Research and Development of Sat-Comm Systems in Asia

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1. Introduction

Satellite communication is employed in an exceedingly range of fields, e.g. to supply trunk links for communication suppliers, non-public networks for firms, and temporary communication systems in disasters. In these things their benefits embrace wide coverage, versatile network configuration, and anti-disaster capability. Additionally, satellite communication victimisation hand-held mobile phones has recently become offered. to supply these services, the governments of many nations, as well as the us, European nations, and Japan have endowed resources in risky analysis and development of satellite communication technologies for quite thirty years. However, the event stage of the technology continues to be removed from the goal of achieving final satellite communication services like broadband and present services adequate terrestrial communication network systems. Therefore, new analysis and development of satellite communication technologies continues to be being conducted in several countries to supply a lot of subtle and convenient satellite communication.

This paper offers an outline of the history of Japan's analysis and development of satellite communication technologies and concisely describes current analysis and development (R & D) comes for successive generation of satellite communication systems like the Engineering check Satellite VIII (ETS-VIII), the broadband Inter-Networking Engineering check & Demonstration Satellite (WINDS), and therefore the Quasi-Zenith Satellite Communication System (QZS).

2. Historical overview

In Japan, R & D satellites have been developed mainly by government organizations,

including the Ministry of Public Management, Home Affairs Posts and Telecommunications (MPHPT, formerly the Ministry of Posts and Telecommunications), the Ministry of Education, Culture, Sports, Science and Technology (MEXT, formerly the Science and Technology Agency), the Japan Aerospace Exploration Agency (JAXA, formerly the National Space Development Agency of Japan), and the National Institute of Information and Communications Technology (NICT, formerly the Communications Research Laboratory). The Nippon Telephone and Telegraph Corporation (NTT) also participated in these national projects since it was a public corporation prior to 1985. Table 1 summarizes the history of the use of R & D satellites in the development of communication technology in Japan.

Table 1 Research and development communication satellites in Japan

Satellite	Period	Main mission	Main technology target
CS	1977-85	• Ka-band fixed satcom	• Ka-band transponder • Ka-band Shaped beam antenna • Ka-band earth stations
ETS-V	1987-97	• L-band mobile satcom	• L-band SSPA • Maritime, aeronautical, and land mobile earth stations
ETS-VI	1994-96	• Ka-band fixed satcom • S-band mobile satcom • S-band Inter-satcom • millimeter personal satcom • optical inter-satcom	• S-band - millimeter wave transponders • Laser communication equipment • S-band phased array antenna
COMETS	1998-99	• Ka-band mobile satcom • Millimeter wave satcom • Ka-band inter-satcom	• Ka-band SSPA device • Onboard signal processing equipment • Ka-band mobile earth stations • Millimeter-wave earth stations
ETS-VIII	2004-	• S-band mobile satcom	• Large deployable reflector • Active phase array feed system • Onboard signal processing
WINDS	2005-	• Ka-band broadband fixed satcom	• Ka-band multi-beam antenna • Ka-band multi-port amp. • Ka-band active phased array antenna • Onboard ATM switching equipment
QZS	2008 ~	• High elevation mobile satcom • High accuracy positioning service	• Communication system in new orbit • H_2 maser Atomic clock

The actual development of satellite communications technology in Japan started from a medium-capacity communications satellite for experimental purposes (CS)[1]. This satellite was launched in 1977 using the US's Delta rocket. The purpose of the satellite was to establish fixed satellite communication technology using Ka-band frequencies. This was the first trial of the use of the Ka-band for satellite communication in the world and the technology has since been transferred to successive practical fixed satellites in Japan, such as the CS-2 (1983), CS-3 (1988), N-Star satellites (1995, 1996), and so on.

In the field of mobile satellite communication, the Engineering Test Satellite V (ETS-V)[2] was developed and launched by Japan's H-I rocket in 1987 to establish an advanced mobile satellite communication system integrating maritime, aeronautical and land mobile communications. A relatively high-gain L-band antenna onboard the satellite played a key role in providing convenient mobile satellite communication with small earth stations. The life of the satellite was 10 years, and various mobile service applications were developed during that period. In addition, international collaborative projects were conducted with Asian nations and the Pacific regions to spread mobile satellite communication technologies to those countries. The results of the mobile satellite communication experiments carried out using the ETS-V were transferred to practical services provided by Japan's N-Star satellite.

