impeling of various departments of the national economy to shift step by step to a new technological foundation, is social progress and service to the lives of the people.

Since the first man made earth satellite went aloft in 1957, the majority of spacecraft have been used in the acquiring and transmission of data. However, speaking in terms of earth and human society, the most important were communications and broadcast satellites, earth observation satellites, as well as satellites associated with the positioning of objects on the earth's surface and navigation. These satellites and related surface systems include measurement and control systems, data processing and application systems. They supply powerful technological means for various types of modern data activities, making communications, broadcasting, metrology, geodesy, navigation, and earth observation fields achieve progress which there has never been before. We can, in general, designate these systems as "space data systems".

Space data systems are modern scientific technologies with high degrees of comprehensiveness. They take foundation sciences and technological sciences as their basis, applying in concentration a good number of the new achievements of engineering technology in the 20th century. As far as astronavigational technology, electronics technology, remote sensing technology, communications technology, computers, oceanographics, metrology, map making, and so on, are concerned, in every case--with regard to the progress of space data systems--important roles have heen played. In regard to these sciences and technologies, among applications of space data systems, there are mutual overlaps and penetrations. Moreover, applications of space data systems also constantly present new requirements for them--promoting the progress of these sciences and technologies.

Space data system applications broaden by the day. With regard to the life of the people, communications and transport, and the global environment, influences become more and more wide spread. Following along with modern advances, the roles which space data systems play in the information activities of human society will become larger and larger. In certain situations it will even be to the point that not using space data system means is impossible. They possess huge social and economic benefits.

II. GENERAL DEVELOPMENT STATUS AND BENEFITS ASSOCIATED WITH SPACE DATA SYSTEMS

1. Communications Satellite Systems

In regard to modern economic, scientific, military, as well as political activities, and so on, there is an urgent need to have modernized communications systems which are adapted to them.

Transmited communications include voice, text, imagery, data materials, as well as control signals, and so forth. In modern communications systems, there is wide spread application of digital communications methods. At the same time, communications systems also often form an important constituent part of an even larger system. Among various types of communications methods, satellite communications systems possess a great many superior performance characteristics.

Satellite communications systems are the product of a combination of electronics technology and astronavigational technology. Between various ground stations, use is made of certain multiple address connection methods. Signal transmission is carried out by communications satellites, forming communications links and networks. Satellite communications systems are composed primarily of communications satellites, surface stations, as well as measurement, control, and tracking systems connecting the two, and so on. Since the U.S. launched its first experimental communications satellite in 1958, satellite communications technology has achieved extremely great development. Due to the fact that satellite communications possess a good number of obvious characteristics such as large communications capacities, long transmission ranges, good transmission quality, capability for all weather communications, the rapid formation of communications networks, and so on, as a result, once satellite communications appeared, they gave rise to wide spread and serious attention from various nations of the world. One after the other, they introduced large amounts of personnel and materiel to carry out the development of applications. /4

In 1963, after the successful launch of geostationary satellites and communications tests, satellite communications systems took as their main thrust synchronous fixed point communications right along. INTELSAT systems have already become the largest communications satellite network in the world. As far as the initial INTELSAT-1 is concerned, the effective band width was 50MHz. There were 2 transmiters. The communications capacity was 240 one way voice channels or one television channel. With regard to the capacity of the INTELSAT-5 operating in orbit now, it far, far exceeds the satellites of several previous generations. On satellite, there are a total of 27 transmiters associated with three types of band widths at 40, 80, and 120MHz. They are capable of containing 12000 voice channels and two television transmiters. In the case of the INTELSAT-6-F4 which was recently launched, on satellite, there are 48 transmiter units. 38 units are C wave band. 10 units are Ku wave band. Overall communications capacity reaches 330 thousand two way voice channels and 4 television channels. The INTELSAT organization currently already has 121 member nations. Nations or regions using the satellites have already reached 167. There are 662 earth stations spread all over the globe. There are 834 antennas (not including small model stations). 1452 all weather international communications channels have been opened up. INTELSAT communications continue a fast growth of 10%-12% a year.

