4-6-4 Data Collection System

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We plan to verify the on-orbit antenna patterns in the framework of the electrical characteristics verification test for the Engineering Test Satellite VIII (ETS-VIII) on-board antenna by using electric power data measured at portable terminals located at multiple points. The Data collection system measures the receiving signal power at each portable terminal and delivers them to the host terminal. The system is designed to minimize operation at the portable terminals and to have all terminals controlled by the host terminal. It is composed of portable terminals with wireless communications, like the Personal Handyphone System terminal or cellular phone terminals (five terminals are planned), and a host terminal located at the Kashima Space Research Center of the Communications Research Laboratory. Commands and data are transferred via the Internet using an Internet Service Provider. Data measurement is performed at each portable terminal based on the commands generated at the host terminal. The frequency and power of the received signals with GPS times are measured at a maximum rate of about four samples per second. Real-time data collection for the host terminal from each portable terminal and visualization of the data enables the operator of the host terminal to immediately verify the data. Additionally, the host terminal can monitor the state of the equipment of the portable terminals: this is called the "health-check" function. It can also set the state of the equipment in the portable terminal.

Keywords
ETS-VIII, Large deployable antenna, Antenna measurement, Data collection, Internet

1 Introduction

The Engineering Test Satellite VIII (ETS-VIII) on-board antennas have Large Deployable Reflectors (Large Deployable Reflector : LDR) whose effective aperture is 13 m in diameter when deployed [1]. To demonstrate the antenna technologies incorporated into these large-scale satellite antennas, an on-orbit test is being planned in addition to ground tests intended to evaluate antenna electrical characteristics [2]. The on-orbit radiation pattern of a satellite antenna is often measured by measuring the receiving signal power at a single ground station while biasing satellite attitude [3]. However, these antennas are expected to experience significantly greater vibrations than ordinary solid reflector antennas when satellite attitude fluctuates, restricting the extent of possible attitude changes. Thus, it is necessary to establish a method for measuring on-board antennas with minimal changes in attitude.

The Communications Research Laboratory (CRL) is planning to evaluate the radiation pattern of the on-board antennas by distributing the portable terminals at several locations to measure the receiving signal power. The CRL is preparing equipment for this experiment including the portable terminals [4]. The data collection system measures the received signal power with a group of portable terminals and gathers all measurements across the Internet at the host terminal. The system seeks to simplify operations with portable terminals and to enable centralized management of all portable terminals from the host terminal, providing functions for automatic data measurement and for monitoring and control of the status of each portable terminal from the host terminal. Please refer to reference material [4] for a detailed discussion of the configuration and electrical characteristics of the portable terminal. This paper will provide an overview of the configuration and functions of the overall data collection system.

2 Data collection system

2.1 System configuration

Fig.1 shows a schematic diagram of the data collection system. The system consists of multiple portable terminals for measuring on-board antennas (hereafter referred to simply as portable terminals: the plan calls for 5 of these terminals) and the host terminal of the data collection system (hereafter referred to simply as the host terminal) placed at the Communications Research Laboratory (CRL) Kashima Space Research Center (referred to as CRL Kashima). The portable terminals are to be placed discretely in and around the coverage area of the S-band antenna beam of the satellite. Each portable terminal contains a radio communication terminal such as a Personal Handyphone System (PHS) or cellular phone. It transmits and receives commands, measured data, and health data to and from the host terminal at CRL Kashima across the Internet via an Internet service provider. The Internet offers certain advantages compared to peer-to-peer links through public telephone lines: It requires the relatively modest hardware investment of a single communication line, even if the number of portable terminals increases; it also ensures a constant link at a fixed price. On the other hand, the Internet has several characteristics that must be noted: Any malfunctions at the service provider will affect the link; security measures must be provided; and the portable terminals may be deployed only within the range of PHS communication areas, since the current data communication service is available only for PHS terminals.

