



Figure 2.2-12 Internet provision to the general public (left: Kamaishi City; right: Ofunato City)

2.2.2 KIKU No. 8 (ETS-VIII)

2.2.2.1 Outline and characteristics of KIKU No. 8

The KIKU No. 8 Engineering Test Satellite VIII (ETS-VIII) is Japan's largest geostationary satellite. Its purpose is to contribute to today's increasingly networked information society through the development of state-of-the-art satellite common base technologies and technological development of satellite communication systems for future space activities. It was launched using an H-IIA rocket on December 18, 2006.

The satellite's primary mission is to support verification of the following new developments:

1. Technology for an advanced 3-ton-class spacecraft bus in geostationary orbit
2. Technology for large deployment antennas (size: 19 m × 17m)
3. Technology for a mobile satellite communication system using mobile terminals, and for a mobile satellite digital multimedia broadcasting/communication system enabling transmission of images and high-quality voice data
4. Basic technology for a geostationary satellite positioning system

The satellite has the characteristics outlined below.

■ Installation of two tennis-court-sized (19 m × 17 m) large deployment antennas (reflectors)

JAXA verified the technologies for deploying a large deployable structure on orbit and using large deployment antennas. Currently, only Japan and the U.S. have these technologies.

■ Mobile satellite communication technology

Large deployment antennas enable the establishment of communication links with small-scale ground communication terminals. Such satellite communication terminal equipment is highly portable, meaning that communication lines can be easily set up even if land-based communication networks are disrupted.

This portable equipment uses a TCP/IP interface, and is therefore compatible with commercially available network devices. Ultra-small mobile terminals allow direct communication with KIKU No. 8 with the functionality of transmitting and receiving positioning data and transmitting messages, making it an effective tool in times of disaster. It can also serve as terminal equipment to transmit and receive sensor information relating to remote locations.

* With regard to the verification of mobile satellite communication technology, an abnormality in the low noise amplifier (LNA) in the S-band receiving system for mobile communication made the experiment using large deployment antennas on the receiving side difficult. Accordingly, the originally planned experiment was continued by increasing the output of ground communication terminal equipment, connecting to an external antenna, and using an alternative antenna on the satellite side for reception.

■ Technology for one of the world's largest geostationary satellites and common bus technology

KIKU No. 8 is a 3-ton-class satellite — one of the world's largest — in geostationary orbit, and the common satellite bus technology for it was verified. The DS2000 bus system used for KIKU No. 8 has also been adopted for the First Quasi-Zenith Satellite MICHIBIKI, the Meteorological Satellite HIMAWARI and other overseas commercial satellites.

■ Technology for geostationary satellite positioning technology systems

The basic technology for a geostationary satellite positioning system using an atomic clock was verified. The results were also used for the Quasi-Zenith Satellite System (QZSS).

JAXA verified that the mobile satellite communication technologies of KIKU No. 8 could be applied in a variety of fields through in-orbit technical evaluation efforts (such as experiments to clarify the characteristics of large deployment antennas) and various experiments in mobile satellite communication. These included verification testing for disaster preparation training using portable communication terminal equipment and ultra-small mobile terminals, and experiments involving the transmission and receipt of medical information in preparation for disaster situations.

Figure 2.2-13 shows a conceptual diagram of mobile communication and positioning systems that use KIKU No. 8.