Mobile satellite communications are not subject to limitations associated with geographical conditions or user movement. Coverage areas are vast. It is possible to provide communications services to any mobile user or outlying region. They are capable of comparatively quickly setting up and altering multiple address connections as well as being able to effectively carry out long range communications. Satellites associated with mobile services include INMARSAT, aviation communications satellites, land mobile communications satellites, and so on, as well as related radio positioning and navigation, exploration, and rescue satellites. In 1976, INMARSAT began mobile communications services. At the present time, there are 7000 terminals providing service on large vessels and pleasure craft. In conjunction with this, it is in the midst of expanding to land and sky. The U.S. and Canada are just in the midst of setting up the North American mobile communications satellite (MSAT). Australia has also already designed and set up the Australian satellite mobile communications system (AUSSAT Mobilesat system).

Making use of satellite mobile communication systems composed of synchronous, fixed point satellites has certain drawbacks. Satellites are positioned in orbits at altitudes of 36000km. Therefore, the need to satisfy requirements associated with mobile communications then demands that satellite transmiters have large equivalent omnidirectional radiated powers (EIRP). At the same time, transmiting power associated with user equipment can also not be small. It is necessary to make electromagnetic waves radiated on satellites arrive at a certain place on the earth's surface at a certain strength, or the weak signals received by earth stations then require satellites to have on them large antennas and point beam radiation. This gives satellite manufacture added difficulties. As a result, earth stations in general are all comparatively large. In conjunction with this, it is necessary to make use of large antennas in order to receive transmissions and then transmit to satellites to be passed on to another user. This then adds to communications time delays. With regard to altitudes approaching 40000km, wave time delays are 0.13s. For two round trips, they will approach 0.5s or more--inconvenient for voice communications.

In the last few years--internationally--the idea has been put forward of groups of low orbit, small satellites. In the area of communications, it is possible to make use of multiple satellites placed in nonsynchronous orbital planes, transmiting the signals of surface users at orbital altitudes of between 700-1000km. Due to orbital altitudes being low, it is possible to simplify equipment on satellites and associated with ground users. Direct connections between mobile communications users are also easy to achieve. This type of system is capable of domestic use. However, multiple satellites in motion covering the globe will develop to become a global mobile communications system. In order to make users at any two points on earth able to communicate in real time, it is necessary to resolve such problems as transmission of signals between satellites in motion as well as automatic switching transfers on satellites, and so on. Comparing this and synchronous, fixed point satellite systems--in terms of economic characteristics--there is still a need to make detailed analysis.

The full speed development of satellite communications in terms of technology and services has produced huge social and economic benefits. At the present time, satellite communications are already capable of over 100 types of different services. Besides telegraph, telephone, facsimile, data transmission, television broadcast, long distance education, radio broadcast, as well as maritime mobile communications, and so on, they are also capable of supplying such services as television and telephone conferencing, data transmission, emergency disaster relief, remote medical treatment, bank remittances, electronic document distribution, printing of newspapers and periodicals, electronic mail, data checks and delivery, as well as computer networking, and so on. Looked at from a macro angle, exploring the value of satellite communications, use is made of the INTELSAT system as an example. Recently, the Satellite System Engineering company (SSE) and the Future Systems limited stock company (FSI) reached the conclusion that, despite the fact that the INTELSAT system (it takes responsibility for 60% of the amount of U.S. international long range communications services) annual income is only 500 million U.S. dollars, it still, however, directly did 8 billion U.S. dollars for world commercial long range telecommunications departments. Moreover, speaking in terms of terminal users, there are 40 billion U.S. dollars in earnings each year. As far as utilization of satellite communications services for such things as bank and currency transfers, loan credit verifications, investment data related to securities, financial documents relating to bank deposits, foreign exchange rates, as well as commodities trading, and so forth, is concerned, each year, approximately 50 billion U.S. dollars of earnings are made directly or indirectly--accounting for 10% of the earnings from economic activities related to satellites in the entire world. Space telecommunications services related to commodities trading do ten billion U.S. dollars. The economic benefits of satellite communications are obvious to see. However, the social benefits have given rise to even higher degrees of serious attention among people. The social applications of satellite communications are very wide spread. Moreover, they are expanding constantly. Satellite television education has huge prospects for application. Over half the states in the U.S. have educational television programs belonging to the state or mass organizations.

According to investigations by the China Educational Television Station in 1989, persons watching educational television programs reach ten million. At the present time, in the country as a whole, there are 1.5 million students at various types of schools who watch television instruction on an organized basis. Besides this, there are 15 million people who watch for their own instruction. In accordance with plans, by the year 2000, Chinese educational television's broadcast time every day will reach 60 hours.

