Technology Reports

Special Articles on WIDESTAR II High-speed Mobile Satellite Communications Service for Diverse Satellite Communications

Overview of WIDESTAR II Mobile Satellite Communications System and Service

WIDESTAR II began mobile satellite communications service covering all of the Japan landmass and the maritime area around it in April 2010 using four beams of the N-STAR c/d geostationary satellites. The new system provides all of the previous WIDESTAR services and expands data communications at lower charges. Base station equipment and mobile stations were newly developed, and core node equipment was developed to add only the functions specific to mobile satellite communications and incorporate IMS and other general-purpose IP technology to allow economical operation and provision of diverse high-speed mobile satellite communications services.

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1. Introduction

The mobile satellite communications service offered by NTT DOCOMO has been in operation for more than ten years under the name of WIDESTAR. The satellite telephone service [1] began in March 1996 and the satellite packet communications service [2] began in March 2000. WIDESTAR provides an important means of communications for ships at sea in times of distress, and has been certified as the means of radio telegraphy for general communications by the Global Maritime Distress and Safety System (GMDSS)[*1]. For land mobile use, the system has served as a solution for data communications services on distant islands, in mountainous regions and in other such areas where mobile phone signals are not available as well as a means of communications for disaster response by local governments [3].

WIDESTAR II is a new mobile satellite communications service that was launched simultaneously across Japan in April 2010 [4]. In addition to continuing the services provided by WIDESTAR, WIDESTAR II is intended to realize diverse satellite communications services with higher data communications speed in order to expand data communications and the solution usage. Also, the new system developed and implemented services in accordance with the trends in the transition toward data-centered traffic in the use of mobile phones and other forms of mobile communications.

In this special article, we begin with an overview of WIDESTAR II mobile

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*1 **GMDSS**: A world-wide system for safety at sea.

satellite communications system and service development and go on to explain the specific development of technology in the communications scheme [5], core network system [6], base station equipment [7], the base station maintenance and monitoring system [8] and mobile station [9].

2. Overview of WIDESTAR II

The WIDESTAR II system outline is shown in **Figure 1**.

WIDESTAR II uses two geostationary satellites, N-STAR c[10] and d, whose four beams of 600-km in radius cover a service area that includes the Japan landmass and the surrounding maritime area. The N-STAR c/d communications satellites, successors to the N-STAR a/b satellites of the original WIDESTAR, feature improved repeater capability for higher data communications speed. The feeder link between the base station and the satellite uses the C band[*2] (6/4 GHz), and the service link between the mobile station and the satellite uses the S band[*3] (2.6/2.5 GHz), a radio frequency band that is robust to rain attenuation. Four beams are used to provide the service coverage area.

3. Requirements

3.1 Service Requirements

WIDESTAR II continues to provide the legacy basic voice and data communications services offered by the previous WIDESTAR, revises the provided services according to satellite communications use and demand, and provides some other communications services such as multicast communications as solutions. In addition to that, it is a necessary and sufficient requirement that the communications charges can be made more economical in order to promote the extensive use of data communications and to expand solutions.

3.2 Facility Requirements

One requirement for all WIDESTAR II facilities is the extensive use of general-purpose technology to reduce the development and operation cost. Another requirement is to enable both systems to be accommodated by the same communications satellites through the use of frequency division multiplexing[*4] and prevention of interference between the systems for smooth and step-wise system migration from WIDESTAR. The frequency plan used by both the new and old WIDESTAR systems has a bandwidth of 15-MHz for each satellite, within which all channels are configured to prevent mutual interference (**Figure 2**). Furthermore, to serve as a system that can be used continuously and with high reliability even during large-scale disasters, it must be possible to change radio frequency band settings flexibly to allow increased voice traffic at times of disaster.

4. System

The configuration of the WIDESTAR II mobile satellite communications system is shown in **Figure 3**. Higher data communications speed is achieved by newly developed base station and mobile station equipment and taking advantage of the repeater capa-

