Space-based Information Network for Earth Observation

Jingshan Jiang Guoliang Bian

Center for Space Science and Applied Research, CAS P.O.Box 8701 Beijing, China, 100080
Tel: 86-10-62559575, Fax: 86-10-62559575 E-mail: jsjiang@www.mirit.poac.ac.cn

ABSTRACT: The role of the space activities in the next century will doubtlessly span the entire conceivable fields from global change research, improvement of the living environment of human being to the development of science and technology and obtaining more and more knowledge about planetary. Space will be the medium for information collection and distribution in the next century. Space systems have strong capability of operating freely at any point above the earth, communicating with other satellites and ground people, distributing information to numerous users in near real time. Establishing a high capable space-net is one of the important activities of space in the next century. We are now proposing to enhance the research and development activities in China.

In this paper, the concept of space-based earth observation information network as an important part of the space-based synthesized information network of China is discussed and some ideas of designing the space-net are given. Besides these, the key problems need to be solved for designing the SBIN are discussed and a brief description of the state-of-the-art technologies concerned with SBIN is also given.

KEY WORDS: Space based network, Earth observation, Information, Remote sensing

1. The Concept of the Space-based Synthesized Information Network (SBIN)

The development of the satellites as a space-based platform has continued for more than 40 years. It started from 1957 and has experienced three developing stages: firstly, a single satellite with single function; secondly, a single satellite with multifunction and thirdly, multi-satellites with multifunction (satellite constellation). A space based synthesized information network is an intelligent space system composed of multifunctional satellite on different orbits. On the purpose of getting a maximum information sources, the system should be able to collect, process, storage and allocate information. The SBIN has several unique applications, such as synthesize and distribute information with high function, high efficiency, high intelligence and high reliability. The SBIN involves the Earth observation system (EOS), positioning and navigation system, communication system, space environment testing system and meteorological satellites system, it can be applied for monitoring and early warning of environmental hazards, precision agriculture, digital earth and military applications. The SBIN can be classified by different functions as: observation net, data transferring net, positioning and navigation net, space science and technology net, and so on.

2. The Earth Observation Space Network System

2.1. Main Applications of the Earth Observation Network Are AsFollows:

- Research of global change
- Monitoring and broadcasting the environment hazard
- Digital earth problems
- Precision agriculture problems
- National security

2.2. Features of Earth Observation (EO) Network

- Multi orbit and multi-platform
- A comprehensive electromagnetic observation
- Multi temporal and phase information
- Multi-mode multi-angle observations
- Different resolution
- Combine of different application functions
- Global and local observations

2.3. Some Key Technical Problems of the EO Net

To realize the space based earth observation network, there are many key technical problems need to solve. The main key problem will be concerned as the following areas:

- Small satellite and its networking and recombining technologies
- Advanced payload technologies with high function density, high autonomous capability, light weight, miniaturized devices and low cost and so on

Table 1 some small launched satellites during past 10 years

Mission	Launch Time	Status	Main payload	Users
UoSAT-1	1981		Technology demonstration and research	UoS
UoSAT-2	1984	Operational	S and F communication, research	UoS
UoSAT-3	1990	Operational	S and F communications (for medical network)	National life
UoSAT-4	1990	Non-operational	Technology demonstration	DRA, ESA
UoSAT-5	1991	Operational	Communication, Remote sensing, Sciences	UoS, DRA
KITSAT-1	1992	Operational	Communication, Remote sensing, Sciences	Korea
S80/T	1992	Operational	Communication research at low orbit	CNES
PoSAT	1993	Operational	Communication, Remote sensing, Sciences	Portugal
HeathSAT-2	1993	Operational	Communication (for medical network)	National life
KITSAT-2	1993	Operational	Communication, Remote sensing, Sciences	Korea
Ceries	1995	Operational	For military (secrecy)	MoD France
FASAT-Alfa	1995	Non-operational	Remote sensing, data collection	Chile
UoSAT	1997	Under integrating	Remote sensing, communication in S,L bands	UoS
FASAT-Braro	1997	Under testing	Remote sensing, data collection	Chile
TM SAT	1997	Under integrating	Remote sensing, data collection	Thailand