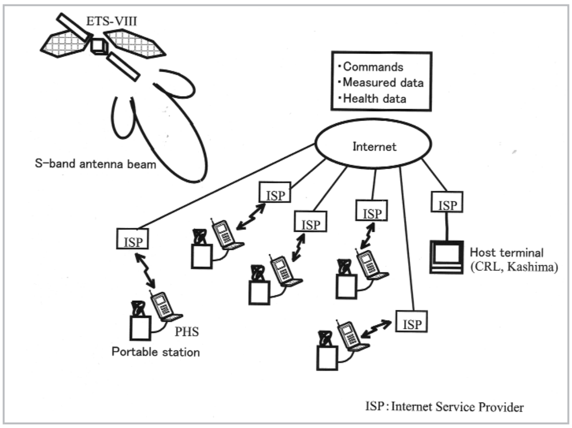

Fig.1 *Schematic diagram of the data collection system*

Fig.2 shows the configuration of the portable terminal. (Please refer to reference material [4] for detailed information.) Thick lines in the figure indicate the units linked to the data collection system. The portable ter-

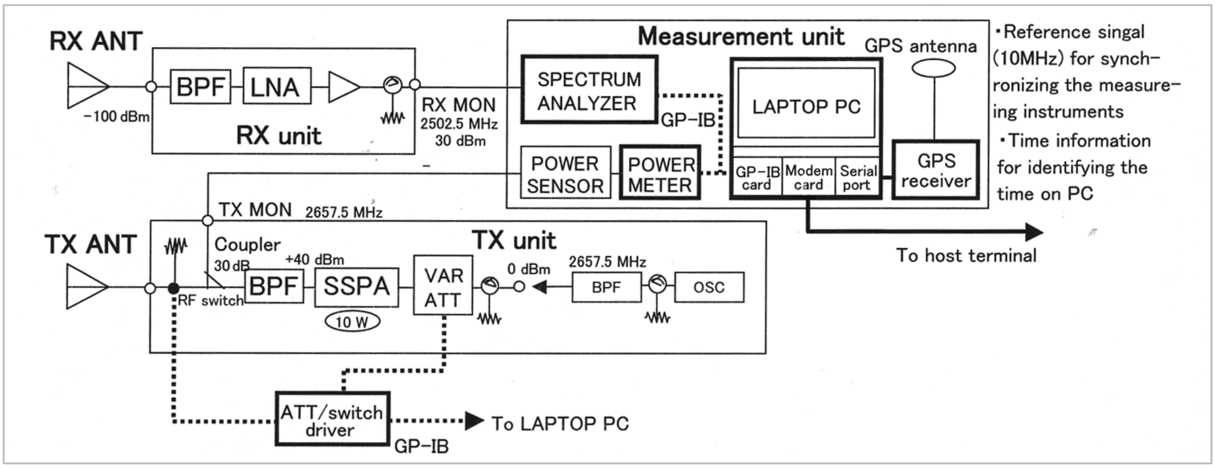

Fig.2 *Configuration of portable terminals for measuring on-board antennas*
The thick lines in the figure indicate units linked to the data collection system

minal has a spectrum analyzer for monitoring the receiving signal power in the 2.5 GHz band to measure radiation patterns of the onboard transmit antenna. It also has a power sensor and power meter for monitoring the transmission signal power in the 2.6 GHz band to measure radiation patterns of the onboard receive antenna. The portable terminal also has a Global Positioning System (GPS) antenna and a GPS receiver to identify the current position and time of data collection and to acquire the reference signal (10 MHz) for synchronizing the measuring equipment. A step attenuator (ATT) and an RF (Radio Frequency) switch are located in the input and output side of the Solid State Power Amplifier (SSPA), respectively, to control the transmission signal power. The settings for these devices can be changed with an attenuator/switch driver (ATT/SW driver). A laptop PC collects data from and controls the measuring instruments. The spectrum analyzer, power meter, and the ATT/SW driver connect to the laptop PC through General Purpose Interface Bus (GPIB) ports, while the GPS receiver links to the laptop PC through a serial port. The laptop PC controls the measuring instruments with LabVIEW, commercially available software for controlling equipment offered by National Instruments.

2.2 Functions

The data collection system seeks to simplify operations with the portable terminals and to manage all portable terminals from the host terminal in an integrated manner. The host terminal is designed to provide various functions. Fig.3 illustrates the concepts underlying the functions of the data collection system. As shown in the figure, the main functions are real-time data collection, data storage and display, modification of various settings, and health checks. Each portable terminal measures data upon receiving the appropriate command from the host terminal. The receiving signal frequency and power, which are synchronized to GPS time, are measured at maximum measuring intervals of 4 samples per second. Data from each of the portable terminals is collected at the host terminal in realtime and stored at the host terminal. The host terminal can display the stored data in the form of simple graphs, which allows the user to inspect measured data instantly.

The host terminal also provides a function for modifying settings for measuring instruments and other devices installed at each portable terminal. The settings for the following items can be modified: the display mode of the spectrum analyzer; the switching of the RF switch between the antenna side and the dummy load side; and the amount of the ATT located at the input side of the SSPA. Each portable terminal provides a health check function for monitoring the status of the measuring instruments installed.