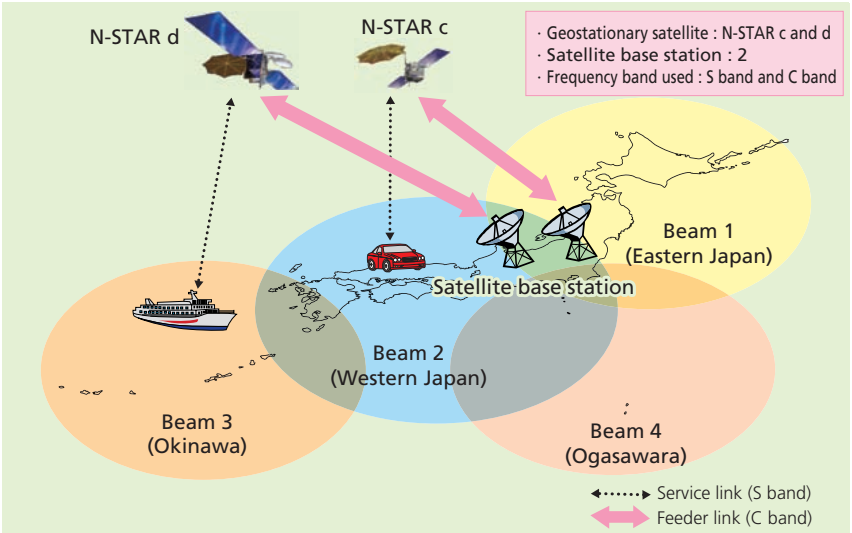

Figure 1 WIDESTAR service image

*2 **C band**: A name for the frequency band from 4 to 8 GHz. WIDESTAR uses the 6/4 GHz frequency band.

*3 **S band**: A name for the frequency band from 2 to 4 GHz. WIDESTAR uses the 2.6/2.5 GHz frequency band.

*4 **Frequency division multiplexing**: A multiple access scheme in which radio frequencies are divided and allocated to mobile terminal radio channels.