- The information transmission technology with high data compression rate, reliable transferring link, advances in satellite to satellite, satellite to ground data links and onboard processing and control
- The application function design and realization
- Network control
- Information system and interface to users

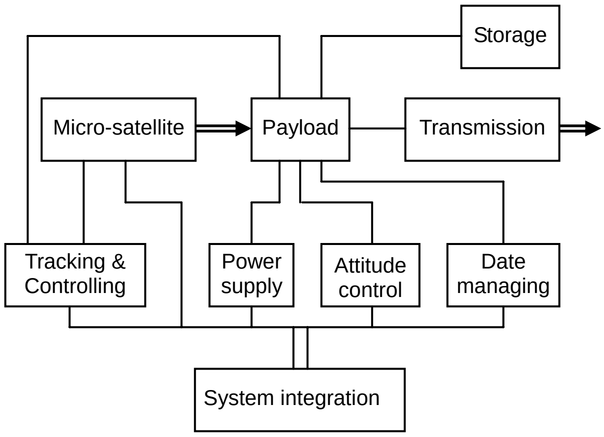


Fig. 1 The Structure of Micro-Satellite

3. A brief Discussion on the Key Problems of EO Net

3.1. On the Small Satellite System

The modern small satellite technology has been developed rapidly in the past ten years. To improve design lower cost, increases flexibility, and enhances survivability. Key design considerations include satellite size, longevity, power and propulsion requirements, radiation-hardened electronics, satellite autonomy, and satellite disposition.

Many countries and organizations have made great achievements in small satellite design and launches. Table 1 shows some small satellites, which launched during the past 10 years. Fig. 1 shows the key technology concerned with small satellites.

To meet wide users' need, China developed series of small satellites including scientific satellite SJ-4, SJ-5 and earth observation small satellites HY-1 oceanographic satellite, TS-1 earth explore satellite and so on. In resent time, an EFS-small satellite system intending for Earthquake forecast has been proposed by Prof. Chen Fangyun et al. The orbit parameters of this satellite are:

Semi-major axis: $a = 1.088339R_E$
$= 6941.1$Km
Eccentricity: $e = 0.00107$
Inclination: $i = 97.65°$
Period: $P= 96$min

The average altitude of the orbit 564Km and the distance between successive orbits at the equator is 26789Km. The orbit of the satellites in the system is well designed so that any place in the world could be visited twice a day in accordance with the optical small satellites system.

3.2. Payload Technologies for Small Satellites

The heart of the small satellites is the payload system. The Band used in earth observations can cover from visible to microwave. Fig. 2 shows the spectrum used for remote sensing.

The miniaturization of payload especially for several key parts is an important problem for small satellite. Fig. 3 shows the important technologies for smart payloads.

There are several payloads designed for small satellite mission of China:

- A compact multi-spectrum CCD camera with high spatial resolution
  Spectral range: 0.45~0.52μm, 0.52~0.6μm 0.63~0.69μm, 0.76~0.9μm
  Ground resolution: 50m (at 772Km satellite high)
  Ground swath: 400Km
  Total weight: ≤10Kg
- A multi-frequency microwave radiometer

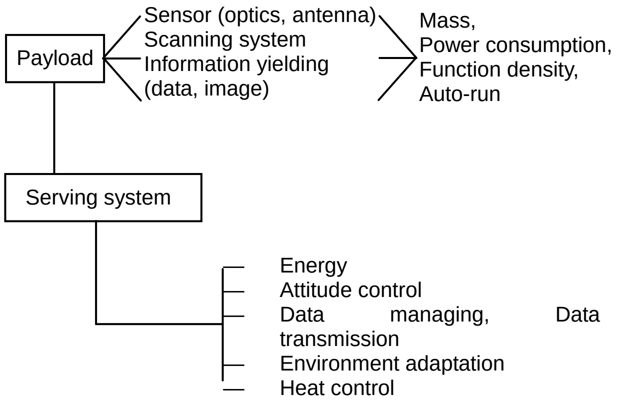


Fig. 3 Miniaturization of Payload –
Earth observation. Science sounding.