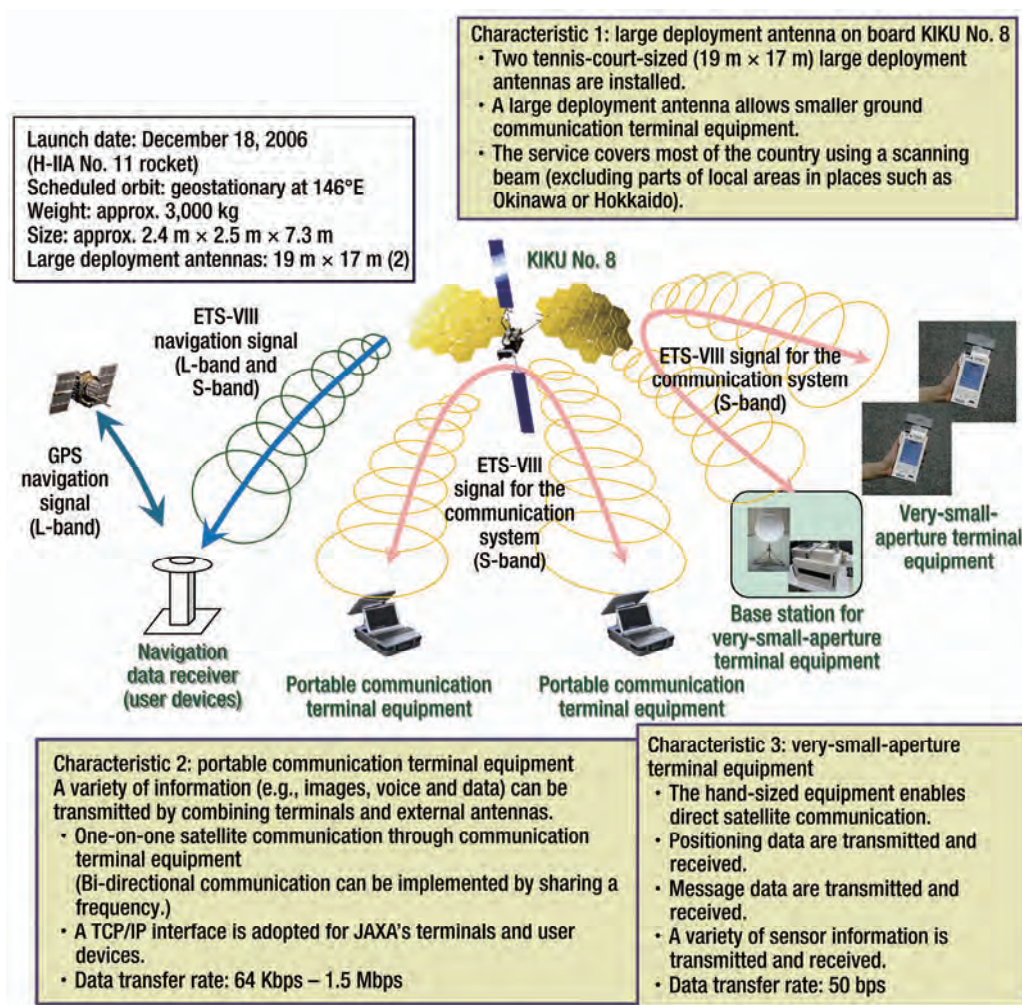


Figure 2.2-13 Conceptual diagram of mobile communication and positioning systems using KIKU No. 8

2.2.2.2 Chronicle of events in the provision of communication lines to disaster areas

The following is a chronicle of events in the provision of communication lines to disaster areas following the Great East Japan Earthquake.