2. Satellite Navigation and Positioning Systems /5

Satellite radio positioning services are the carrying out of range finding or speed measurements on surface objects through radio and satellite hook ups. Calculating out their own positions on the earth and knowing the coordinates of their own position as well as change data, it is then possible to know the direction of their own course. The application ranges associated with positioning navigation systems in the past were small. Positioning accuracies were low. It was only with the appearance of satellite positioning systems that problems associated with large range, global, as well as highly accurate, fast positioning were resolved.

In 1960, the U.S. launched the TRANSIT-1B navigation satellite for the navy. The number of satellites associated with this system was inadequate (4-5 satellites). The system makes use of single satellite Doppler frequency measurement positioning principles. The measurement time required for one iteration of positioning is over 2 min. As far as positioning accuracies are concerned--with regard to moving vessels--they are from 200m to 80m. In respect to fixed points, it is possible to reach 100m to 10m. In the 1960's and 70's, TRANSIT navigation satellites were not only universally applied on vessels. They were, moreover, also used in land based coordinate measurements. However, certain characteristics associated with the system in question awaited improvement--for example, the number of positioning iterations was comparatively small. The time required to precisely specify one position was too long. There was no ability to adapt to high speed movement of targets (for example, aircraft). Positioning accuracies required improvement. It was not possible to carry out data exchange between moving stations or moving objects that had been positioned and the base stations, and so on.

In 1978, the U.S. began implementing the Global Positioning System (GPS). This is a type of radio navigation system which uses satellites as its foundation. Space sections are composed of 18-24 satellites distributed in 6 orbital planes. Users at various places in the globe are capable of seeing 4 or more satellites whenever necessary. Capturing the distance code sent out from the satellite, their own positions are calculated. Positioning times are short. Accuracies are high. There are accurate clocks on GPS satellites. It is possible to simultaneously use them in timing and time period synchronicity. However, GPS is primarily used in the military. High accuracy range finding encryption sections are strictly classified. The positioning accuracies can reach within 10m. With regard to the rough code that is open for civilian use, positioning accuracies are approximately 100m. At the present time, the 21 GPS satellites which are operating in orbit are capable of positioning all over the globe at any time.

The former Soviet Union's global navigation satellite system (GLONASS) and the U.S. navigation and positioning system are similar. Its purpose is to provide radio positioning for aircraft in a range covering the whole globe. It is also capable of providing navigation for that country's vessels. This system is composed of 9-12 satellites. Satellites are distributed within 3 orbital planes. Each orbital plane has 3-4 satellites. The angle of inclination of the various orbital planes is 63°. Intervals are 60°. Orbital altitudes are 20000km. Movement periods are 12 hours. Satellites use the L wave band at 1240-1260MHz and tramsmit navigation signals at frequencies of 1597-1617MHz. Positioning accuracies are similar to the civilian portion of GPS. At the present time, the two are just in the midst of being fused into one, making receivers capable of simultaneously accepting the two types of signals--mutually complementing each others shortcomings. Making use of these navigation systems above, users are capable of measuring their own locations. If one wishes to create contacts with main control or dispatched sections, there is still a need to be fitted with communications systems.

Newly developed dual satellite positioning systems possess capabilities that combine communications and navigation together.

They make use of two synchronous, fixed point satellites. Users and central stations do range finding and positioning through satellites. Although this type of system is regional, the region it is capable of covering is, however, very large (for example, all of China and Southeast Asia). Moreover, it is capable of developing into global characteristics (using 6 satellites). Positioning precisions are determined with a view to range finding speeds and are capable of reaching within 10m. Timing precisions, by contrast, are capable of being made even higher. Degrees of frequency stability associated with transmiters on satellites drop. Data processing is concentrated in main stations. In conjunction with this, carrying out two way data transfer, user equipment is simplified. Data communications functions are strengthened, making the three--navigation, positioning, and communications--combine together in an organic way. Central station motion control functions are strengthened, facilitating commercial applications. The global applications of the systems in question require the combining of the systems of multiple regions--forming quasi global systems. As a result, the technical parameters of this system and signal formats must be unified. This determines the necessity of international cooperation. This type of system is capable of being used in long range trucking, riverine and coastwise shipping, and railroad systems--very, very greatly increasing the operating safety and efficiency of highway and railroad systems. Making use of relative positioning to carry out geodetic measurements, it is possible to make use of them in mining and petroleum departments. They are also capable of being brought into play in rescues, emergency communications, communications in outlying and agricultural village regions, as well as search and rescue functions. In summary, the setting up of this type of system has very great roles with regard to all such things as national defense, traffic, transport, the development of outlying areas, disaster fighting, as well as time synchronization with a pannational scope.

