

# Satellite-based Disaster Management System for Asia-Pacific Region

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In 2005, a disaster management support system for Asia was proposed at the Asia-Pacific Regional Space Agency Forum (APRSAF). This led to the Sentinel Asia project with participants (at the time) from 23 agencies in 14 countries and 4 international organizations. The aim was to reduce the number of victims and economic loss caused by natural disasters in the Asia-Pacific Region. The Japan Aerospace Exploration Agency (JAXA) is contributing to this effort by playing an active role as the Sentinel Asia Secretariat. The Satellite-based Disaster Management System for the Asia-Pacific Region, the "Sentinel Asia STEP 2 System," provides disaster response agencies in disaster-affected countries with relevant information, including data reflecting conditions on the ground, obtained by earth observation satellites. It supports the monitoring of disasters in the Asia-Pacific Region by ICT. Fujitsu began developing this system in 2008, and it has been in operation since March 31, 2010. This article presents an overview of the technologies provided by Fujitsu and example results of its use in response to natural disasters.

## 1. Introduction

The occurrence of natural disasters (floods, earthquakes, tsunamis, volcanic eruptions, wildfires, etc.) in the Asia-Pacific Region has been increasing steadily over the last 30 years, often resulting in severe damage to the countries affected. Remote sensing, using earth observation satellites to survey target regions on earth from space, is an effective approach to monitoring such disasters. Periodic images of wide areas in particular regions can be taken, enabling the comparison of before and after images of disaster-stricken regions. This enables quick determination of the scope and conditions of the disaster in an area.

A disaster management support system, "Sentinel Asia," was proposed at the Twelfth Session of the Asia-Pacific Regional Space Agency Forum (APRSAF-12).<sup>1)</sup> Sentinel Asia is an international project aimed at reducing the number of victims and economic loss due to disasters in the Asia Pacific Region. This is made possible by collecting disaster-related information using earth observation and communications satellites and then sharing that information using satellite and terrestrial communications systems.

This initiative coincides with the "promotion of international cooperation (space diplomacy)" espoused in the Basic Plan for Space Policy, formulated on January 25, 2013, by the Strategic Headquarters for Space Policy—an organization established on the basis of Japan's Basic Space Law.<sup>2)</sup>

The Joint Project Team (JPT) of Sentinel Asia consists of 76 agencies from 25 countries and regions in the Asia-Pacific Region and 14 international agencies (as of July 2013). It works closely with the member agencies of the Asian Disaster Reduction Center (27 member countries and 5 advisory countries). The JPT members from various countries comprise agencies that respond to disasters, agencies that provide disaster-related information, and agencies that analyze disaster-related data and provide analysis results. The Japan Aerospace Exploration Agency (JAXA) plays an active role in this by serving as the JPT secretariat.

Fujitsu, in turn, developed the "Sentinel Asia STEP 2" satellite-based disaster management system for the Asia-Pacific Region (hereinafter the "Sentinel Asia System") to contribute to disaster-prevention-and-reduction activities in Asia. The Sentinel Asia System

has been up and running since March 31, 2010.<sup>3)</sup>

In this paper, we present an overview of the Sentinel Asia System, describe the problems that had to be solved in constructing the system, and introduce the technologies that were used to solve them. We also present example results of using the Sentinel Asia System in response to natural disasters.

## 2. Overview of Sentinel Asia System

Following a natural disaster in the Asia-Pacific Region, the Sentinel Asia System provides disaster response agencies in stricken countries with relevant information such as earth observation data, photos of affected regions, and the results of analyzing disaster conditions (**Figure 1**). The idea is to share the information obtained at the time of a disaster so that it can be used for implementing disaster countermeasures.

The Sentinel Asia System provides three main services to disaster response agencies:

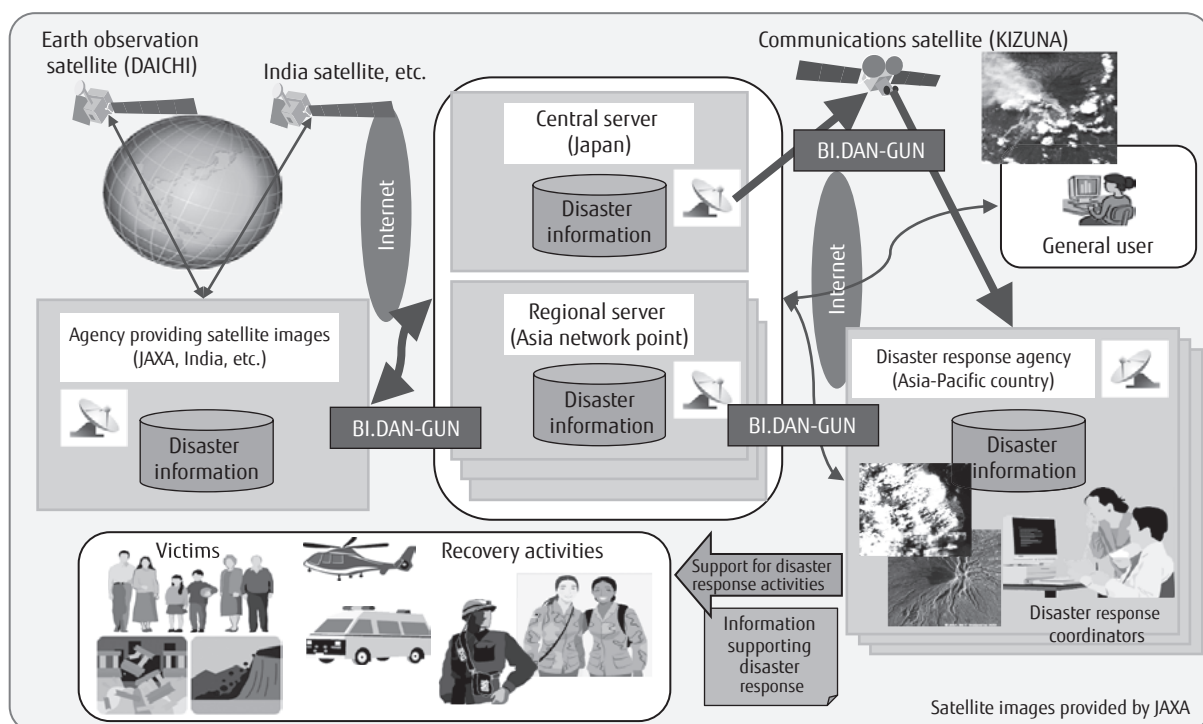
### 1) Responding to requests for disaster-related information

A disaster response agency in a country that has been hit by disaster can ask agencies in other

countries to provide disaster-related information for use in determining the extent of the damage. The disaster response agency can thereby obtain the assistance of agencies in other countries in collecting information about the affected areas and can access diverse types of information for understanding disaster conditions and formulating recovery and restoration plans.

### 2) Sharing of disaster-related information

Disaster-related information registered with the Sentinel Asia System can be provided over the Internet so that a disaster response agency in a stricken country can obtain relevant information, including information about affected areas, and use that information for formulating disaster countermeasures. This service enables disaster-related information to be overlaid with other types of relevant information such as geographical information, including national boundaries, rivers, and lakes, land-cover information, such as urban areas and vegetation, and even statistical information, such as population data. The user can thereby better understand the disaster's effects by viewing disaster-related information together with other types of information in a composite manner.



**Figure 1**  
Overview of Sentinel Asia System.

3) Periodic providing of relevant information

This service goes beyond the provision of disaster-related information at the time of a disaster by periodically obtaining information about cloud cover, rainfall, forest fires, etc. from data provision agencies and providing that information to disaster response agencies. A disaster response agency can use this information to uncover signs or make an early discovery of a pending disaster.

### 3. Problems and solutions

Two problems were faced in constructing the Sentinel Asia System:

- How to share disaster-related information over a wide area
- How to transmit data between national agencies

#### 3.1 Sharing disaster-related information over a wide area

##### 3.1.1 Problem

A typical system for sharing data stores the data at one location, and users access that data as needed. However, good data download performance requires a short physical distance between the user and the storage site, plus reliable telecommunication links between network points. Since the Sentinel Asia System needs to share data throughout the Asia-Pacific Region, storing data at only one location would mean a long physical distance between most users and that location, resulting in poor performance. Furthermore, only a certain portion of the data is to be used by each agency, so simple data sharing will not work.

##### 3.1.2 Solution

Fujitsu configured the Sentinel Asia System with a wide-area distribution system consisting of a server located in Japan that centrally manages the disaster-related information and of servers in each area of the region that manage only the information needed by authorities in that area. This means that a disaster response agency can use disaster-related information from a relatively close regional server, thereby shortening the physical distance between network points and improving download performance. As a result, the system is more convenient for users. In addition, storing only the disaster-related information needed by each area facilitates the management of access privileges.