- March 15: In response to the quake of March 11, 2011, JAXA began studying the possibility of providing disaster areas with communication lines using communication terminal equipment for KIKU No. 8, whose operation had been suspended. Concurrently, the Agency began coordinating with partner businesses toward securing sufficient staff to confirm the integrity of this equipment, and with other institutions involved in experiments using KIKU No. 8 to secure satellite lines on an ad hoc basis.
- March 16–18: Tests to confirm the integrity of communication terminal equipment were implemented. The dispatch of personnel by partner businesses and the securing of communication lines using KIKU No. 8 were coordinated.
- March 18: The integrity tests showed that the equipment would function properly, thereby paving the way for the provision of satellite channels in disaster areas.
- On the same day, preparations were made to move into action with a complete set of communication equipment and supplies. A support system was put in place through coordination to dispatch staff from JAXA and partner businesses and by securing satellite channels on an ad hoc basis.
- March 19: JAXA attempted to contact municipalities in Miyagi Prefecture that had sustained heavy damage, but with little success. No requests for communication line support were made because communication disruption was minimal in the few municipalities the Agency was able to contact.
- On the same day, the difficulty of communicating information on the effective use of KIKU No. 8 to disaster areas prompted JAXA to make inquiries to NPO Aichi Net, with which it enjoys collaborative relationships in regard to KIZUNA, disaster prevention drills and other matters.
- March 20: Via NPO Aichi Net staff who were dispatched to Ofunato City in Iwate Prefecture, JAXA received a request from Ofunato City Hall to use KIKU No. 8.
- March 22: Ofunato City Hall asked the Ministry of Education, Culture, Sports, Science and Technology (MEXT) to secure a means of communication using the KIKU No. 8 Engineering Test Satellite VIII. On the same day, MEXT asked JAXA to provide support to secure a means of communication using the satellite based on this request.
- March 23: JAXA dispatched two staff to Ofunato along with communication equipment and supplies.
- March 24: In the morning, equipment and supplies were delivered to Ofunato City Hall, ETS-VIII portable communication terminal equipment and antennas were installed, and satellite channels between Ofunato and the Tsukuba Space Center were established. Communication lines were opened in the afternoon, and were used to provide the disaster countermeasures office with a way of collecting information via the Internet and IP phone for business use.
- April 2: JAXA received a similar request for communication lines from Iwate's Otsuchi Town Central Public Hall, which served as the disaster countermeasures office and as an evacuation site. Late in the afternoon on the same day, equipment, supplies and two staff members were dispatched to the site.
- April 3: Equipment and supplies were installed at Otsuchi Town Central Public Hall, and communication conditions were checked.
- April 4: Satellite channel provision began in Otsuchi Town, with lines mainly being used for two purposes: 1. allowing evacuees to collect information on people's safety over the Internet; and 2. enabling disaster countermeasures office staff to perform their duties.
- Midnight, April 7: One of the largest aftershocks since March 11 struck (seismic intensity: upper 6).



-
- April 8: Aftershocks caused power failures in Ofunato City and Otsuchi Town, and mobile phones also became temporarily unusable. JAXA provided Internet service via KIKU No. 8 using portable generators.
 - April 10: In response to the recovery of most Internet connections at the disaster countermeasures office in Ofunato, JAXA ended support via KIKU No. 8 after discussions between the disaster countermeasures office and MEXT.
 - April 21: The provision of communication lines using KIKU No. 8 was ended at Otsuchi Town Central Public Hall after Nippon Telegraph and Telephone Corporation (NTT) set up temporary Internet connections.
 - April 22: JAXA received a request from the Onagawa Town Disaster Countermeasure Office in Miyagi Prefecture to use communication lines provided via KIKU No. 8.
 - April 25: Three staff members were dispatched to the site along with communication equipment and supplies.
 - April 26: Equipment and supplies were installed at the Kaisenkaku evacuation site in Onagawa Town's Takashirohama district in the morning, and communication lines via KIKU No. 8 were opened in the afternoon. The facilities were used primarily by evacuees to collect information on everyday living via the Internet.
 - May 12: The provision of communication lines using KIKU No. 8 in Onagawa's Takashirohama district was ended after the Widely Integrated Distributed Environment (WIDE) Project began providing IPSTAR broadband satellite Internet services at the evacuation site.
 - May 13: The equipment and supplies in Onagawa were removed.

2.2.2.3 Communication modality and results of communication line usage

To confirm the integrity of communication terminal equipment, interfaces were inspected using the video transmission system (a setup with a proven track record for peer-to-peer transmission of image and voice data using KIKU No. 8) to evaluate the overall performance of related equipment in addition to checking of individual terminal. Initially, JAXA examined the idea of offering support by providing communication lines using the proven video transmission system. However, the feasibility of providing Internet connections was also checked to maximize the benefits of using KIKU No. 8 in disaster areas. This approach was taken in response to the lack of information about needs in these areas and the limited availability of resources in terms of capacity to operate the video transmission system, equipment and supplies, staff numbers and communication lines to be provided.

Although JAXA had no experience of Internet connection trials using KIKU No. 8 communication terminal equipment, such lines were found to offer the advantages of enabling Internet and IP phone usage from multiple PCs despite limited data transfer rates. The simplicity of operation compared to that of the video transmission system was also considered an advantage. As the first attempt confirmed that KIKU No. 8's communication terminal equipment could also be used to provide Internet connections, two modality types were set up to enable the use of the video transmission system and Internet connections. Ultimately, JAXA provided Internet connections using KIKU No. 8 in line with disaster-area needs for information gathering over the Internet. The details of preparations made in Tsukuba are outlined in Figure 2.2-14.