3. Earth Observation Satellite Systems

Earth observation is one of the main application targets associated with space data systems. In fact, one of the missions associated with the people who came after the launching of man made earth satellites was nothing else than the acquiring of large range, high altitude atmospheric data. Moreover, today's metrological observations, oceanic observations, land environmental statuses, as well as natural resource surveys have already become the main missions of a good number of satellites. Earth observation data systems are capable of supplying large amounts of data associated with such things as the study of the atmosphere, geology, biology, botany, oceanography, as well as ecology, and so on. In conjunction with this, it is possible to reveal various types of surface targets, thereby providing an extremely effective means for mankind with regard to the exploitation and management of global resources and the prevention and monitoring of natural disasters. /6

Since the U.S. launched the first metrological satellite--Tyros No.1--in 1960, they have gone through over 30 years of development. In world terms, metrological satellites have already become an enormous space data system. Metrological satellites are of two types. One is near earth, polar orbit metrological satellites. The second is synchronous, fixed point metrological satellites. The orbital altitudes of the former are approximately 800-1500km. They are capable of making use of visible light and infrared to photograph cloud charts. In conjunction with this, measurements are made of vertical water vapor distributions in the atmosphere--for example, the U.S. Tyros satellites as well as new Tyros-N satellites and Noah satellites. From altitudes of 35800km, the latter observe and photograph large area cloud charts--understanding the status of their changes and thereby acquiring movement processes for wind and atmospheric piling up--for example, the U.S. geostationary orbit environmental satellite (GOES), Japan's geostationary metrological satellite (GMS), as well as the European metrological and environmental satellite (MES), and so on. They comprise global systems. The two in combination play important roles in regard to medium and short term weather forecasts over large and small ranges. The U.S. already has statistical data which clearly show that--in the area of agriculture--if it is possible to have 3-5 day forecasts with regard to natural disasters, it is then possible to reduce losses 40%. On the basis of analysis of incomplete data, the U.S. invests 300 million U.S. dollars in metrological satellite engineering each year. Application results convert to increased production and reduced losses of 2 billion U.S. dollars each year. The investment to benefit ratio is 1:7. The former Soviet Union estimated the investment to benefit ratio at 1:10. With regard to protection of lives and property, it is even larger. China makes use of metrological satellites to carry out weather forecasting, estimates of agricultural production, as well as the monitoring of floods, droughts, forest fires, and so forth, and they also play important roles. In metrological satellites and their applications and development processes, one will also be confronted with a new leap--for example, proliferation in the types of monitoring instruments and frequency band expansion. Doppler high resolution remote sensing systems will develop a step further. This will provide even more effective means for the monitoring and study of such problems as improved ground surface monitoring, the distinguishing of regions of atmospheric pile up, global climate anomolies, global water circulation, the greenhouse effect, and so on.

The purpose of ground environmental monitoring is to get a better grasp on resources. As a result, it requires rapid and accurate acquisition of large amounts of data in order to facilitate the extraction from among them of data associated with geographical, geological, environmental, and vegetation resources. These data include the search for and discovery of energy resources and mineral deposits, the utilization of soils, geologies, and agricultural land, environmental changes associated with cities and agricultural villages, the occurrence and development of natural disasters, and so on.
Recently, China's national earthquake bureau also discovered that the evolution of phenomena associated with abnormal satellite thermal infrared developments are capable of providing warning sign data for earthquakes. In conjunction with this, verification was obtained in multiple earthquakes. Due to the fact that metrological satellite observations are over large areas, their resolutions with regard to the surface are then comparatively low. It is not possible for them to play a role in detailed observations. If it is necessary to observe the surface environment in detail, it is then necessary to rely on global resource satellite systems.

The earliest resource satellite was the Earth Resources Technology Satellite-1 (ERTS-1) which the U.S. launched in 1972. Just in the midst of operations at the present time is the Land Satellite-5 (LANDSAT-5). Orbital altitude is approximately 800km. Satellites have Doppler scanning instruments used in order to record surface scenery data. The resolution is 80m. There are also "theme map making instruments" which include among them far infrared (thermal radiation detectors) with relatively small scanning ranges (185km) and comparatively high resolutions.