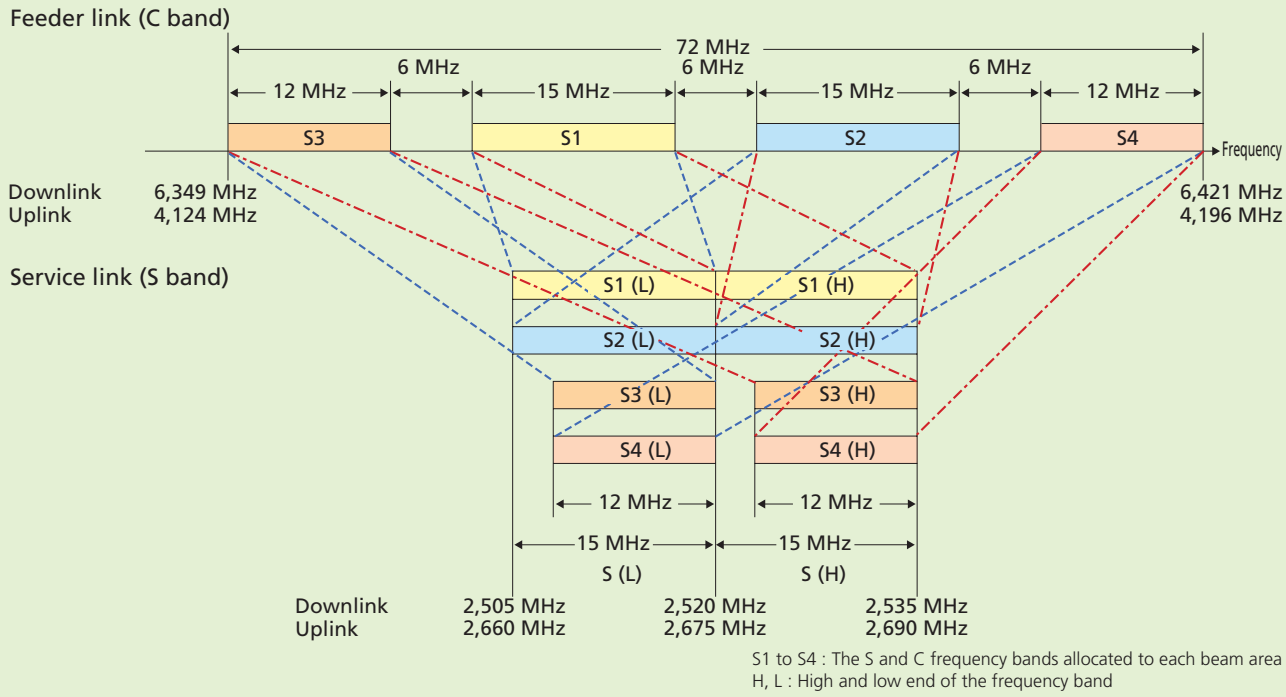

Figure 2 WIDESTAR frequency band configuration

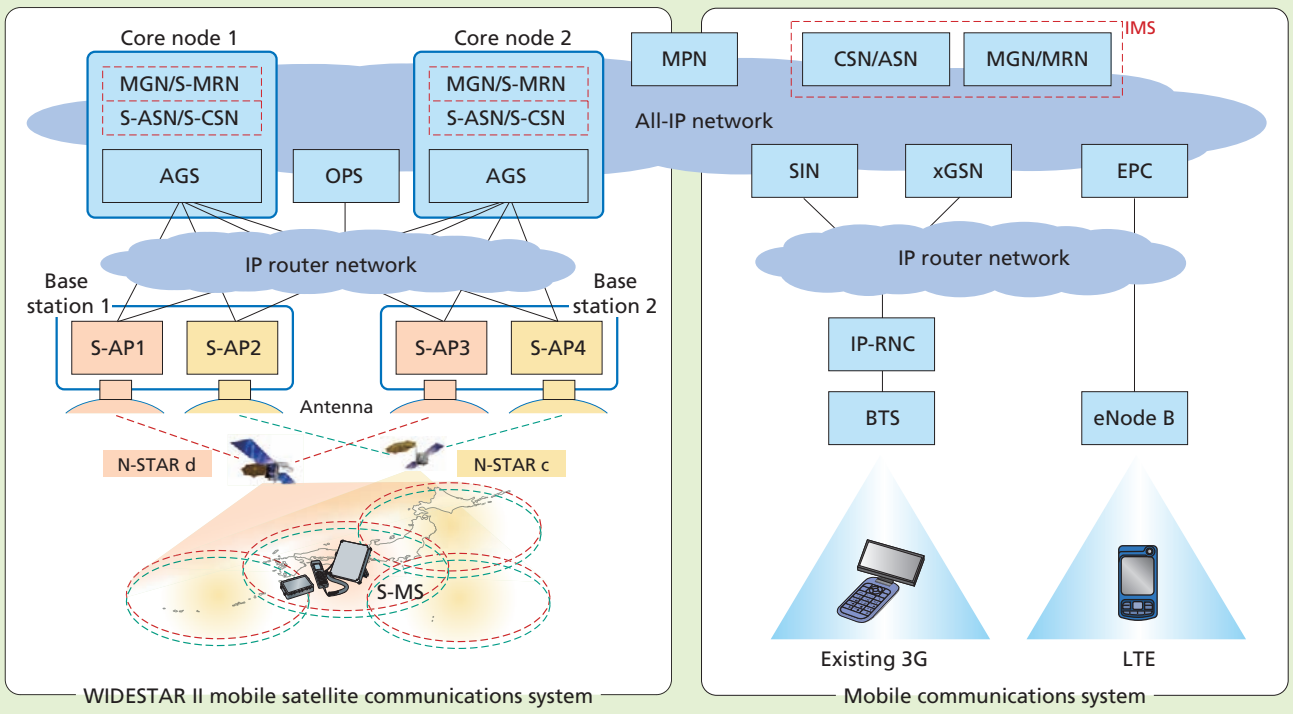

Figure 3 WIDESTAR II system configuration

bility attained through use of the N-STAR satellites and other existing radio facilities. For the core network, an economical system was developed and realized through renovation of core nodes from PDC to 3G-based equipment, new development of only the functions required for mobile satellite communications, and adoption of equipment that applies IP Multimedia Subsystem (IMS)[*5] [11] and other such general-purpose IP technology.

4.1 Reliability Legacy and New Features

1) System Configuration

WIDESTAR II adopts a conventional configuration that comprises two each of communications satellites, base stations and core node stations so that service can be continued even in the event that one of each type of station is damaged or destroyed in a disaster.

2) Base Station Redundancy Configuration

Base stations are affected by the sun transit phenomenon[*6] twice a year, in spring and autumn. That phenomenon occurs when the communications satellite and sun are in alignment, temporarily degrading communications quality. Also, because the system capacity is reduced by half if signal transmission from one of the base stations to a satellite is halted for repair work or other such reason, a redundant equipment configuration is used to allow both base stations to communicate with both satellites. The system maintenance control is the function that selects the unaffected base station to accommodate all of the communications, thus suppressing the effect on the service.

3) Load Balancing

To balance the communications load over the two satellites and the core nodes, mobile stations autonomously select a satellite and core node for priority use thus achieving load balancing. If the priority core node cannot be used, communication is conducted on the other station side.