Preparation, materials, etc.	Amount, data transfer rate, etc.
Period for function confirmation	March 16 – 18
ETS-VIII portable communication terminal equipment	Number of available terminal units: 6
20-W amplifier	Number of available amplifiers: 4
90-cm antenna	Preparation of three sets for disaster areas
1.2-m antenna	Preparation of three sets for Tsukuba
Data transfer rate	Upload rate: up to 768 Kbps Download rate: up to 768 Kbps
Number of communication lines available	Number of lines: up to 3 (if no extra lines are provided)
Attached equipment	PC for Internet IP phone FOMA mobile card Transmission system for images, etc.
Others	Required number of LAN cables Required number of RF cables Preparation of power generation, etc.
Utilization form	Internet service provision Flexible response to user requests

Confirmation of functions in Tsukuba / preparation

Figure 2.2-14 Preparation details

Figure 2.2-15 shows a schematic representation of support provided for disaster areas via communication lines using KIKU No. 8 in the prefectures of Iwate and Miyagi, and Figure 2.2-16 outlines the Internet connections provided using the satellite.

ETS-VIII portable communication terminal equipment, antennas, laptops and other equipment were provided to Ofunato City and Otsuchi Town in Iwate Prefecture and Onagawa Town in Miyagi Prefecture, while ETS-VIII portable communication terminal equipment for disaster areas connected to Internet networks was set up at the Tsukuba Space Center. Internet service was made available to disaster areas by connecting them with Tsukuba via KIKU No. 8.

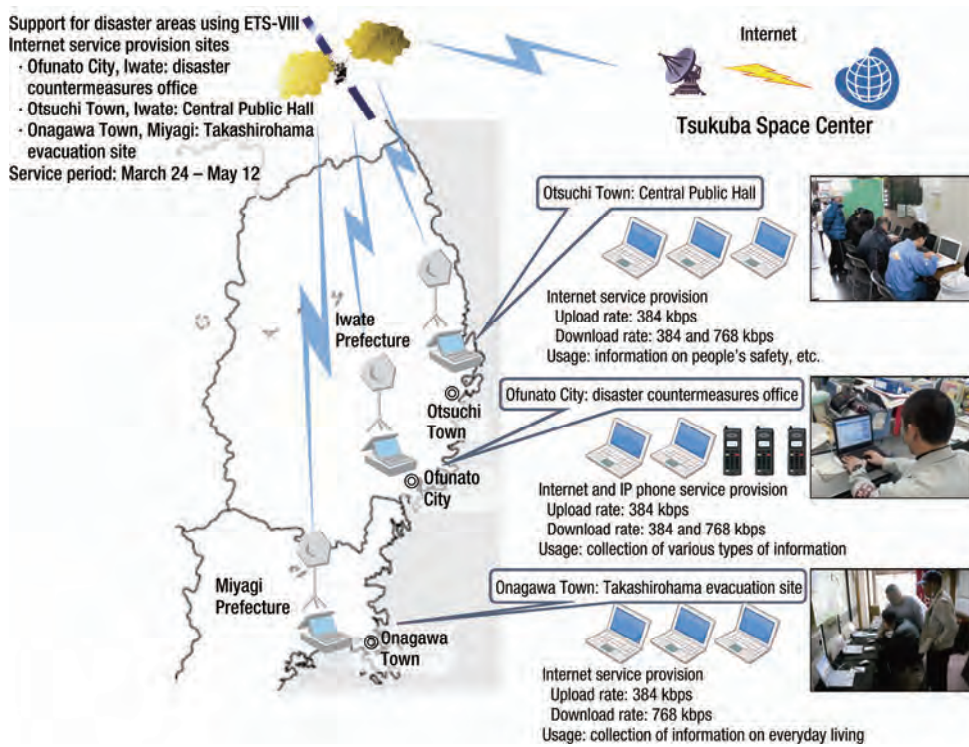


Figure 2.2-15 Outline of support for disaster areas via the provision of communication lines using KIKU No. 8 in the wake of the Great East Japan Earthquake