Their resolutions are capable of reaching 20m. Besides that, as far as global resource satellites are concerned--in order to achieve relatively high surface resolutions--the observation belt which it is possible to scan on one orbit is then not comparable to the widths of metrological satellites. If it is necessary to make a general observation of the globe as a whole, there is also a requirement for over ten days time. High resolution theme map making instruments are then only capable of flying a satellite at certain time past a place in question once. Scanning cameras on the French Sibote (phonetic) are capable of adjusting viewing angles. In adjacent orbits, it is possible to slant views at the same target. In this way, it is not only possible to acquire three dimensional imagery. It is also possible to make periods associated with observations of the same target shrink to under two and a half days. However, with regard to certain natural disasters, this period is still too long. We believe that it is possible, through combined utilization of many types of satellites, to jointly consider combined observations from multiple satellites, and only then is it possible to resolve this problem. Speaking in terms of this point, international cooperation is very important.

Through observations of the oceanic environment, it is possible--at different time scales--to grasp the status of the oceans, and, in conjunction with that, make observations. Following along with the development of services exploiting the oceans, the activities of the human race on the seas are also more frequent by the day. In order to avoid the occurrence of accidents at sea, and, at the same time, acquire maximum economic benefits, people have a great need to understand and grasp the status of the oceanic environment as well as possible changes. In 1987, the U.S. launched the first Sea Satellite (SEASAT-1). The satellite carried radar altigraphs, wind field scattering gauges, synthetic aperture radars, scanning type multichannel microwave radiometers, as well as visible light and infrared radiometers. Measurements were carried out of sea surface wind direction, wind speed, wave height, wave length, spectra, internal waves, ocean surface temperature, atmospheric water content, as well as sea water coverage and sea water movement parameters. At the same time, such auxilliary parameters as cloud layer locations, clear sky sea surface temperature, cloud top brightness, and so on, are provided. Such countries as the former Soviet Union and Japan also launched sea satellites in succession. Future oceanic satellite remote sensing technology can be roughly divided into three types. The first type is comprehensive oceanic observation satellites. They supply broad observation data for most oceanic users. The second type is a specialized oceanic research and applications satellite supplying more precise and more accurate remote sensing data. The third type is comprehensive remote sensing satellites capable of satisfying the application requirements of users associated with the oceans, the land, the weather, and so on. Sea satellites also have obvious roles in forecasting natural disaster environments.

4. Systematic and Comprehensive Utilization

Among the various systems introduced above, what we emphasized the introduction of were satellites. However, in order to make systems function smoothly, consideration must then be given in terms of an integration of sky and earth. If one wants to put satellites aloft, it is necessary to have appropriate carrier rockets and launch bases. As far as launch and operating periods are concerned, the ground must have measurement and control equipment associated with optics and radio to carry out measurements (observations) and control with regard to satellites and carrier rockets. With respect to satellite applications, the ground must have corresponding application systems. Only then is it possible to play the role. As an example, surface communications stations and broadcast centers associated with communications broadcast satellites, surface reference stations and central computer stations (with regard to dual satellite positioning systems) associated with navigation and positioning satellites, and earth observation systems must have surface data receving stations and processing centers. These surface application systems are connected to millions and millions of users. In conjunction with this, there are mutual relationships with other departments of the national economy--expanding data interchange and utilization. Space data systems are applications of space science and technology. We must--from the actual results which they are capable of producing--evaluate their advantages and disadvantages. During designing, it is also necessary to carry out optimization from an integration of economic characteristics and convenience associated with users and systems. Experience clearly shows that--speaking in terms of the space section--satellite economic characteristics and long life are of critical importance. Economic characteristics of newly developed, small, low orbit satellites are key in the necessary economic reliability associated with interchangable parts of satellite bodies. All of these things must be considered with regard to space data systems. Moreover, they also lead to a series of questions associated with the selection of correct technological paths as well as the preparation of components, and so on.

The benefits of space systems are great. However, their one-time investment characteristics are also quite great. People often hesitate to go forward because the necessary investment is comparatively large. In order to reduce the economic burden, making comprehensive use of systems can be one way out to consider. Moreover, comprehensive utilization of space system applications such as communications, navigational positioning, earth observation, and so on, as well as the combining of roles with other nonsatellite systems is an important development direction. In 1979, India launched an Indian satellite associated with a three in one combination of communications, broadcast, and metrology, which is an even more comprehensive system. Its multiple types of functions achieved serious attention internationally. With regard to small satellites or small satellite groups, questions of comprehensive utilization can also be considered.

