Introduction of the Contributions of KIZUNA and KIKU No. 8 in Disaster Management

The 46th UNCOPUOS/STSC, Vienna

12 February 2009

Masahiko SAWABE
Space Applications and Promotion Center (SAPC)
Japan Aerospace Exploration Agency (JAXA)
Contents

1. Overview of KIZUNA
   (WINDS: Wideband InterNetworking test and Demonstration Satellite)

2. KIZUNA Experiments

3. Sentinel Asia Project

4. Outline of KIKU-No.8
   (ETS-8: Engineering Test Satellite No.8)

5. Summary
Features of KIZUNA

■ High-Speed Data Communication Rate
  • 155 Mbps for home use
    (small terminal with 0.45m diameter class antenna )
  • 1.2Gbps for business use
    (large station with 5m diameter class antenna )

■ Wide Coverage
  Ultra-high-data rate communications in a wide area of Asia /Pacific region

■ Establishment of the Flexible Satellite Communication network
  On-board switching provides the flexible network.

Remarks:
  KIZUNA is a R&D satellite and is open to the experiment users, such as of the institutes and universities, who study and develop the satellite communications technologies.
Outline of KIZUNA System

- Ka-band Satellite with High Speed Transmission Capability Gbps order
- Bent pipe and Onboard ATM Switching
- Multi-Beam Antennas (MBA) and Active Phased Array Antennas (APAA) with high speed scanning capability

Outline of KIZUNA

<table>
<thead>
<tr>
<th>Launch Schedule</th>
<th>February 23rd, 2008 by H2A Launcher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mission Life</td>
<td>5 years</td>
</tr>
<tr>
<td>Location</td>
<td>143 degree E</td>
</tr>
<tr>
<td>Dimension</td>
<td>3 x 2 x 8m</td>
</tr>
<tr>
<td></td>
<td>Span of Solar Paddles: 21.5m</td>
</tr>
<tr>
<td>MASS</td>
<td>4,850 kg (lift off)</td>
</tr>
<tr>
<td>Electric Power</td>
<td>5,200W / EOL, Summer Solstice</td>
</tr>
<tr>
<td>Attitude Control</td>
<td>Zero-momentum 3-Axis Control</td>
</tr>
<tr>
<td>Frequency</td>
<td>U/L: 27.5 – 28.6 GHz</td>
</tr>
<tr>
<td></td>
<td>D/L: 17.7 – 18.8 GHz</td>
</tr>
<tr>
<td>Satellite G/T</td>
<td>&gt; 18 dB/K (MBA)</td>
</tr>
<tr>
<td></td>
<td>&gt; 7 dB/K (APAA)</td>
</tr>
<tr>
<td>Satellite EIRP</td>
<td>&gt; 68 dBW (MBA)</td>
</tr>
<tr>
<td></td>
<td>&gt; 55 dBW (APAA)</td>
</tr>
<tr>
<td>Onboard Processing</td>
<td>ATM Baseband SW</td>
</tr>
</tbody>
</table>
MBA (Multi Beam Antenna)
APAA (Active Phased Array Antenna)

APAA can hop its beams to required points in 2msec interval to provide a wide coverage area.
Ground Terminals vs. Data Rate

Uplink
- LET (>5m\(\phi\))
- SDR-VSAT (2.4m\(\phi\))
- HDR-VSAT (1.2m\(\phi\))
- USAT (45cm\(\phi\))

MBA Spot Beam Area

KIZUNA
- Bent-pipe
  - (622Mbps x 2)
  - 1.2Gbps

- Bent-pipe
  - ~622Mbps

Onboard Switch

Downlink
- LET (>5m\(\phi\))
- SDR-VSAT (2.4m\(\phi\))
- HDR-VSAT (1.2m\(\phi\))
- USAT (45cm\(\phi\))

MBA Spot Beam Area

1.5~155Mbps
1.5~6Mbps
155Mbps
155Mbps
155Mbps
KIZUNA User Terminals

LET (Large Earth Station Terminal) (NICT)

SDR-VSAT
(NICT)

NICT: National Institute of Information and Communications Technology
# KIZUNA User Terminals (Fixed Type) (for MBA area)