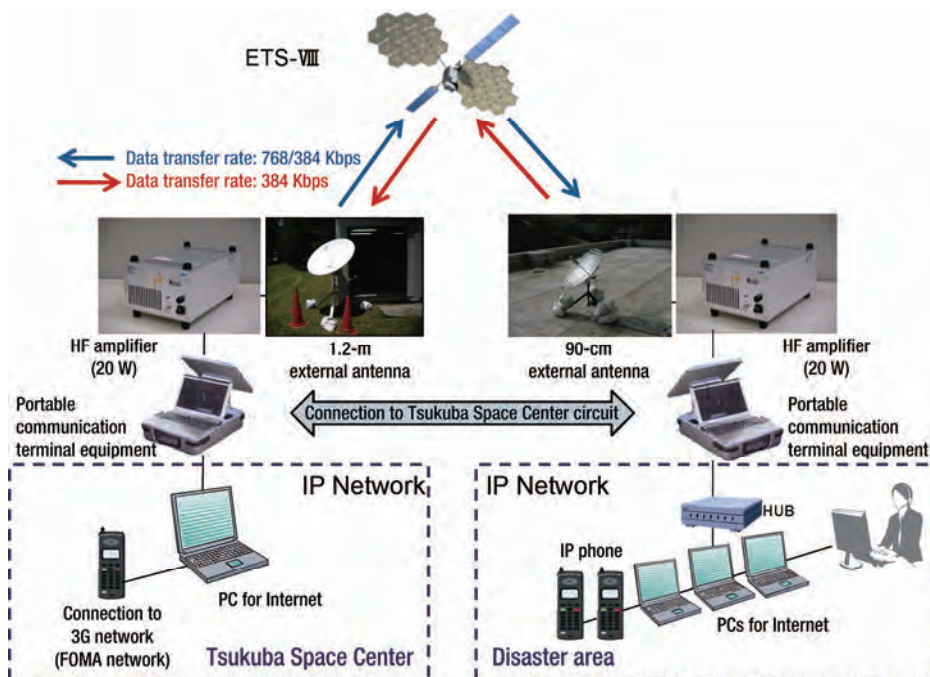


Figure 2.2-16 Outline of Internet connection provision using KIKU No. 8

(1) Usage at Ofunato City Hall in Iwate Prefecture

Communication lines were used at Ofunato City Hall's disaster countermeasures office for the provision of Internet and IP phone services. Two PCs and three IP phones were installed for this purpose.

In terms of communication infrastructure, Ofunato City Hall had only a few voice lines as of March 24 when JAXA offered communication support, and needed Internet connections to enable information gathering.

The Internet service provided at the disaster countermeasures office was widely used, and the office informed JAXA that the connections provided enabled information collection and were therefore very useful. As the IP phones also had less delay than satellite-based mobile phones, they were considered easy to use.

While satellite-based mobile phones use the double-hop system, KIKU No. 8 allows direct IP communication using the single-hop method, and this is considered to be a factor behind the reduced delay.

On March 25, the establishment of Internet connections using KIKU No. 8 was announced at a regular Ofunato City Government press conference.

Late at night on April 7, one of the largest aftershocks since March 11 struck (seismic intensity: upper 6), disrupting the restored power and communication infrastructure until April 8. While power supplies were cut off and mobile phones and other appliances were unavailable, JAXA provided Internet connections using the previously arranged portable generators. This service enabled information collection at the disaster countermeasures office.

The installation and usage of communication terminal equipment in Ofunato City are described below.