Comprehensive utilization on satellites involves, at the same time, surface system distribution and management problems. Different types of users and different areas of application also require contact, management, and processing by specialized agencies. As a result, surface department data hook ups, distribution, and collection are important problems in systems. With a view toward a certain application--besides space systems--there are also other systems that are capable of being utilized. In certain situations, they are just more effective as widely applied systems, and that is all--for example, in municipal cable communications, cellular type mobile communications networks, maritime Luolan (phonetic) navigation systems, aircraft borne remote sensing systems in earth observations, and so forth.

III. RELATED TECHNOLOGICAL PROBLEMS

Despite the fact that space application systems possess huge social and economic benefits, the set up of these systems--including satellites, surface launch, measurement, and control systems, application centers, and so on--require quite large investments. On the other hand, user confidence and widespread utilization requires certain processes. As a result, it often makes leading departments have difficulty deciding and waste time.

Considered as a whole, being able to satisfy practical requirements and achieving these requirements at the most economical cost are two of the most important principles in designing systems. Moreover, this is nothing else than the design problem of "integrated optimization" which was brought up earlier. At the same time, we must look ahead to developments in international terms. If we carry out research on key technologies in systems early on, only then are we able better able to realize the optimization of systems. For example, in international terms, the development of "small satellites" is just in the midst of drawing people's attention. They are definitely not repeats of that type of rudimentary small satellite when the space age began in the 1950's and 60's. They will, however, consider applying microelectronics technology in order to use cheap small satellites or groups of satellites to complete a certain mission. There are some that are for individual space physics survey missions. There are some, by contrast, which are even capable of achieving the same or higher requirements than large model, expensive satellites.

Speaking in terms of the technology of satellite systems, for the sake of economic objectives, we believe that the most important are: (1) reducing expenditures associated with common user sections of satellites themselves. Attitude control and electric power expenditures are primary among these. (2) User equipment that is cheap and good. If user equipment is very expensive, there is then no way to expand use. (3) Increase orbital life in space sections.

Below are presented a number of key technology and component problems which urgently await solution:

(1) satellite use of solid state components;

(2) satellite phase control antennas;

(3) on board satellite processing and exchange technology;

(4) satellite microwave remote sensing;

(5) miniaturization and lightening of satellite optical and electric remote sensing equipment.

IV. OUTLOOK

"With the imminent arrival of the 21st century, space technology will play an even greater role with regard to the earth and the human race." This is the consensus of international and domestic scholars. Space application systems will still take human society and the global environment as the objects of development toward even higher levels. Satellite applications and the range of satellite applications will expand to the whole earth.

Looking forward to the future, we can make the several preliminary predictions below.

1) Synchronous, fixed point satellite application systems will still develop. Communications satellite operating frequency bands will rise to the millimeter wave band and point beam coverage in order to accomodate even more users. There is a possibility of developing toward the placement of multiple satellites at one fixed point position. They have different frequency bands and functions. However, positioning accuracy problems need to be solved to prevent the various satellites colliding.

2) New developments in small satellites (if one considers comprehensive utilization of functions, medium model satellites are certainly not excluded). Besides increases in timeliness, flexibility, and specialized utilizations, there will be further steps taken to make space utilizations develop in the direction of an international character. The reason is that the motions of low orbit, small satellites combined with the spin of the earth makes them cross the air space of various places in the world at different times. Starting out from global applications is doubtless a kind of waste. For example, as far as global observation satellites for monitoring disasters are concerned--if we are hoping to monitor various places in China twice a day--it is then necessary to launch multiple satellites (possibly requiring 6-10). This is even more the case for communications satellites. Global mobile communications satellite systems have already been put forward by enterprises and departments of the U.S. and the former Soviet Union. Moreover, they are just in the midst of actively setting them up. For the benefit of the people of the world and to promote international cooperation the presentation or selection of corresponding systems is necessary.

3) Systems associated with comprehensive utilization will achieve development. This will save funds for space

utilizations--for example, mutual combinations of positioning and communications, earth observation satellites simultaneously possessing a certain communications capability, and so forth. In the development of the international character of small satellite groups, this is particularly worthy of consideration. To this end, satellite processing technologies must correspond to developments.