Table 1 shows various measuring data and monitoring status items. Table 2 shows the

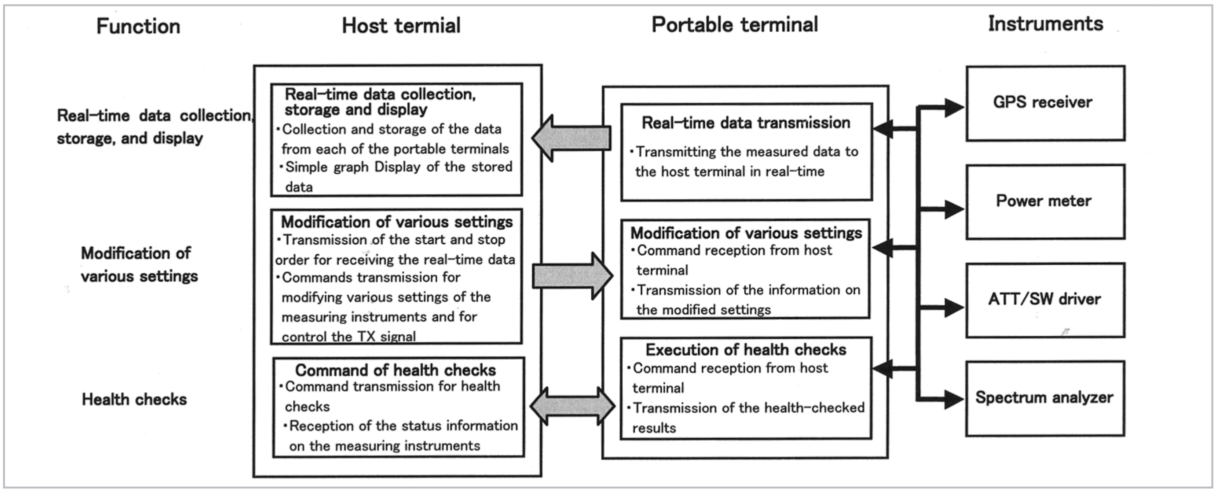

Fig.3 *Functions of the data collection system*

configurable items for the instruments and other devices.

3 Summary

The preceding briefly described the configuration and functions of the data collection system. The portable terminals and software for the data collection system will be ready for experimental trials by 2003. The data collection system will be used to measure the electrical characteristics of the on-board antennas in the initial checkout after the launch of the ETS-VIII scheduled for 2004 and in the basic experiment phase thereafter. The following conditions need to be noted for system operations. The portable terminals may be vehicular mounted terminals or semi-fixed terminals, though vehicular mounted terminals offer better portability and ease of management at the installation location. Whether the portable terminals are unmanned or manned must be determined by considering several factors, such as the need for a licensed radio operator when transmitting data from the portable terminals and methods for managing the portable terminals at the installation sites. The general position of the installation sites are first determined from the estimated beam pattern for each of the measurement items. The location of the installation site is then refined by considering the various requirements, including the security of the power supply and PHS communication range. Each portable terminal must be calibrated by one of several methods. (These include collecting all portable terminals at a location to receive signals such as beacon signals or measuring the level diagram at each terminal.) Given the possibility of manned operation of the portable terminals, communication methods must be prepared between the host terminal operator and the portable terminal operators. Since the data collection system links will be established across the Internet, e-mail and instant messaging functions are currently under consideration.

Table 1 *Data measurement and status monitoring items*

Instrument	Measuring data	Measuring interval	Remarks
Spectrum analyzer	RX Frequency	4 sample/s (MAX)	
	RX power	4 sample/s (MAX)	
Power meter	TX power	4 sample/s (MAX)	
GPS receiver	GPS time		Time information for identifying the time on PC
	Longitude, latitude		Only one time report in the measurement start
ATT/SW driver	ATT. Value, RF switch status		Report of the setting value

†These items will be finally decided in software improvement scheduled in 2004.

Table 2 *Configurable items for the measuring instruments and other devices*

Instrument	Setting item	Setting method	Remarks
Spectrum analyzer	Display setting	Setting execution by the command from the host terminal	Center frequency, Span, and so on.
ATT/SW driver	Change of the ATT value (0 - 81 dB, 1 dB step)	The same as the above	
	Change of the RF switch status	The same as the above	

†These items will be finally decided in software improvement scheduled in 2004.

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