Development of the Wideband InterNetworking Satellite WINDS (KIZUNA)

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Abstract

The WINDS (Wideband InterNetworking engineering test and Demonstration Satellite, also called KIZUNA) is a stationary satellite developed for the technological development and demonstration of an ultrahigh-data-rate satellite communications system using the Ka band that has high affinity to the Internet. It enables ultrahigh-data-rate communications experiments all over Japan as well as in the Asia-Pacific region. The effectiveness of the satellite has already been demonstrated by many communications experiments conducted over the three years since the launch, and more experiments are planned for the future. This paper introduces an outline of the WINDS project and discusses the results of the main experiments so far.

Keywords

wideband internetworking satellite, multi-beam antenna, multi-port amp, onboard high-speed switching router

1. Introduction

Satellite communications are a very effective means of communication for the mountainous regions and isolated islands where the use of terrestrial communications networks are difficult, as well as for areas that are affected by large disasters. They can also be used to provide a variety of simultaneous communications services that require broadband coverage. In order to enhance satellite communications services, the key is the application of broadband communications. The WINDS (Wideband InterNetworking engineering test and Demonstration Satellite, or KIZUNA) was developed by the Japan Aerospace Exploration Agency (JAXA) and the National Institute of Information and Communications Technology (NICT) (**Fig. 1**). It formed a part of the R&D program related to the creation of advanced information and telecommunications networks under the framework of the "e-Japan Priority Policy Program" of the IT Strategic Headquarters for the Promotion of an Advanced Information and Telecommunications Network Society (IT Strategic Headquarters) of the Japanese government. WINDS covers the entire Japan and the Asia-Pacific region in order to enable ultrahigh-data-rate communications at the top level globally of 1.2 Gbps or high-data-rate communications of 155 Mbps, when received with a household antenna. It is a large stationary satellite weighing about 5 tons at the time of launch and measuring about 22 meters across on orbit. As NEC was appointed as the main manufacturer of the satellite; we developed: the satellite system, the mission equipment including the Ka-band high-power multi-beam antenna (MBA), multi-port amp (MPA), onboard high-speed switching router (ATM switch router, ABS), network information transmitter/receiver (NITR) and IF switch (IFS), and the ground experiment system. WINDS was launched February 23, 2008, from the Tanegashima Space Center and many communications experiments have been conducted successfully since the launch.

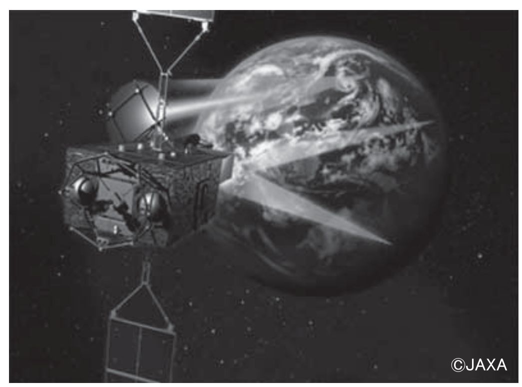

Fig. 1 Wideband internetworking satellite WINDS.

2. Features of WINDS

WINDS uses the Ka-band (20 GHz to 30 GHz) as its communications frequency band. This enables ultrahigh-data-rate, 1.2 Gbps communications with a 5-meter class antenna, and assumes business use or high-data-rate communications of 155 Mbps reception/1.5 Mbps transmission with a 45-cm class antenna that can be installed on the porch of a standard household (**Fig. 2**). It is required to have high transmission/reception capabilities to enable high data rate communications with such small earth stations, WINDS has succeeded in implementing these aims by developing an MBA of large aperture and high gain and an MPA with maximum transmission power of about 280 W (**Photo 1**).

Although the Ka band is advantageous for high-data-rate communications, it has the problem of large attenuation due to rainfall. With WINDS, the transmission powers of the beams of the MBA allocated per communications target areas can be set individually by adjusting combinations of the eight traveling-wave-tube amps of the MPA. This capability enables

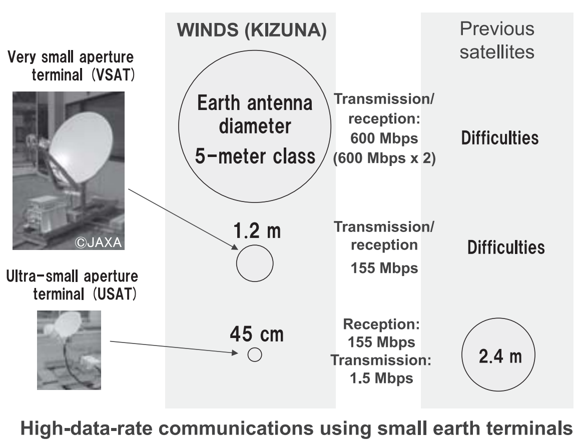

Fig. 2 Features of WINDS.

