

MAXI Data Downlink and Data Transfer on the Ground

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ABSTRACT

We describe the MAXI (Monitor of All sky X-ray Image) data downlink paths and the data transfer in the ground system. The MAXI telemetry data are downlinked using geostationary data-relay satellites, received at the ground system at Tsukuba Space Center, and forwarded to the RIKEN (the Institute of Physical and Chemical Research) ground system for advanced scientific analyses and data releases. A nova search system is placed at Tsukuba, which minimize its downtime due to network communication outages between Tsukuba and RIKEN.

KEY WORDS: High Energy Astrophysics, X-ray Astronomy, ISS, JEM, Kibo, MAXI, All-sky X-ray monitor

1. Introduction

MAXI is an all-sky X-ray monitor and one of its objectives is searching for X-ray transient events. At Tsukuba Space Center in Japan, All the MAXI telemetry data are routed to Tsukuba Space Center OCS (Operation Control System), and received by the MAXI ground system developed by the mission team. To minimize data transfer latency on one hand and to protect the space station's networks and the MAXI data on the other hand, we have developed dedicated ground systems. First we describe the MAXI data downlink paths, which are typical for payloads on the space station, and then briefly mention the data transfer inside the MAXI ground system.

2. Four Downlink Paths

The Japan Experiment Module (JEM) “Kibo” on the International Space Station (ISS) provides a user with up to three different types of data communication ports: MIL-1553B, Ethernet, and FDDI. Those ports are the start points of Low Rate Data Link (LRDL), Medium Rate Data Link (MRDL), and High Rate Data Link (HRDL), respectively.

The MAXI mission uses two of them: LRDL and

MRDL. The LRDL, MRDL, and HRDL are not the names of “physical” networks, but they are “logical” networks. Actually, the MAXI telemetry data transmitted through the MIL-1553B interface (LRDL) and the data through the Ethernet interface (MRDL) both eventually come into the same physical networks on ISS (for example, FDDI). The LRDL and MRDL data are then multiplexed and downlinked as radio frequency (RF) signals.

The RF signals are downlinked through one or both of two data-relay systems utilizing geostationary satellites: one is JAXA's ICS (In-orbit Communication System) using only one satellite named “Kodama”, and the other is NASA's system using TDRSS (the Tracking and Data Relay Satellite System).

Thus MAXI has four different downlink paths: 1) NASA LRDL, 2) ICS LRDL, 3) NASA MRDL, and 4) ICS MRDL. In the MAXI case, the LRDL and MRDL start at MAXI in orbit, and end at the MAXI data acquisition computers at Tsukuba Space Center in Japan.

If we take account of the visibility of data-relay satellites viewed from ISS's antennae only and omit the fact that we have to share downlink resources with other ISS users, the NASA link using more than one data-relay satellite provides higher availability than the ICS link.

For the MAXI team to use the NASA link resource, however, JAXA needs bilateral coordination with NASA. To use the ICS link, the MAXI team needs just JAXA-internal negotiations with other satellite teams.

During communication outages between ISS and the ground stations, the NASA link data are stored on NASA's HCOR (High Rate Communications Outage Recorder), and the ICS link data are stored on JAXA's HRDR (High Rate Data Recorder).

2.1. Low Rate Data Link (LRDL)

LRDL starts with a MIL-1553B bus on JEM "Kibo". The data throughput assigned to MAXI is not large (25 to 50 kbps). Since the MIL-1553B bus provides each user with fixed-sized data slots, data collisions do not occur. Health and status data and a level minimum set of experiment data of MAXI are downlinked through LRDL. MAXI's X-ray nova search is conducted for downlinked LRDL data, and confirmed using more detailed MRDL data. For LRDL data, technically, we can use both the NASA and the ICS links in parallel. To maximize the real-time downlink window, the MAXI team plans to use the NASA link.

Both the NASA and the ICS LRDL are used for command uplinks.

2.2. Medium Rate Data Link (MRDL)

MRDL starts with a 10Base-T Ethernet on JEM "Kibo". The data throughput assigned to MAXI is 200 to 600 kbps. This MRDL throughput allows us to use more data bits for experiment information (for example, measurements of time, positions, and energy) than the LRDL throughput. Some housekeeping telemetry data are downlinked by MRDL only, and are useful for us to obtain reliable results in calibrations and data analyses. Since the JEM Ethernet nodes are connected via a repeating hub, however, there is a possibility of data loss caused by multiple data frame collisions, depending on network traffic.

We have to prepare differently formatted MRDL data inside the MAXI data processor for the NASA link (MAXI data on CCSDS on IEEE802.3 frame) and for the ICS link (MAXI data on UDP on IP on Ethernet II frame). Thus we cannot use the two MRDL in parallel for downlinks. Our preference is using the NASA MRDL for its longer real-time connection.

Only the ICS MRDL is capable for command and file uplinks.

3. Data Transfer on the Ground

The MAXI ground system is located at two separate places, Tsukuba Space Center and RIKEN.

The Tsukuba ground system is for the MAXI operation, the first data reduction, and the X-ray nova search.

The RIKEN ground system receives all the MAXI data from the Tsukuba system. The RIKEN system is for advanced scientific data analyses, and the public release of the MAXI data and results.