4.2 Main Constituent Nodes

1) Base Station Equipment

The base station equipment comprises the Satellite Transmission and Receive Equipment (STRE) and the Satellite-Access Point (S-AP). The main roles of STRE are frequency conversion and signal amplification. It is implemented with general-purpose radio equipment, without newly developed hardware. The S-AP carries out digital signal processing for radio signal dividing and combining, modulation and demodulation, and radio control functions such as radio resource management and call control processing in a single unit of equipment to reduce communication processing load.

2) Core Nodes

The core node equipment is based on the equipment currently operating in the FOMA service. Efficient development and reduced software development scale were achieved by developing only the functions specific to WIDESTAR II and adding them to the established FOMA base.

The Access Gateway for Satellite (AGS) that accommodates base stations is based on the FOMA Serving GPRS Support Node (SGSN)/Gateway GPRS Support Node (GGSN) packet switch and adds the functions required for the voice communication provided by WIDESTAR II.

Voice call processing is handled by the Satellite-Call Session control Node (S-CSN), the Satellite-Application Serving Node (S-ASN) and the Satellite-Media Resource Node (S-MRN), all of which are based on equipment used in FOMA and adapted to WIDESTAR II. The S-CSN performs session control[*7], the S-ASN performs service control, and the S-MRN performs guidance transmission control. The Media Gateway Node (MGN), which performs network connection control, is shared with FOMA.

The FAX communications service control was developed as a single function of the Media Processing Node (MPN) [12].

The core node equipment is installed as specialized equipment for satellite use so as not to be affected by FOMA congestion and to maintain high reliability.

3) Mobile Stations

Two types of WIDESTAR II Satellite-Mobile Station (S-MS) were devel-

*5 **IMS**: A communication system standardized by 3GPP for achieving multimedia services by integrating communication services of the fixed-line network, mobile communications network, etc. using IP technology and SIP (see *8) protocol as used in VoIP.

*6 **Sun transit phenomenon**: When the satellite is eclipsed, overlapping with the sun as seen from the base station antenna, so that communication quality degrades due to noise generated by the sun. This occurs twice a year, in spring and fall, for about one week each.

*7 **Session control**: A function for controlling end-to-end IP communications over the network.

oped, a portable type and a type for ships and vehicles. For both higher data communications speed and longer call time and standby time during battery operation, digital circuit performance and function were improved and the LSI integration scale was increased. Session Initiation Protocol (SIP)[*8] was implemented for voice services.

4) Monitoring System

The new Satellite Access-Operation System (SATA-OPS) monitoring system for the base station equipment shares a distributed data-driven architecture with the NW-OPS monitoring system of the core node equipment for efficiency in development.

5. Services

The services provided by WIDESTAR II are shown in **Table 1**. WIDESTAR II introduces occupied bandwidth services, in which the exclusive use of a certain bandwidth is provided for specified users or user groups, independently of the status of ordinary user traffic. WIDESTAR II also provides the 64-k data communications service and other data communications services.

The modem communications between mobile stations implemented by circuit switching in WIDESTAR is renovated as a direct-connect Peer to Peer (PtoP) data communications service between mobile stations in WIDESTAR II. G3 FAX communication is also implemented as an independent FAX gateway service.

The quality of the voice service, which is the basic service, is also improved. The services provided by WIDESTAR were selected and adapted to WIDESTAR II according to satellite communications use and demand. The multicast communications service and other such services for WIDESTAR are provided as relevant service solutions. The main services are described below.

1) Voice Service

The G.729a voice CODEC used for IP telephony was adopted, improving the voice quality over the previous WIDESTAR.

2) Data Communications Service

The data communications service has two main categories. The packet communication service has asymmetrical communication speeds of a maximum 144 kbit/s uplink and a maximum 384 kbit/s downlink, provided as best effort. The maximum data speed varies with the number of users sharing the radio frequency band and the communications link quality. The 64-k data communications service provides a guaranteed data rate by assigning a separate radio channel with a fixed speed of 64 kbit/s.

Table 1 WIDESTAR II services

		WIDESTAR II	WIDESTAR (previous)
Communications satellite		N-STAR c/d	N-STAR a/b, N-STAR c/d
System		IMT-2000 packet switching, IMS(CS-IP)	PDC circuit switching, PDC packet switching
Service overview	Voice	· High quality voice (G.729a)	· Half-rate voice (PSI-CELP)
	Data	· Packet communication service (best effort) Uplink: Max. 144 kbit/s; Downlink: Max. 384 kbit/s	· Packet communications service Uplink: 4.8 kbit/s; Downlink: Max. 64 kbit/s
		· 64 k data communications service (guaranteed data rate)	· Non-telephone data modem communications (4.8 kbit/s, up- and down-link)
	Original satellite service	· FAX gateway service (G3FAX connection service)	· G3FAX (using modem)
		· Occupied bandwidth service · Direct connect service (PtoP data communications)	· Voice, FAX multicast communications service
Notes		Improved capabilities of the N-STAR c/d communication satellites (N-STAR c is improved by a factor of 5 and N-STAR d is improved by a factor of 10 relative to N-STAR a/b)	Equipment capability limits advances in services

PSI-CELP : Pitch Synchronous Innovation Code Excited Linear Prediction

*8 **SIP**: A call control protocol defined by the Internet Engineering Task Force (IETF) and used for IP telephony with VoIP, etc.

