DARTS: JAXA's Multi-disciplinary Space Science Data Archives

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ABSTRACT

DARTS (Data Archives and Transmission System: http://darts. jaxa.jp) is JAXA's multi-disciplinary space science data archive, which covers space astronomy (X-ray, infrared and radio), solar physics, solar-terrestrial physics (STP), and lunar and planetary science. DARTS is developed and maintained by Center for Science-satellite Operation and Data Archive (C-SODA) at JAXA/ISAS. We archive all the telemetry data of the ISAS satellite for the last ~30 years, and high-level data of most science satellites since 1980`s. Currently we support seven active missions: Hinode (solar), Suzaku (X-rays), Akari (IR), Geotail (STP), Akebono (STP), Reimei (STP) and Hayabusa (planetary). These satellite data are highly processed , and the high-level data are archived at DARTS. Almost all the data go public after some proprietary periods, of which lengths depend on individual projects.

Keywords: data archives, space science, astrophysics, solar physics, solar-terrestrial physics, lunar and planetary science

INTRODUCTION

Data ARchives and Transfer System (DARTS; http://darts.jaxa.jp) is the scientific satellite data archive at Institute of Space and Astronautical Science (ISAS), which is a part of JAXA. DARTS is developed and maintained by Center for Science-satellite Operation and Data Archives (C-SODA) in ISAS. Development of DARTS started in 1997 with the aim of archiving scientific data of ISAS satellites, and providing the space science data by Japanese missions to global space science community. In 2003, JAXA was established as the sole public organization encompassing Japan's space development, and ISAS became a part of JAXA. See [1],[2] and [3] for the reports of early developments of DARTS.

DARTS archives almost all the science satellite data launched by ISAS or JAXA since 1980's. Future science satellite data by JAXA will be also archived at DARTS. In principle, DARTS data are publically available, so that researchers all over the world can retrieve these data by free of charge, and publish scientific results using DARTS.

DARTS have four categories; astrophysics, solar physics, solar-terrestrial physics (STP), and lunar and planetary science. One of DARTS's characteristics, compared to other space science databases in Europe and USA, is that it handles space science data in diverse fields with many satellites. Still, the same people are developing DARTS under the same philosophy for different fields. By sharing the infrastructures and developers, we are able to efficiently develop databases for more than a dozen of satellites in diverse fields in space science.

DATA FLOW

Figure 1 indicates schematic view of ISAS satellite data system. Satellite telemetry data are sent to ISAS from multiple ground stations inside and outside of Japan, concatenated, removed duplication, attached data reception time, then kept in the database named "SIRIUS (Scientific Information Retrieval

and Integrated Utilization System)". SIRIUS archives almost all the telemetry data of ISAS satellites since 1970's with minimum data processing from the original formats.   The telemetry data are reformatted to more standard formats (such as FITS in astronomy), and instrument specific calibrations are performed. These reformat and calibration processes are dependent on individual missions. For example, in the case of Suzaku, the processing system was developed in collaboration with NASA/GSFC. The highly calibrated data are stored in DARTS, and distributed to general users world-wide via ftp and http protocols. Some data go immediately public (e.g., Hinode), whereas other proprietary data are encrypted during the proprietary periods. The decrypting keys are e-mailed to the observers who own the data. When the proprietary periods are over, these data are automatically decrypted and go public.
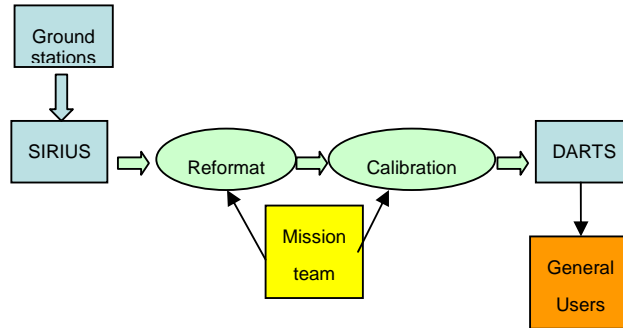
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Figure 1: A schematic diagram of the ISAS satellite data flow.

AVAILABLE SATELLITE DATA

Table 1 shows the currently available satellite data at DARTS.

Mission Name	Operational Year	Field	Available Data/software
Tenma	1983-1989	X-ray astronomy	Observational log
Ginga	1987-1991	X-ray astronomy	FITS wrapped telemetry, analysis software
Akebono	1989-	STP	Processed data
Yohkoh	1991-2004	Solar physics	Processed data, software
Geotail	1992-	STP	Processed data
ASCA	1993-2000	X-ray astronomy	Processed data
IRTS	1995-1995	Infrared astronomy	Data products
HALCA (VSOP)	1997-2005	Radio astronomy	Event data
Hayabusa	2003-	Asteroid mission	Data products
Suzaku	2005-	X-ray astronomy	Processed data
Reimei	2005-	STP	Data products
Akari	2006-	Infrared astronomy	Processed data, software
Hinode	2006-	Solar physics	Processed data, software

Table 1: List of the space science data archived at DARTS

Kinds of products and levels of data processing are different for different satellites, but DARTS provides a consistent user interface for different fields/satellites.