<table>
<thead>
<tr>
<th></th>
<th>HDR-VSAT</th>
<th>REF-VSAT</th>
<th>USAT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Antenna System</strong></td>
<td>Diameter: 1.2 m</td>
<td>Diameter: 1.2 m</td>
<td>Diameter: 45 cm</td>
</tr>
<tr>
<td><strong>Frequency Band</strong></td>
<td></td>
<td>Uplink 27.5 - 28.1 GHz, Downlink 17.7 - 18.3 GHz</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Uplink 1.5-155 Mbps, Downlink 155 Mbps</td>
<td>Uplink 1.5-51 Mbps, Downlink 155 Mbps</td>
<td>Uplink 1.5 - 6 Mbps, Downlink 155 Mbps</td>
</tr>
<tr>
<td><strong>Maximum Data Rate</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>HPA (High Power Amplifier)</strong></td>
<td>100 W (250W TWTA)</td>
<td>40 W (SSPA)</td>
<td>5-10 W (20W TWTA)</td>
</tr>
<tr>
<td><strong>Maximum EIRP</strong></td>
<td>66.9 dBW</td>
<td>61.7 dBW</td>
<td>48.8 dBW</td>
</tr>
<tr>
<td><strong>G/T (Figure ofMerit)</strong></td>
<td>19.0 dB/K</td>
<td>19.0 dB/K</td>
<td>11.5 dB/K</td>
</tr>
<tr>
<td><strong>Modulation</strong></td>
<td>QPSK</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>Approx. 4420kg</td>
<td>Approx. 300kg</td>
<td>Approx. 76kg</td>
</tr>
<tr>
<td><strong>Power consumption</strong></td>
<td>1,200W</td>
<td>1,100W</td>
<td>700W</td>
</tr>
</tbody>
</table>

* This data rate is for the satellite link, and includes overhead bits.
## KIZUNA User Terminals (Portable Type) (for MBA area)

<table>
<thead>
<tr>
<th></th>
<th>Portable VSAT</th>
<th>Portable USAT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Antenna System</strong></td>
<td>Diameter: 1.0 m</td>
<td>Diameter: 45 cm</td>
</tr>
<tr>
<td><strong>Frequency Band</strong></td>
<td>Uplink 27.5 - 28.1 GHz</td>
<td>Uplink 1.5 - 6 Mbps</td>
</tr>
<tr>
<td></td>
<td>Downlink 17.7 - 18.3 GHz</td>
<td>Downlink 155 Mbps</td>
</tr>
<tr>
<td><strong>Maximum Data Rate</strong></td>
<td>Uplink 1.5-24 Mbps</td>
<td>Uplink 1.5 - 6 Mbps</td>
</tr>
<tr>
<td></td>
<td>Downlink 155 Mbps</td>
<td>Downlink 155 Mbps</td>
</tr>
<tr>
<td><strong>HPA (High Power Amplifier)</strong></td>
<td>40 W (SSPA)</td>
<td>10 W (SSPA)</td>
</tr>
<tr>
<td><strong>Maximum EIRP</strong></td>
<td>60.0 dBW</td>
<td>48.8 dBW</td>
</tr>
<tr>
<td><strong>G/T (Figure of Merit)</strong></td>
<td>19.0 dB/K</td>
<td>11.5 dB/K</td>
</tr>
<tr>
<td><strong>Modulation</strong></td>
<td>QPSK</td>
<td></td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>Approx. 250kg</td>
<td>Approx. 53kg</td>
</tr>
<tr>
<td><strong>Power consumption</strong></td>
<td>1,100W</td>
<td>700W</td>
</tr>
</tbody>
</table>

*This data rate is for the satellite link, and includes overhead bits.*
Contents

1. Overview of KIZUNA
   (WINDS: Wideband InterNetworking test and Demonstration Satellite)

2. KIZUNA Experiments

3. Sentinel Asia Project

4. Outline of KIKU-No.8
   (ETS-8: Engineering Test Satellite No.8)

5. Summary
KIZUNA Experiments

Basic Experiments:
The experiments to be carried out by the satellite development agencies such as JAXA and NICT* in order to confirm the normality of the KIZUNA satellite functions and to demonstrate some applications of the broadband satellite communications system.

Application Experiments:
The experiments to be carried out by the users who proposed the KIZUNA experiments under the open invitation made by the government of Japan (MIC*) and approved their experiments by the government of Japan.

NICT: National Institute of Information and Communications Technology
MIC: Ministry of Internal Affairs and Communications
# Milestones for KIZUNA Experiments

<table>
<thead>
<tr>
<th>FY2007</th>
<th>FY 2008</th>
<th>FY2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan - Mar</td>
<td>Apr - Jun</td>
<td>Oct - Dec</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Launch (Feb. 23)**
- **Critical Phase (until Mar. 1st)**
- **Geostationary (Mar. 14)**
- **Check-out**
- **Basic Experiments**
- **Application Experiments**
JAXA successfully launched the KIZUNA by the H-IIA Launch Vehicle No.14 at 5:55 p.m. on February 23, 2008 (Japan Standard Time, JST) from the Tanegashima Space Center.
World's Fastest Satellite Internet Connection to 45 cm User Terminal Using "KIZUNA" (WINDS)