3) FAX Gateway Service

FAX gateway service was developed to continue the G3 FAX service often used by ships. In this service, a FAX adapter (FAX ADP) is connected to the mobile station to convert G3 FAX to mail and to conduct data communications with the FAX gateway service equipment, which is one function of the MPN. Communications with the G3 FAX in the general public network are done via the iFAX®*9 service provided by NTT Communications Corporation.

4) Occupied Bandwidth Service

An occupied bandwidth service is provided so that specified users or user groups can use combinations of various services for their dedicated use. A group ID is designated for each contract for the resource management of a radio frequency band. The occupied frequency bandwidth can be used independently of general subscribers and groups other than those designated for the occupied bandwidth service, and is thus unaffected by the status of other group traffic. Any one of voice, 64-k data communications, or packet communications can be provided with this service.

6. Conclusion

This article described the WIDESTAR II mobile satellite communications system that began operation in April 2010 and the services provided by this system. This system was designed for high-speed data communications and to conform to the technological trend toward the All-IP network by equipping mobile stations with SIP for voice services over IP, IMS and other such functions.

The future development plan is to proceed with introduction of diverse solutions and expand the use of data communications services. The importance of service provision and ensuring a means of communication during times of emergency and disaster, a role inherited from the previous mobile satellite communications system, is increasing, so it is expected that the value of the WIDESTAR II mobile satellite communications system will also increase.

REFERENCES

[1] S. Ueno et. al: "Special Articles on Satellite Mobile Communication System/ 1. Overview of the N-STAR Satellite Communication System," NTT DoCoMo Technical Journal, Vol. 4, No. 2, pp. 6-9, Jul. 1996 (in Japanese).

[2] K. Nakagawa et. al: "Special Articles on Satellite Packet Communication Service/ System Overview," NTT DoCoMo Technical Journal, Vol. 2, No. 2, pp. 4-8, Sep. 2000.

[3] DOCOMO Business Online: "WIDESTAR and Services."

[4] NTT DOCOMO Press Release: "New WIDESTAR II satellite telephone service and satellite portable terminal 01 are now available," Apr. 2010.

[5] M. Inoue et. al: "Overview of WIDESTAR II Mobile Satellite Communications Scheme," NTT DOCOMO Technical Journal, Vol. 12, No. 2, pp. 43-49, Sep. 2010.

[6] T. Yamamoto et. al: "WIDESTAR II Satellite Core Network System," NTT DOCOMO Technical Journal, Vol. 12, No. 2, pp. 50-57, Sep. 2010.

[7] S. Sasaki et. al: "WIDESTAR II Satellite Base Station Equipment," NTT DOCOMO Technical Journal, Vol. 12, No. 2, pp. 58-63, Sep. 2010.

[8] H. Ouchi et. al: "WIDESTAR II Base Station Maintenance and Monitoring System," NTT DOCOMO Technical Journal, Vol. 12, No. 2, pp. 64-69, Sep. 2010.

[9] Y. Kiba et. al: "WIDESTAR II Satellite Mobile Station," NTT DOCOMO Technical Journal, Vol. 12, No. 2, pp. 70-76, Sep. 2010.

[10] Y. Yasui et. al: "N-STAR c and Satellite Control System," NTT DoCoMo Technical Journal, Vol. 11, No. 1, pp. 67-76, Apr. 2003 (in Japanese).

[11] Y. Shimada et. al: "IP-based FOMA Voice Network toward Enhanced Services and Improved Efficiencies," NTT DOCOMO Technical Journal, Vol. 12, No. 1, pp. 4-14, Jun. 2010.

[12] A. Miyata et. al: "Media Processing Node for Providing Value-added Media Services," NTT DOCOMO Technical Journal, Vol. 11, No. 1, pp. 4-12, Jun. 2009.

*9 **iFAX®**: A registered trademark of NTT Communications Corporation.