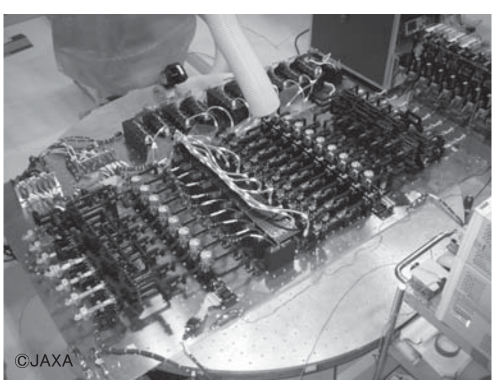

Photo 1 Ground test of MPA.

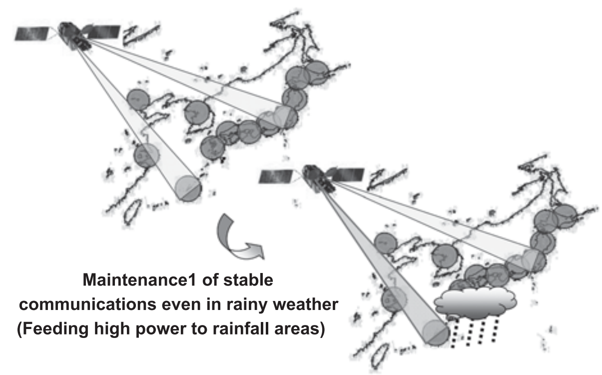

Fig. 3 Diagram explaining rainfall compensation by MPA.

flexible power distribution to the target areas, e.g., by transmitting high-power data to rainfall areas, and low-power data to the dry areas. Stable communication quality can thereby be maintained even in rainy weather and it can also contribute to the effective power utilization that is important for the satellite (**Fig. 3**).

The MBA beams of WINDS are connected via the ABS, which is a satellite-borne router, so that information can be sent only to those limited areas that need it. This enables efficient satellite power utilization without emitting radio waves to unnecessary areas as was the case with previous satellites.

One of the weak points of communications using a stationary satellite is the delay time due to the long distance between the satellite at 36,000-km altitude and the earth station. Thanks to the use of ABS, the WINDS can halve the communications delay time compared to that of previous satellites that had no router function and for which the two-way communications between the satellite and Earth was required to relay the signal via a ground switching center.

3. Systems Outline

3.1 Satellite System

The satellite system of WINDS is composed of a mission module for use in communications experiments shared with the Earth station and the bus module that is in charge of power supply to the entire satellite operation, attitude control, etc. The mission module includes: two 2.4-meter diameter MBAs capable of transmitting multiple beams to the Japanese domestic area and the Southeastern Asia area, an MPA with eight I/O ports and eight parallel-connected traveling-wave-tube

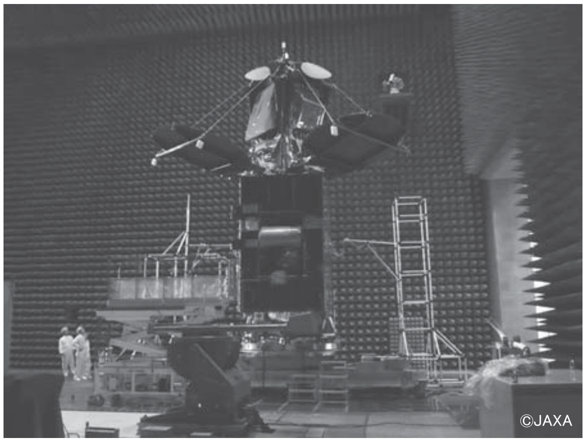

Photo 2 Preparation for the RF emission test.

amps, an active phased array antenna (APAA) capable of electronic scanning of a broad area, an ABS for regenerative switching relay, an NTRX for transmitting/receiving network control signals and an IFS for connecting them. The satellite bus is designed to improve reliability while inheriting the previously developed technologies. The solar array paddle made in Japan employs highly efficient multi-junction solar cells to decrease the weight. **Photo 2** shows a view of a ground test.

3.2 Ground Based Experiment System

The ground based experiment system is composed of the reference station controlling the network, the beacon station used as a pointing reference for the satellite antenna and user stations of the communications users. The reference station is located at the JAXA Tsukuba Space Center and the beacon station at the JAXA Tracking and Communication Station.

User stations of the regenerative link include: the 155 Mbps high-data-rate VSATs (uplink/downlink 155 Mbps max.), portable VSATs (uplink 51 Mbps max., downlink 155 Mbps max., equipped with a 1-meter auto-acquisition antenna), ship borne stations (uplink 51 Mbps max., downlink 155 Mbps max, equipped with a 1.3-meter auto-acquisition antenna). Those of the bent-pipe link include large earth based stations (uplink/downlink 1.2 Gbps max.). Together they form an IP broadband network environment making use of features of WINDS.