ASTROPHYSICS

In astrophysics, we have seven missions, Tenma, Ginga, ASCA, IRTS, HALCA, Suzaku and Akari. In the followings, we put some notes on these satellite data:

Tenma is Japan's second X-ray satellite (first is Hakucho launched in 1979, of which data we do not have at DARTS). Although observation logs are kept at DARTS, we do not keep data analysis software, so it is practically impossible to analyze Tenma data now (neither Hakucho). It is from Ginga that we started archiving the complete satellite data and analysis software. The Ginga data and software are identical to the ones used on the ISAS mainframe computer while Ginga was alive; without loss of information, data and software are ported to FITS format on the Unix environment. Using the Ginga data archive, journal papers are being published even ~20 years after the launch [4],[5]. Alternative Ginga data archive is present at the Leichester University, which has in principle the same dataset as DARTS, but in a different format.

For ASCA and Suzaku, next X-ray satellites after Ginga, data archives were developed in collaboration with NASA/GSFC, and the identical datasets are available at HEASARC (http://heasarc.gsfc.nasa.gov). Analysis softwares are distributed from HEASARC (in the FTOOLS package). Suzaku specific analysis softwares developed in Japan are delivered to NASA/GSFC, packaged into FTOOLS and maintained there.

In radio astronomy, while DARTS archives the HALCA/VSOP event data, the HALCA/VSOP survey database is maintained by the VSOP project at ISAS (http://wwwe.vsop.isas.jaxa.jp/survey/) and University of Calgary (http://www.ras.ucalgary.ca/survey.html).

In infrared, IRTS data products are archived completely. Akari data consists of pointing data and survey data. Pointing data go public after proprietary periods, and can be downloaded from DARTS. The survey data produced all sky point source catalogs, which are currently used within the Akari team, and planned to go public in early 2010. All sky survey images may be also produced and go public soon.

JUDO and UDON

At DARTS, we not only store data and provide data query service, but also develop web-based data browsing and quick analysis systems. Two examples in astrophysics are JUDO (JAXA Universe Data Oriented; http://darts.jaxa.jp/astro/judo) and UDON (Universe via DARTS ON-line; http://darts.jaxa.jp/astro/suzaku/udon.html). Both systems work on standard web-browsers. In JUDO, users can display the celestial sphere in different coordinates, zoom-in, zoom-out and navigate using mouse. Suzaku and other satellite images are displayed in color (indicating energies). Suzaku public and proprietary observations are visually distinguished on the sky, and when the data go public, data are automatically processed and the new images will appear. Using UDON, users can display images with arbitrary colors depending on the user-specified energy bands, and can extract energy spectra and light curves from specified regions on the image. UDON is implemented using ION (IDL ON-the-net) and Flash technologies.

SOLAR PHYSICS

Yohkoh and Hinode databases are developed in the framework of international collaboration, and several Yohkoh and Hinode data centers are present in the United States and Europe. In Hinode, data are shared with National Astronomical Observatory Japan (NAOJ). The DARTS disks are exported to NAOJ via a dedicated Gbit network, and people at NAOJ can use Hinode data just as if on the local disks. DARTS provide low-level Hinode data, while NAOJ carries out further data processing and create higher level products.

SOLAR-TERRESTRIAL PHYSICS (STP)

We have three satellite data, Akebono, Geotail and Reimei. Kinds of data products and levels of the data processing are diverse, since there are many different types instruments on these satellites. Reimei is a small engineering satellite, which has a CCD camera to capture aurora images in three different colors. Those aurora color movies immediately go public via DARTS.

Conjunction Event Finder (CEF)

CEF is a popular web-service at DARTS/STP. In the field of STP, satellite data are distributed from many different data centers, while it is important to study multi-satellite data of the same events. In CEF, users enter date and time of interest, then CEF returns links to the events recorded by different satellites not only at DARTS but also at other foreign data centers. In this manner, researchers can save a lot of time to search for conjunction events, so that they can start detailed event data analysis without much pain.

LUNAR AND PLANETARY SCIENCE

Lunar and planetary sciences are new fields in DARTS. In fact, Kaguya and Hayabusa are practically the first Japanese missions to have taken valuable scientific data of the solar system (moon and asteroid, respectively). Currently, Hayabusa data are in DARTS, while Kaguya has an independent database that is separated from DARTS.

FUTURE PLAN

In 2009, two Japanese instruments on the International Space Station (ISS) have started operation (MAXI for X-ray all sky monitor and SMILES for upper-atmosphere observation). In 2011, Akatsuki (PLANET-C) will be launched to study Venus climate, and EXCEED (SPRINT-A) will be launched in 2012 to study Jupiter from low earth orbit. These data will be eventually archived at DARTS. Future planetary missions such as Hayabusa2 and SELENEN2 are planned at JSPEC (JAXA's Space Exploration Center). As the sole space science data archive at JAXA, DARTS will accommodate these JSPEC mission data too..

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