Table 2 Typical technical indexes designed

Operative height	800Km
Radar frequency	13.5GHz
Transmitted power (peak)	1.1Kw
Signal bandwidth	320,80,20MHz
Antenna aperture	0.7m × 2.0m
3dB beam-width	0.6° × 2.0°
Baseline length	3.0m
Off-nadir observation angle	2.0°
Swath	22Km
Ground resolution	100m × 400m (azimuth × range)
Height accuracy (average) Height accuracy (pixel)	Ocean: 10.0cm, land:3m Ocean: <3m, land:5~10m

  Frequency: 85.5GHz, 37GHz, 22.235GHz, 9.76GHz
  Total weight: ≤40Kg
- A image Spectrometer
- Microwave Imaging Altimeter (CIALT)
  The CIALT is a new sensor working in new mechanism and now under design. The typical specifications are shown in Table 2.

3.3. On-orbit Processing and Communication Link

The key point of controlling information are the quantum increases in the speed and capacity of information processing systems and the ability to move processing and correlation function into space. Equally important is the integration of hardware, software and information from the user sector. On-orbit processing of data and the resulting rapid distribution of critical information to the special individual users, just in time or on demand, is a vital step in maintaining land, air and space dominance. As technology advances, the feasibility of automating data collection, fusion and distribution becomes a reality. In order to increase the distributing speed of information, space-based assets must be available to all levels friendly. Advances in computer processing speed, artificial software, data storage, and power supplies will enable on-orbit processing.

The heart of any processing systems is the software. There will be a fundamental shift from programming computer actions to allowing computers to sever as a thinking agent, anticipating needs based on preprogrammed criteria and real-time inputs from priority users.

Information-processing in space will require tremendous in the storage capacity of “hard drives”. The day research indicates that the future of information storage is in optical system. Budding technologies such as holographic data storage system (HDSS) will exponentially increase the ability to archive and retrieve data. With this storage capacity on-orbit and in-theater, archived information is available when needed by the user.

To further multiply the value of HDSS, new technologies in data compression are being studied. For example, imagery products require a large amount of storage space and are ideal for compression. Fractal compression research offers high compression rates and high resolution after decompression.

The communication is one area of the key technology study for space-net, which requires great advances in satellite to satellite cross-links. Relay satellite will become the norm for satellite control. By using relay satellites, the controller is not required to have the target satellite in view. The relay satellite can then cross-link the signal to any other relay satellite to transfer the message to the intended operational satellite anywhere in the solar