3.1. Tsukuba Ground System

The Tsukuba ground system consists of the following two components:

1. Database inside the JAXA Operation Control System (OCS) area, acquiring telemetry data from the upper streams, storing time-sorted housekeeping and experiment data, conducting engineering units conversion, and distributing data for quick look, nova search, and the RIKEN ground system;
2. Nova search system inside the JAXA OCS area, searching for significant X-ray transient events, and issuing nova alerts to the Internet on detection of significant events;

3.1.1. Data Diode

To protect the JEM "Kibo" OCS from illegal network attacks, the MAXI data are transferred out from OCS through secure one-way data paths (Fig.1). We plan to use two types of one-way paths: two-ported hard disks and a photo coupler with an optical fiber between the emitter and the receiver.

3.1.2. MAXI-DB

Component 1 is a group of software modules, developed by JAXA and named "MAXI-DB" (Fig.1 and Fig.2). Each MAXI-DB consists of four main functional services of data receiving, data recording, data searching and supplying, and data processing for analysis. MAXI-DB also provides data backup service, system maintenance service, and GUI service. Using each individual service on several separate computers, we achieve the load balancing for quasi-real-times data processing.

3.1.3. Nova Search System

The Nova Search System searches for X-ray transient events. To avoid the downtime of the Nova Search System due to the network communication outage between Tsukuba and RIKEN, Tsukuba Space Center hosts the system, instead of RIKEN. This system sends nova alerts to registered users when significant events occur. The MAXI nova alert system is described by Negoro et al (2008).

3.2. RIKEN Ground System

The RIKEN ground system consists of the following two components:

1. Pipe-lined data analysis system running on a cluster of computers for advanced scientific data analyses

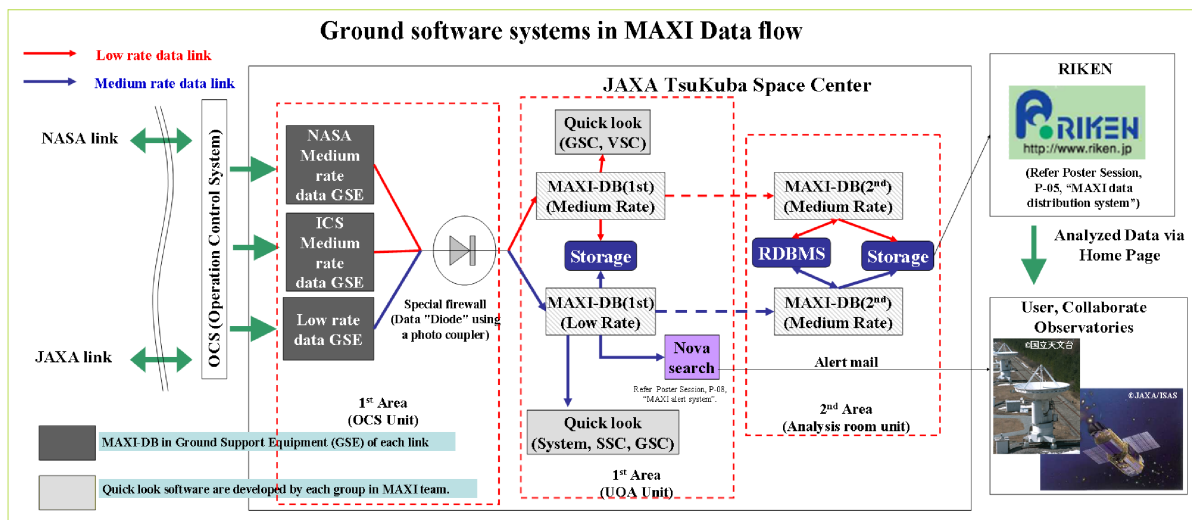


Fig. 1. MAXI Ground System and Data Flow

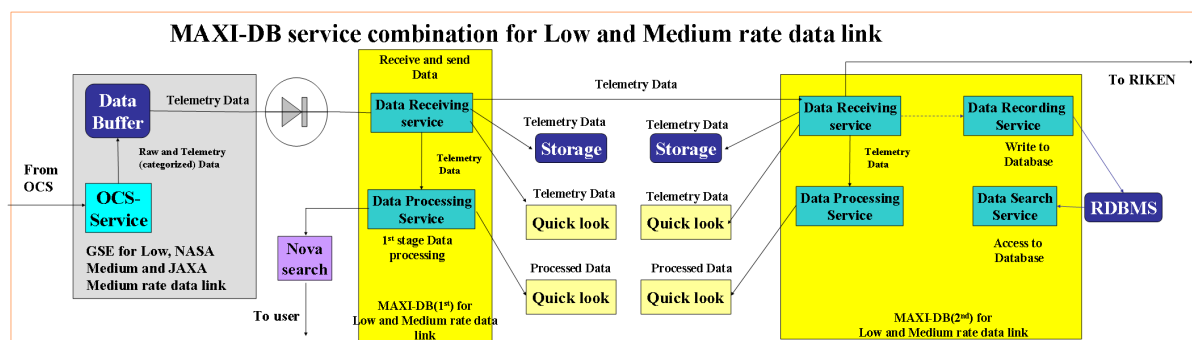


Fig. 2. MAXI-DB System at Tsukuba Space Center

2. Database on the Internet, providing images, spectra, and light curves in response to the public user access using web browsers;

The data analysis scheme is presented by Sugizaki et al (2008), and the data distribution system is presented by Kohama et al (2008).

4. Summary

We have four different downlink paths for the MAXI telemetry data. To obtain the real-time connection as much as possible, our preference is using the NASA link for both LRDL and MRDL data.

To protect the ISS operation network and the MAXI data, we use a secure hardware-level one-way data paths.

By distributing the services of MAXI-DB to several separate computers, we have succeeded in quasi-real-time pipe-line data processing.

References

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 Sugizaki, M. et al. 2008, in this proceedings