JAXA and NICT performed in 2008 a verification of regenerative switching functions between an USAT (ultra small-size user terminal with 45 cm-diameter antenna and a HDR-VSAT (high-speed small ground station with 1.2 m-diameter antenna using the onboard multi-beam antenna (MBA) of KIZUNA, and confirmed that Internet protocol (IP) communications with a transmission speed of 155 Mbps were successfully performed.
Carries out World's Fastest Satellite Data Communication at Speed of 1.2 Gbps

On May 2, 2008, JAXA and NICT successfully achieved ultra high data rate communication at a speed of 1.2 Gigabit per second (1.2 Gbps: 622 Mbps x 2 waves), which is the fastest communication speed in the world through communication satellites. This was achieved when a communication test was conducted between the KIZUNA's multi-beam antenna and a super high data rate earth station (a 2.4m diameter antenna) set on a car at the NICT Kashima Space Research Center during the initial functional verification operations of the KIZUNA that were jointly carried out by JAXA and NICT.
Successful Satellite Data Communication at Speed of 622 Mbps by the Active Phased Array Antenna (APAA)

On May 12, 2008, JAXA and NICT successfully achieved high data rate communication at a speed of 622 Mega bit per second (622Mbps) using the KIZUNA's Ka-band Active Phased Array Antenna (APAA) between Large Aperture Terminal (5 m diameter antenna) in the NICT Kashima Space Research Center and a super high data rate earth station (a 2.4 m diameter antenna) set on a car in Kushiro, Hokkaido. The speed was achieved during the initial functional verification operations of the KIZUNA jointly carried out by JAXA and NICT. It is the fastest speed in the world using active phased array antenna.
HDTV Transmission Experiments in Beijing Olympics

(1) Multiplied HDTV Transmission
(2) Remote Editing of HDTV Program
(3) Multicast of HDTV video signals
HDTV Transmission Experiments in Beijing Olympics

NHK Shibuya Broadcast Center

51M-VSAT
NHK Shibuya

Remote Editing of Video Program

3 HDTV Channels via the WINDS Transmission

HDR-VSAT
Beijing Olympic Center

IDU of HDR-VSAT

Operator in Beijing

IBC (International Broadcast Center) in Beijing
Emergency Transmission Experiments
(participating in the Disaster Drill in Tokushima Pref.)

HQ in Local Government

WINDS

Meeting Room of Disaster Prevention Center

Video Conference

Image of disaster area

(1) Video Transmission

Disaster Hitted Area

Ground of Disaster Prevention Center

Wireless LAN

Video of disaster area

WINDS

ALOS

Satellite Image Data

JAXA Earth Observation Center
(Hatoyama in Saitama Pref.)

(2) Distribution of Satellite Image data distribution

(3) Sharing of the information relating to the disaster

Video Conference

Conf. Room of Disaster Prevention Center

ALOS Satellite Image

HQ in Municipal Office
Emergency Transmission Experiments
(participating in the Disaster Drill in Tokushima Pref.)

Shooting the disaster area by HDTV handy camera

Earth Observation Satellite image

Sharing the information relating to the disaster

HDTV video image of the disaster area

Demonstration of WINDS portable terminal

Characters on the board are visible clearly on the HDTV display
Remote Education Experiment using a Hyper Mirror System

(1) The children of both sides between two elementary schools took a class with a hyper mirror system*. 
(2) Transmission HDTV images of the class between both schools. 
(3) To confirm that the KIZUNA communication network system is effective for the large-capacity, real-time two-way communication which is necessary for E-Learning in digital divide area.

*Hyper mirror system
A system to electrically create a new environment (like a world in a mirror) for conversation. Unlike conventional conversation, the system enables all participants to feel that they are talking at the same place through synthetic images.
Scenes of Experiments on DVD

1. HDTV Transmission Experiment in Beijing Olympics

2. Emergency Transmission Experiments
   (participating in the Disaster Drill in Tokushima Pref.)

3. Remote Education Experiment using a Hyper Mirror System
Contents

1. Overview of KIZUNA
   (WINDS: Wideband InterNetworking test and Demonstration Satellite)

2. KIZUNA Experiments

3. Sentinel Asia Project

4. Outline of KIKU-No.8
   (ETS-8: Engineering Test Satellite No.8)

5. Summary
Utilization of KIZUNA for Sentinel Asia System

Disaster related information disseminate to the disaster management agencies in the Asia – Pacific region by using of the high speed data link of ”KIZUNA (WINDS).”