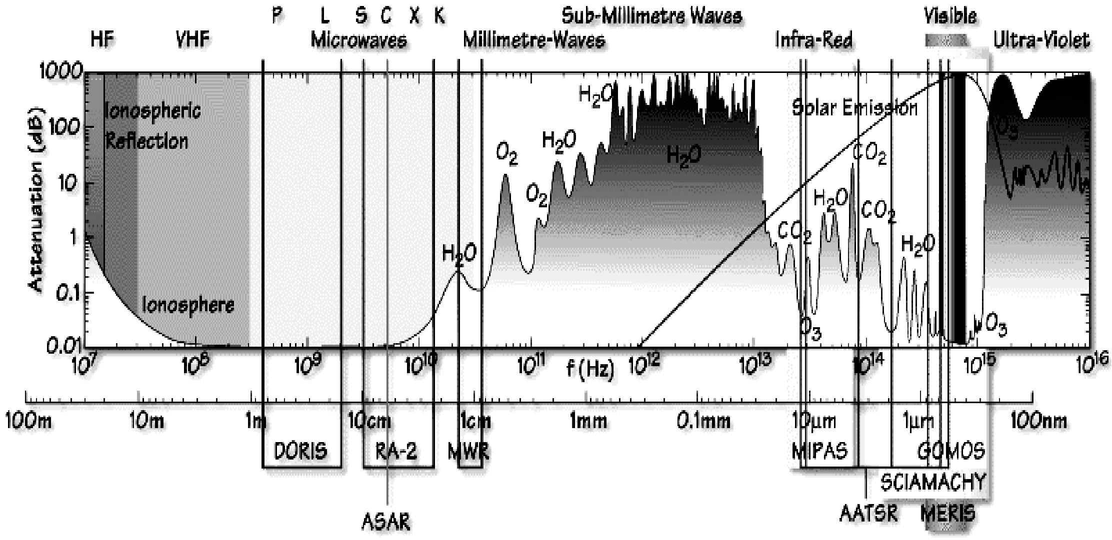


Fig. 2 Schematic diagram of Electromagnetic Spectrum

system. Network control software distributed to each relay satellite will allow the network to adjust automatically to outage, rerouting information around degraded satellites and maintaining a constant level of service to operational satellites.

4. SBIN Design Philosophy

To establish a most affective SBIN, there are several philosophies should be obeyed. The main control and management. The SBIN should be have high capability of re-organizing the space-net

Fig.4 shows a space-net communication

system according to users requirement.

Fourthly, network security. As reliance on these systems increase, it will become more important for them to regenerate the system if satellites are

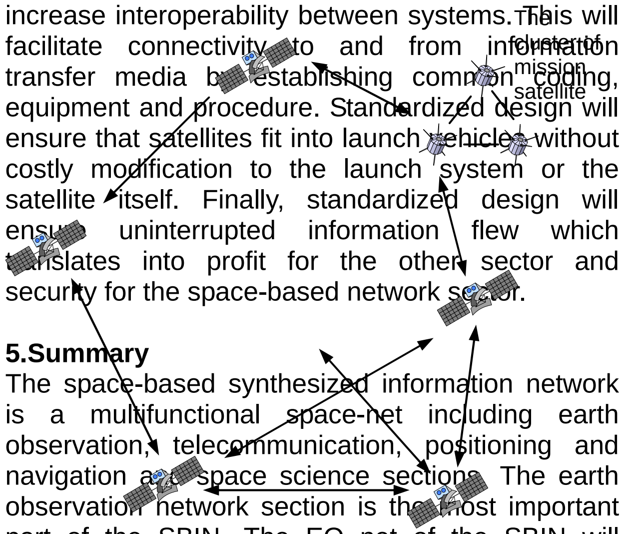
points are as follows:

Firstly, satellite design is critical. Improved design with lowers cost, increases flexibility, and enhances survivability.

Secondly, key design considerations include satellite size, longevity, power and propulsion requirement, radiation-hardened electronics, satellite autonomy and satellite disposition.

Thirdly, networking mechanism and network destroyed, since both SBIN and other satellites systems are valuable to a variety of threats, cooperation between these sectors will be mutually beneficial in many ways.

Fifthly, SBIN standardize. Standardization will increase interoperability between systems. This will facilitate connectivity to and from information transfer media by establishing common coding, equipment and procedure. Standardized design will ensure that satellites fit into launch vehicles without costly modification to the launch system or the satellite itself. Finally, standardized design will ensure uninterrupted information flew which translates into profit for the other sector and security for the space-based network sector.



5.Summary

The space-based synthesized information network is a multifunctional space-net including earth observation, telecommunication, positioning and navigation and space science sections. The earth observation network section is the most important part of the SBIN. The EO net of the SBIN will operates as a heart of the earth observation system in the next country. There are many new technologies need to develop for establishing a more effective space-based earth observation network and the SBIN will play an important roles in national economy development and for national security.

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