4. Communications Experiment Situations

Since the start of regular operations in July 2008, experiments making use of the WINDS' features such as broadband, mesh and IP multi-cast functions were conducted one after another and achieved significant success. They included: the multi-location HDTV conference/e-learning experiments in the Asia/pacific region, emergency communications/disaster information distribution experiments making use of the excellent portability of user terminal systems, and ocean ship communications experiment in the EEZ (Exclusive Economic Zone) sea areas of Japan that are the typical digital divide region (region in which the broadband network infrastructures such as optical cables are not arranged).

Among these experiments, the subsections below will introduce the HDTV relay experiment held during 2008 Beijing Olympic Games and the HDTV relay experiment of the total solar eclipse from the Iwo-jima Island in 2009.

4.1 HDTV Relay Experiment of the Beijing Olympic Games

On the occasion of the Beijing Olympic Games in 2008, an HDTV relay experiment was conducted connecting the International Broadcasting Center (IBC) in the Olympics

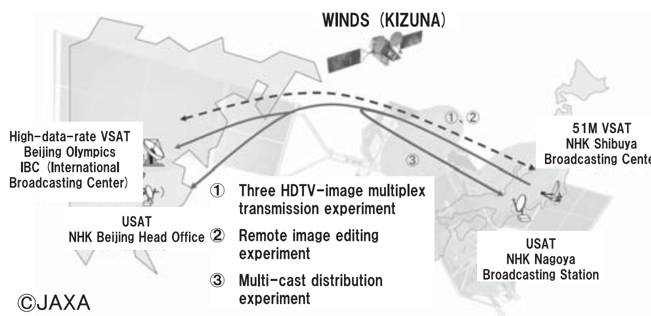

Fig. 4 Outline of Beijing Olympic Games HDTV relay experiment.

Photo 3 User station installed in IBC and NEC experiment staff.

stadium, NHK China Head Office, NHK Shibuya Broadcasting Center and NHK Nagoya Broadcasting Station (**Fig. 4** , **Photo 3**).

This experiment included the three HDTV-image multiplex transmission experiment, remote image editing experiment and the multi-cast distribution experiment. It demonstrated that the satellite broadband environments provided by WINDS user terminals can be used with various applications-just as in the Japanese domestic terrestrial broadband environments and that they can be deployed and installed very easily.

4.2 HDTV Relay Experiment of Total Solar Eclipse at Iwo-Jima Island

On July 22, 2009, a total solar eclipse was observed in the Japanese land territory for the first time in 46 years. To observe the solar eclipse at Iwo-jima island where total eclipse lasted for about 5 minutes and to relay viewing via HDTV, a joint team was organized by NHK (relay), the National Astronomical Observatory of Japan (observation), JAXA (satellite transmission route) and NICT (providing the car-mount station and domestic broadband network) (**Fig. 5** , **Photo 4**).

On the day of the total solar eclipse, four HDTV image circuits and five IP phone circuits were established between the car-mount WINDS terminal installed in Iwo-jima island and the portable KIZUNA terminal installed at the NICT Koganei Station, waiting for the expected event. As Iwo-jima island had been struck an hour before by a torrential squall in the total eclipse time zone, we were concerned that stable observation might be affected. However, by good fortune, the weather began to recover gradually about 30 minutes before the eclipse. Eventually, in the total eclipse time zone from 11:25 to 11:30,

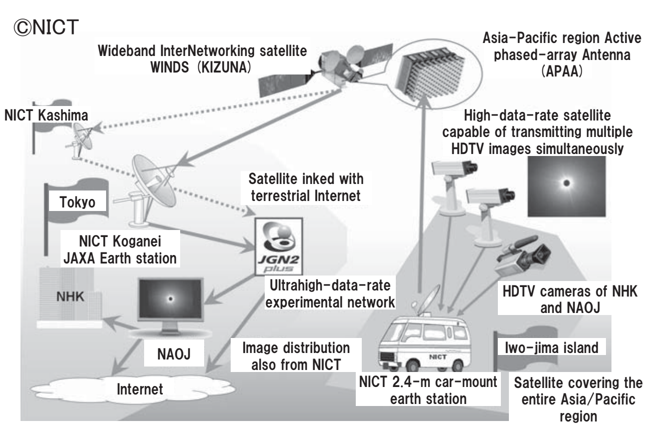

Fig. 5 Iwo-Jima Island total solar eclipse HDTV relay experiment

Photo 4 Car-mount WINDS station dispatched to Iwo-jima Island.

the impressive images were broadcast to the delight of viewers throughout Japan.

5. Conclusion

Many governmental institutions and educational organizations from both inside and outside Japan are planning various experiments utilizing the excellent features that are enabled by WINDS. These are expected to contribute significantly to the implementation of an information communication society in which high-data-rate communications services will be of benefit to anyone, anytime and anywhere, without the need for a large ground based communications station.

NEC is currently developing an ultra-broadband satellite communications system applying a multilevel modulation/demodulation technology. Our aim with this system is to achieve satellite communications with a data rate of over 2 Gbps by exceeding the current top global data rate of 1.2 Gbps, which has already been achieved in experiments using the WINDS satellite.

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