Earth Observation Satellite

Satellite Image data
Achieve Data

Earthquake
Tsunami
Volcano
Flood
Wildfire

Disaster Information Platform

High Speed Data Link
(10Mbps - 155Mbps)

Internet

Sentinel Asia Central Server

Website Contents

Disaster Management Agencies in the Asia-Pacific region
Geo-Informatics and Space Technology Development Agency (GISTDA), Thailand
National Institute of Aeronautics and Space (LAPAN)
National Disaster Coordination Council (NDCC), the Philippines
Indian Space Research Organization (ISRO), etc.
Milestones for KIZUNA Experiments

<table>
<thead>
<tr>
<th>Year</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>KIZUNA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Launch 23rd Feb.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C/O Mar.-Jun.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MIC invited the KIZUNA Application Experiments.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RFP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sentinel Asia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Basic Experiment (~ 2010)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Application Experiment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Step 2 (KIZUNA Application)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Contents

1. Overview of KIZUNA
   (WINDS: Wideband InterNetworking test and Demonstration Satellite)

2. KIZUNA Experiment

3. Sentinel Asia Project

4. Outline of KIKU-No.8
   (ETS-8: Engineering Test Satellite No.8)

5. Summary
Outline of KIKU-8 (ETS-VIII)

Main Characteristics

<table>
<thead>
<tr>
<th>Item</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Launch Date</td>
<td>December 18th, 2006</td>
</tr>
<tr>
<td>Orbit</td>
<td>Geostationary Orbit (GEO)</td>
</tr>
<tr>
<td></td>
<td>Longitude 146ºE</td>
</tr>
<tr>
<td>Mass</td>
<td>5.8 ton (at launch)</td>
</tr>
<tr>
<td></td>
<td>3 ton (initially on GEO)</td>
</tr>
<tr>
<td></td>
<td>1.2 ton (payload mass)</td>
</tr>
<tr>
<td>Generated Electric Power</td>
<td>7,500 W</td>
</tr>
<tr>
<td></td>
<td>(at summer solstice after 3 years)</td>
</tr>
<tr>
<td>Attitude Control</td>
<td>3-axis-stabilized</td>
</tr>
</tbody>
</table>

Missions

- 3-ton class geostationary satellite bus
- Large-scale deployable reflector (LDR)
- Mobile satellite communications and multimedia broadcasting system
- Satellite positioning
Demonstration for Disaster Management using KIKU-8

KIKU-8 satellite is used to demonstrate the effectiveness of the satellite communications for the disaster management support and relief requirements.

Image of Demonstration for Disaster Management

Portable Terminal (8 kg)
64 kbps – 1.5 Mbps

Handheld Terminal (300 g)
50 – 400 bps (TX)
1.6 kbps – 12.8 kbps (RX)
Summary of the Demonstration using KIKU-8

**Demonstration**
JAXA joined in disaster prevention trainings held by local governments and demonstrated emergency communications experiments via KIKU-8 with portable and handheld terminals.

(1) Victims management using RFID  
(2) Visual confirmation of evacuation  
(3) Visual confirmation in disaster site (Wearable camera)  
(4) First-aid support in disaster site (Triage)  
(5) Situation report from disaster site

**Result**
JAXA confirmed that;
- required stable satellite communications networks were established.
- mobility and correctness of disaster applications performed by KIKU-8.
JAXA also verified that;
- effectiveness of victims management and visual confirmation.
- effectiveness for relief support and evacuation center remote operation.

High appraisal from the local governments
Contents

1. Overview of KIZUNA
   (WINDS: Wideband InterNetworking test and Demonstration Satellite)

2. KIZUNA Experiments

3. Sentinel Asia Project

4. Outline of KIKU-No.8
   (ETS-8: Engineering Test Satellite No.8)

5. Summary
Summary of KIZUNA

1. The KIZUNA was successfully launched, and it is confirmed through various functional checkouts and tests of the satellite that the KIZUNA system is available to provide the high speed data link within the Asia-Pacific region.

2. Some basic and application experiments using the KIZUNA satellite have been conducted so far, and those experiments have achieved the expected results.

3. JAXA/NICT are continuously going to develop the above satellite communications system, and it should be considered that those small KIZUNA user terminals be used in the Sentinel Asia Step 2 system.
Summary of KIKU-8

1. The most remarkable feature of KIKU-8 is two large-scale deployable reflectors. These reflectors enable to communicate with very small user terminals.

2. JAXA joined in disaster prevention trainings held by local governments and demonstrated emergency communications experiments via KIKU-8 with the portable and handheld terminals.

3. As the result of this demonstration experiment,
   
   JAXA confirmed that;
   
   mobility and correctness of disaster applications performed by KIKU-8. JAXA also verified that;
   
   effectiveness of victims management and visual confirmation, and
effectiveness for relief support and evacuation center remote operation.

4. From now on, JAXA will promote to utilize “disaster prevention application” to be practicable and apply among local governments.
Thank you for your attention
Please visit at JAXA website

http://www.jaxa.jp/projects/sat/winds/index_e.html

sawabe.masahiko@jaxa.jp