#### 3.2 Transmitting data between national agencies

##### 3.2.1 Problem

Disaster-related information provided by data-provision and data-analysis agencies in response to data requests from stricken countries must be promptly provided to the disaster response agencies in those countries. This provision of data involves the long-distance transmission of data across national boundaries, which makes the deployment of a telecommunication platform to support that data transmission extremely important. However, a reliable and extensive telecommunication platform had yet to be deployed in the Asia-Pacific Region as telecommunication circuits were generally of poor quality or of narrow bandwidth.

##### 3.2.2 Solution

Considering that the telecommunication platform in the Asia-Pacific Region was not sufficiently built up at the time, the Sentinel Asia System uses satellite communication circuits in addition to terrestrial communication circuits, such as the Internet. The central server sends disaster-related information to the regional servers via the "KIZUNA" (WINDS)<sup>4)</sup> ultra-high-speed communication satellite. This means that data can be transmitted without having to use circuits in a region that does not have a sufficiently built-up telecommunication platform, enabling prompt provision of data.

### 4. Fujitsu-provided technologies

Communication circuits and transmission-path-optimization and high-speed, high-reliability data transmission technologies provided by Fujitsu were used to solve these problems.

1) Communication circuits and transmission-path-optimization technology

Two types of transmission paths are used for delivering disaster-related information to disaster response agencies: terrestrial communication circuits and satellite communication circuits. The delivery of disaster-related information to disaster response agencies must be done in a short period of time while taking into account the conditions of circuits in the destination region, the priority of the various types of information, the time periods during which WINDS is available, the regions for which transmission is possible during those

time periods, and constantly changing telecommunication conditions.

The Sentinel Asia System takes into account all relevant information, including the delivery destination, priority, and amount of disaster-related information, the regions for which WINDS transmission is possible and the corresponding availability times, the regions with regional servers, their communication environments and whether they have WINDS antennas, and basic information required for data delivery, such as circuit type and data priority. Then, on the basis of this information, the system selects the type of circuit (terrestrial or satellite) and the transmission path (direct delivery from central server to destination regional server or relay delivery via regional server closest to destination server) that can most quickly provide the information to the requesting disaster response agency. The circuit type and path so selected makes it possible to provide disaster-related information promptly to the disaster response agency in the stricken country.

## 2) High-speed, high-reliability data transmission technology for low-quality circuits

In addition to technology for formulating optimal delivery plans, Fujitsu has also introduced proprietary technology for optimizing the efficiency of data transmission.

In general, data transmission on a low-quality circuit involves frequent resending of files due to lost packets. This extends the time needed to complete the

delivery of needed data and degrades data transmission efficiency.

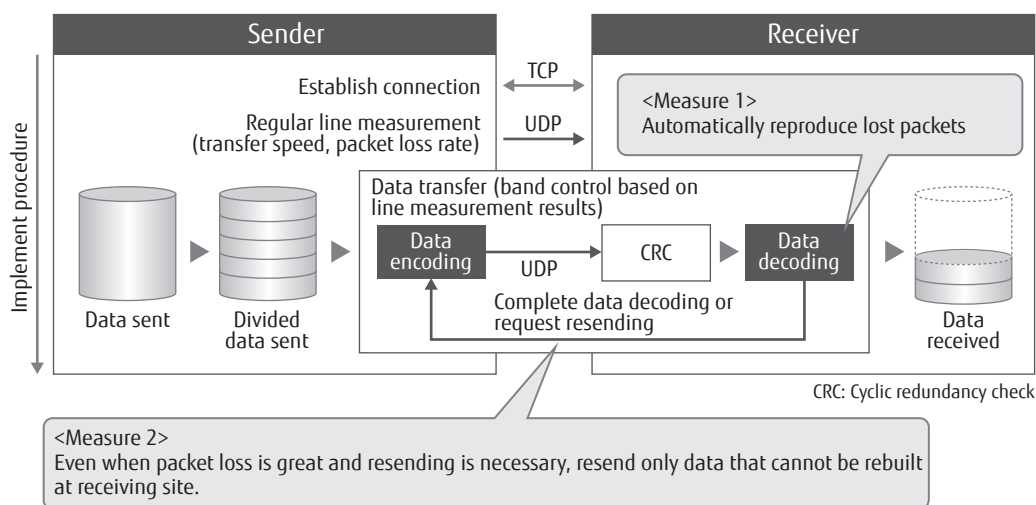
Taking this into account, the Sentinel Asia System applies Fujitsu's BI.DAN-GUN<sup>5)</sup> high-speed file transfer package, which enables efficient delivery of data compared to ordinary means of transmission (performance ~20 times that of the file transfer protocol). BI.DAN-GUN (**Figure 2**) combines the User Datagram Protocol (UDP) with Random Parity Stream (RPS)<sup>6),7)</sup> an erasure correction code, which was independently developed by Fujitsu Laboratories. The result is high-reliability and high-performance file transfers even on Internet circuits that pass through regions with poor circuit quality and frequent interruptions or packet retries. Furthermore, as the file-transfer portion of BI.DAN-GUN uses UDP communications, BI.DAN-GUN can achieve high-speed file transfer even for unidirectional satellite communications using WINDS.