Table 2.2-1 Installation and usage of communication terminal equipment in Ofunato City

Support site	Support period	Service line, etc.	Usage:	Notes
Ofunato City, Iwate Disaster countermeasures office	March 24 — April 10 (18 days)	Upload rate: 384 Kbps Download rate: 768/384 Kbps (*) *Downloads provided at 384 Kbps between April 4 and 10 thanks to frequency sharing with Otsuchi Town, Iwate.	collection of information by the disaster countermeasures office • Collection of information released by the Japan Meteorological Agency • Collection of information using aerial photography released by the Geospatial Information Authority of Japan • Simulated tsunami information (existing) → Comparison of hazard maps and actual damage from the disaster • Searching of disaster-related ordinances • Reading of news and use of e-mail function	• Two notebook computers available • Three IP phones available

Network situation on the first day of support in Ofunato City Hall (March 24)

- Fixed-line telephone and Internet services: not available (date of re-installation was unknown)
- Satellite mobile telephone lines: 3 (provided by NTT)
- Telephone and fax for disaster use only: 1 (connections were limited)
- Mobile phone lines: Only NTT Docomo was available thanks to its special base station (frequent congestion)
- Radio communications for communicating with the fire service and police, radio communications for police, and radio communications for the Self-Defense Forces were introduced.



Figure 2.2-17 Ofunato City Hall (left: outside; right: local countermeasures office)

(Access to the roof)

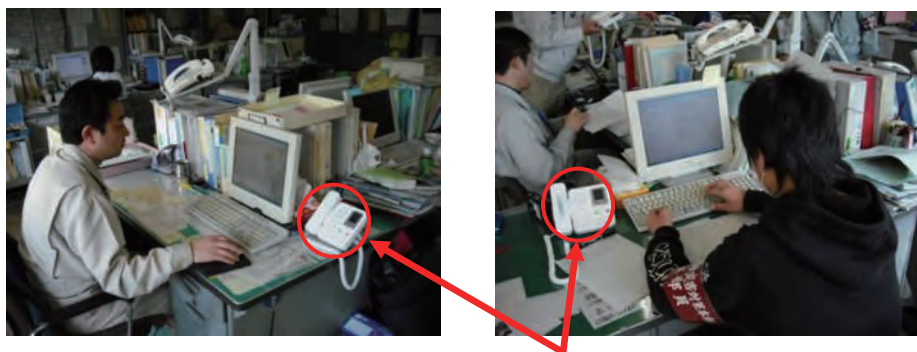
(Installation on the roof of City Hall)



(Generators used during power failure on April 8)



Figure 2.2-18 Communication equipment installed (left: 90 cm ϕ portable antenna; center: portable communication terminal equipment; right: portable generators)



KIKU No. 8 IP phones

Figure 2.2-19 Usage at the countermeasures office



Figure 2.2-20 Use of communication lines during power failure on April 8
(rooftop generator operation due to power failure in the office)



Figure 2.2-21 Tsunami damage (near Rikuzentakata City)



Figure 2.2-22 Urban area of Ofunato City

(2) Usage at Otsuchi Town Central Public Hall in Iwate Prefecture

In Otsuchi Town, communication lines were provided at the disaster countermeasures office, which doubled as an evacuation site, and were primarily used to offer Internet services to disaster victims. As of April 4 (the day when communication lines were first opened), five special NTT satellite telephone lines were provided at the town's Central Public Hall as communication infrastructure for the general public. In conjunction, JAXA provided communication lines exclusively for Internet access and installed three PCs.

The facilities were primarily used by disaster victims and disaster relief support staff to collect information on people's safety, research disaster-related matters (such as the issuance of disaster victim certificates), browse the web and send e-mail.

On April 8, the day after one of the largest aftershocks since March 11 struck, satellite channels were

provided using portable generators.

The installation and usage of communication terminal equipment are described below.

Table 2.2-2 Installation and usage of communication terminal equipment in Otsuchi Town

Support site	Support period	Service line, etc.	Usage:	Notes
Otsuchi Town, Iwate Central Public Hall	April 4 – April 21 (17 days)	Upload rate: 384 Kbps Download rate: 768/384 Kbps (*) *Downloads provided at 384 Kbps between April 4 and 10 thanks to frequency sharing with Ofunato City, Iwate. Downloads from April 11 provided at 768 Kbps.	provision of Internet service for evacuees • Collection of information on people’s safety and evacuees • Collection of information on evacuation sites • Collection of disaster information and news browsing • Confirmation of disaster victim certificates and insurance details • Cancellation of electricity, telephone, gas services, etc. • Utilization of e-mail function	• Three notebook computers available An average of 20 – 30 users per day utilized the service.