After the CS and ETS-V satellite projects, two R & D satellites, ETS-VI[3] and the Communications and Broadcasting Engineering Test satellite (COMETS)[4], were launched using H-II rockets in 1994 and 1998, respectively. Unfortunately, they could not be placed in a geo-stationary orbit and both became elliptical orbiting systems due to the failure of the ETS-VI's apogee-engine and a problem with the second-stage rocket engine in the COMETS. In the ETS-VI, various kinds of communication technologies were developed for fixed satellite, mobile satellite, inter-satellite, millimeter wave, and space optical communications. In the COMETS, mobile satellite communication equipment for the Ka and millimeter-wave bands was developed for future mobile systems using high frequency bands. For both satellites, in-orbit communication experiments were conducted to evaluate the performance of the onboard equipment. Some of the results made a useful contribution to the R & D satellites described in the next section.

The ETS-VIII is an R & D satellite for the next generation of mobile satellite communications[5]. Figures 1 and 2 show an overview of the ETS-VIII satellite and its service image, respectively. The main purpose of the development of the ETS-VIII is to establish a technology for handheld satellite phone systems using a geo-stationary satellite..

MPT began the conceptual study 10 years ago when there were no actual handheld satellite phone systems in the world. However, actual systems became available several years later using US satellite technology such as Iridium, Globalstar, Garuda, and Thuraya. Meanwhile, due to the failure of the H-II rockets the launch of Japan's ETS-VIII has been delayed from the original launch date of 2000 to autumn 2004, when it is planned to launch the satellite using a H-IIA rocket augmented by large solid boosters.

The key technologies to be developed for the ETS-VIII satellite are:

- A large-scale deployable reflector in the S-band to enable earth stations to be miniaturized,
- A phased-array feed system to provide electronically steerable multi-beams,
- Onboard signal-processing technology for voice and data communications to provide flexible connections between multi-beams,
- A reliable 3-ton class satellite bus.

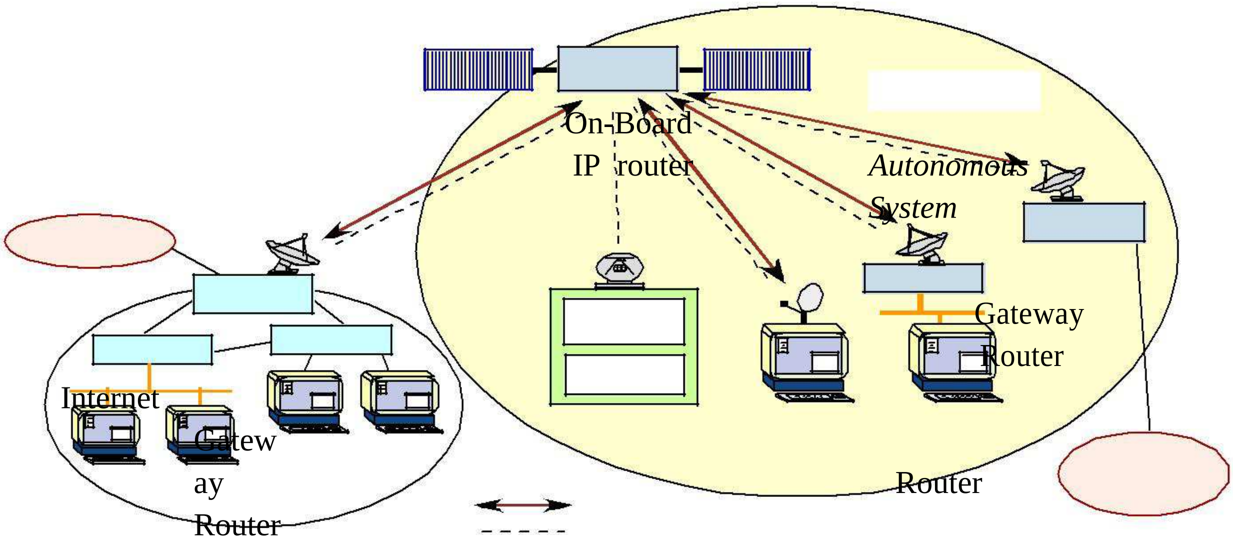
The deployable reflector is 19m x 17m in orbit, which is almost the same size as a tennis court. In addition to the mission of developing mobile satellite communications, the ETS-VIII has a US-made atomic clock onboard to establish high-accuracy ranging and positioning technology using geo-stationary satellites.