These technologies make it possible to quickly provide disaster-related information to disaster response agencies in the Asia-Pacific Region. Fujitsu is also applying other proprietary technologies to the full-est to provide ICT support to the Sentinel Asia System.

## 5. Results

### 1) System rollout in Asia-Pacific Region

Regional servers are now deployed at 14 locations in the Asia-Pacific Region (**Figure 3**), and they are regularly updated with the latest relevant information.



**Figure 2**  
Transmission method for BI.DAN-GUN high-speed file transfer package.



**Figure 3**  
Regional servers in Asia-Pacific Region.

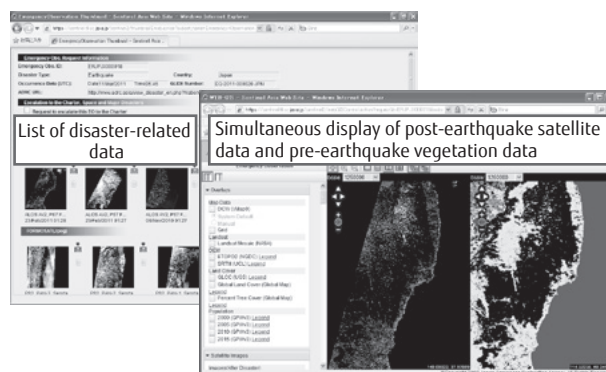
## 2) Requests from disaster response agencies

There were 142 requests from disaster response agencies for relevant information from March 2007 to July 2013, and 4971 items of disaster-related information were provided. In 2010 and 2011, there were many natural disasters with a high concentration of occurrences from July to October. Many natural disasters occurred in Indonesia, the Philippines, and Vietnam, with flooding being the most prevalent, and diverse types of natural disasters have occurred in Indonesia and the Philippines, including earthquakes and volcanic eruptions in addition to flooding. The Sentinel Asia System has been used for all these types of disasters.

## 3) Contributions to Great East Japan Earthquake response

After the Great East Japan Earthquake on March 11, 2011, Japan requested disaster-related information from the Sentinel Asia System and received information provided by a variety of satellites including the JAXA Advanced Land Observing Satellite (ALOS) "Daichi" and earth observation satellites of various national agencies such as FORMOSAT-2 (Taiwan), IRS (India), and THEOS (Thailand). This information enabled Japan to determine the extent of the damage and to begin preparing recovery and restoration plans. Various types of relevant information could be obtained from the Sentinel Asia System Web site, and offers of co-operation by agencies in various countries could be monitored and acknowledged (**Figure 4**).

The support provided by the Sentinel Asia System led to the sending of a certificate of appreciation<sup>8)</sup> from the Cabinet Office Counselor for Disaster Prevention to



**Figure 4**  
Disaster-related information following Great East Japan Earthquake (Sentinel Asia System Web site).

the Sentinel Asia secretariat (JAXA).

## 6. Conclusion

The Sentinel Asia System, which is supported by Fujitsu technologies, has come to play an important role in reducing the number of victims and economic loss caused by natural disasters in the Asia-Pacific Region. Fujitsu will continue to contribute to safety and security in the Asia-Pacific Region by supporting the Sentinel Asia System.

In conclusion, Fujitsu would like to extend its heartfelt appreciation to all concerned at JAXA and related agencies for their valuable guidance in the development of this system.

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