Network situation on the first day of support at Otsuchi Town Central Public Hall (April 4)

- Special satellite telephone lines provided by NTT: 5
- Mobile phone lines: available (service limitations due to line congestion and access failure)
- Internet service for evacuees: not available

Central Public Hall roof



Access to the roof



Figure 2.2-23 Communication equipment and other devices installed (left: antenna; right: equipment and supplies)

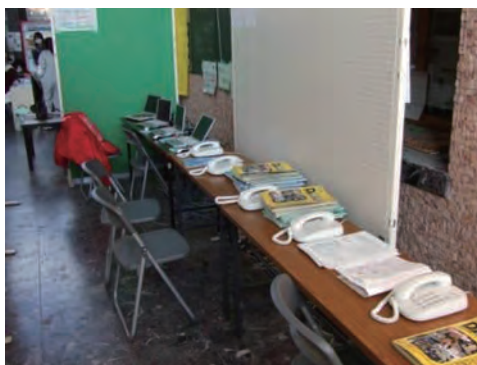


Figure 2.2-24 JAXA PCs for Internet access and special NTT telephone lines installed in the lobby of Central Public Hall



Figure 2.2-25 Internet users

(3) Takashirohama Evacuation Site in Onagawa Town, Miyagi Prefecture

Communication lines were provided at the evacuation site in Onagawa Town so that evacuees could access the Internet. As of April 25, general subscriber telephone lines in the town remained cut off, although mobile phone networks had been restored. Mobile phone connectivity at the Takashirohama evacuation site where JAXA provided communication lines was poor due to its geographical location.

In the same way as for Otsuchi Town, Internet connections for public use were provided in Onagawa. The service at the evacuation site was used to collect disaster-related information on matters such as the issuance of disaster victim certificates, and on everyday considerations such as used cars, second-hand boats and ships, mail-order services for clothes and other commodities, and job openings. People also used the Internet to collect information specific to the area such as daily tide times, as earthquake-related subsidence caused urban areas to flood during high tide. The installation and usage of communication terminal equipment are described below.

Table 2.2-3 Installation and usage of communication terminal equipment in Onagawa Town

Support site	Support period	Service line, etc.	Usage:	Notes
Onagawa Town, Miyagi Takashirohama evacuation site, Kaisenkaku	April 26 — May 12 (18 days)	Upload rate: 384 Kbps Download rate: 768 Kbps	provision of Internet service for evacuees <ul style="list-style-type: none"> • Collection of information on temporary housing and mail-order (clothes and furniture) • Collection of information on tide tables/post-disaster situations and news browsing • Collection of information on used cars, boats and ships • Confirmation of employment opportunities and information on hospitals and schools • Cell-phone subscriptions and other general information on everyday living In response to a request from the evacuation site, the service is available between 14:00 and 21:00.	<ul style="list-style-type: none"> • Three notebook computers available An average of 20 users per day utilized the service.

Network situation on the first day of support in Onagawa Town and at the Takashirohama evacuation site (April 26)

- Fixed-line telephone and Internet services: not available (re-installation in May)
- Mobile phone lines: available (instability of radio wave environment)
- Rental cell-phones available for evacuees



Figure 2.2-26 Communication equipment and other devices installed (left: antenna; right: equipment and supplies)

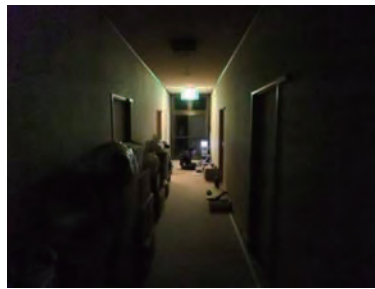


Figure 2.2-27 Nighttime Internet service



Figure 2.2-28 Internet users



Figure 2.2-29 Onagawa Town (left: downtown area; right: commuter road (during high tide))

(4) Support results

A total of 15 staff from JAXA and partner businesses worked in rotation over a period of about two months from March 16 (when it was confirmed that communication equipment was working) to May 13