The WINDS is an R & D satellite for Gbps-class broadband satellite communications [6]. Figures 3 and 4 show an overview of the WINDS and its service image, respectively. The main purpose of developing the WINDS is to establish technology for broadband satellite communications in Japan, Asia and the Pacific Islands.

The conceptual design and development of the test equipment were carried out at NICT more than five years ago to study the feasibility of high-speed satellite communications using a Ka-band scanning phased-array antenna onboard a satellite to cover the entire Pan-Pacific region including Asian nations, Hawaii and much of Oceania. The idea is a good solution for resolving the problem of the digital divide in developing countries. This research activity and a new satellite development plan at JAXA supported by the e-Japan Priority Policy Program of the Japanese government, were combined to become a new project, WINDS. The WINDS is scheduled for launch in 2006 using a H-IIA rocket.

To provide broadband satellite communications over a wide service area including the domestic area of Japan, large Asian cities, and the Pacific region, sophisticated Ka-band multi-beam antenna systems and high-speed signal switching equipment have been installed in the WINDS. One of the antennas onboard the satellite is a fixed multi-beam antenna which covers the area of Japan and large Asian cities such as Seoul, Beijing, Shanghai, Bangkok, etc. In those areas, data communications of hundreds of Mbps are available using earth stations equipped with dish antennas several meters in diameter. The other onboard antenna is an active phase-array antenna that covers the Pacific region using electronically

Fig. 3 Overview of the WINDS



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Connection Control

Fig. 4 Service image of the WINDS

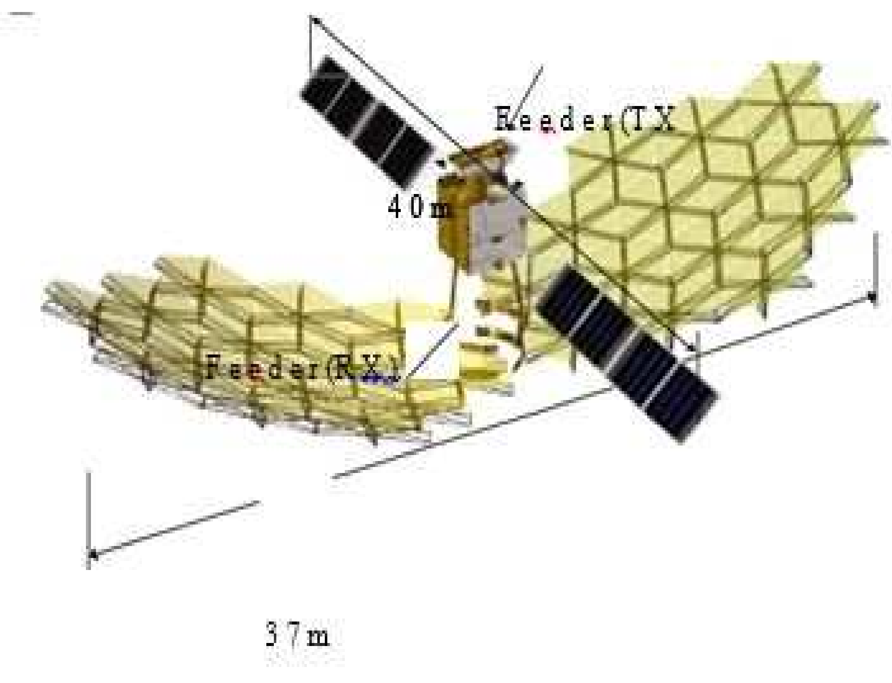
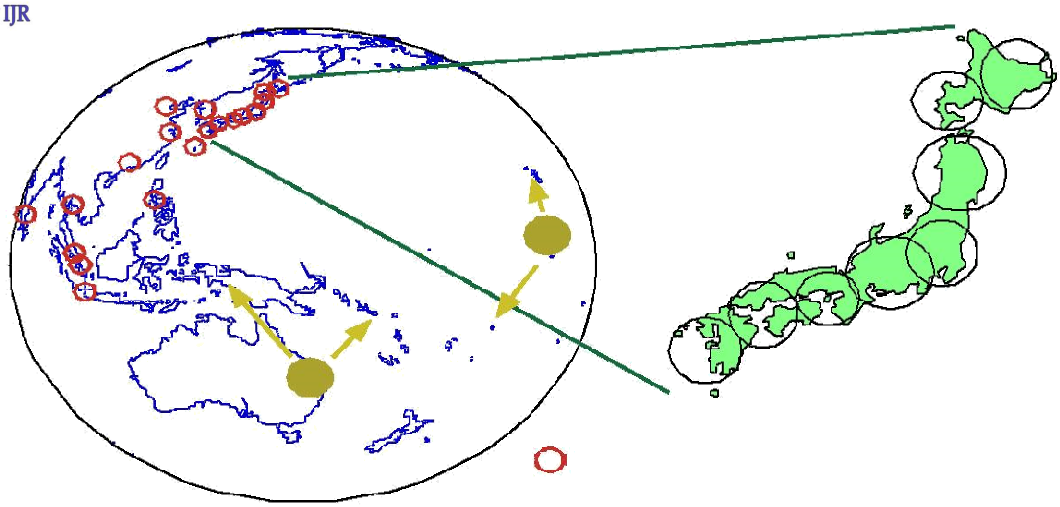


Fig. 1 Overview of the ETS-VIII

Fig.2 Service image of the ETS-VIII



APAA spots can be scanned
over all visible area

: Fixed Multi-Beam Coverage
Other Area : covered by APAA

Fig. 5 Service area of the WINDS

steerable beams. A communication network between Pacific regions is provided by a combination of the active phased-array antenna and onboard signal switching equipment, which features high-speed asynchronous transfer mode (ATM) switching. An example of the service area is shown in Figure 5.

3.3. Quasi-Zenith Satellite System (QZS).

One of the main features of the QZS system is the communication capability of high-elevation angles in mid-latitude areas because the satellite periodically reaches the zenith direction even in mid-latitude areas. Three satellites are enough to provide 24-hour continuous communication services. As a result, mobile satellite communications with almost no shadowing or blocking effects are feasible, even in urban areas where there are tall

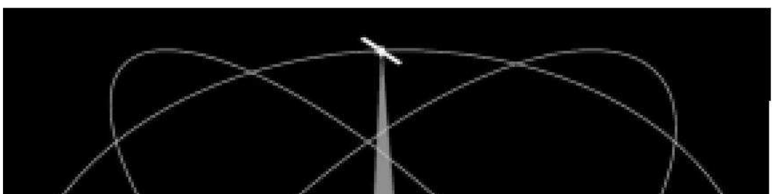


Fig. 6 Orbit system of QZS

buildings and numerous obstacles. An example of the QZS orbit is shown in Figure 6.

Fundamental research into high-elevation communication using high-frequency bands such as the Ku, Ka, and millimeter-wave bands, has been conducted at NICT for several years. The use of high-frequency bands is not only a countermeasure against the likely future shortage of lower frequency bands, such as the L and S-bands, but it also contributes to the miniaturization of earth stations, which can use a coin-size patch antenna without a satellite tracking mechanism

In addition to the fundamental research, the Japanese government, NICT, JAXA and the private sector have conducted a collaborative study of QZS systems including positioning services because these systems have the capability to provide high-accuracy positioning services when combined with existing GPS systems or by adding optional satellites. This year, the government decided to provide financial and technological support and conceptual design has begun with the goal of launching an experimental QZS system in 2008[7].

4. Conclusions

The analysis and development of satellite communications in Japan are delineate. Satellite communication is a component of thusciety's basic infrastructure so R & D activities ought to still be undertaken. However, these activities square measure being littered with the recent severe economic downswing in Japan and, therefore, nearer cooperation between the general public and personal sectors is vital. Finally, we have a tendency to believe that stronger international cooperation can play a crucial key role in facilitating future R & D activities.

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