Ground data processing for spacecraft operations and science

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Lunar and Planetary explorations in Japan

1985.01.08
Sakigake (MS-T5)
Halley’s Comet

1990.01.24
Hitent (MUSES-A)
Moon Swing-by

1998.07.04
Nozomi (PLANET-B)
MARS Orbiter (FAILED)

2003.05.09
Hayabusa (MUSES-C)
Asteroid Sample Return

2007.09.14
Kaguya (SELENE)
Lunar Orbiter

2010.05.20
Akatsuki (PLANET-C)
Venus Climate Orbiter

2014.12.03
Hayabusa2 (Hayabusa2)
Asteroid Sample Return

2018.10.20
Mio (BepiColombo-MM0)
Mercury Orbiter

2023 SLIM
Accurate landing and the demonstration of the techniques on the moon

2024 MMX
Phobos sample return
Ground stations for deep space

Usuda Deep Space Center (UDSC)
Diameter 64m
Frequency: S/X band

Misasa Deep Space Station (MDSS)
Diameter 54m
Frequency: X/Ka band
Typical On-board Camera example
Data flow in ground data systems

- Spacecraft
- JAXA antennas
- Telemetry Input
- Telemetry Distributer
- Sagamihara Operation room (SSOC)
  - Command
  - QL
  - Data distributor
  - SLE Gateway
  - Time calibration system
- Server Room
  - SIRIUS
  - EDISON (Engineering Conversion)
  - Data Distributer
  - Reformatter
  - DARTS
- NASA/ESA antennas

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Communication Protocol: SDTP

- Space Data Transfer Protocol
- Specific protocol used in JAXA/ISAS implemented on TCP/IP
- The same layer protocol is H-II protocol/SLE protocol
- For telemetry receive, the following parameters are available
  - Mode (real transfer or late buffer)
  - Spacecraft ID
  - Antenna ID
  - Transfer frame or CCSDS Space Packet
- SDTP is designed on a bucket relay.
Space system and technical map

**Spacecraft**

**System Application**
- OS: UNIX (Solaris/Linux)
- Know.: Satellite Op./OS/IPC/TCP-IP
- Lang.: C/Shell Script/Python/IDL

**Web Application**
- OS: UNIX (Solaris/Linux), Windows
- Know.: Server/Database/Web/IT Security
- Lang.: Java/PHP/Ruby/JavaScript/Go/Python

**Embedded System**
- OS: None, Real-time OS
- Know.: Hardware/Satellite
- Lang.: Assembler/C

**Ground System**

**Publication System**

**Level0**

**Level1**

**Level2**

**DB**

**www**
Mature form of Data Archiving

- Project tasks:
  - Definition
  - Production
  - Documentation
  - Integration
  - Evaluation

- Data Center tasks:
  - Preservation
  - Publication
  - Identification

- Community tasks:
  - Utilization
  - Collaboration
  - Standardization

Data Archives
Standards in space

Spacecraft design and operations
- CCSDS
  - The Consultative Committee for Space Data Systems
  - Found: 1982
  - Major 6 technical topics:
    - Space Internetworking Services
    - Mission Operations And Information Management Services
    - Spacecraft Onboard Interface Services
    - System Engineering
    - Cross Support Services
    - Space Link Services

Science
- PDS
  - Planetary Data System
  - Found: 1990’s
  - Provide Scientific data standards with peer-review
  - Quality that withstands scientific analysis
- SPICE
  - Define ancillary data such as time, trajectory, attitude, etc.
  - Provide fundamental data such as planetary ephemeris, axis, etc.
  - Provide tools and software library to handle SPICE defined formats
  - Almost all spacecraft in NASA/ESA/JAXA provide ancillary data in SPICE format
Japanese organization for data archives (Role)

Program Director

Projects

Senior Chief Officer of Fundamental Technology for Space Science

Science Satellite Operation and Data Archive Unit (C-SODA)

Lunar and Planetary Exploration Data Analysis Group (JLPEDA)

Any missions ... Scientists, Engineer (To make archives for advanced analysis)

PDS, SPICE, and other data archive tasks should be sustainable

Space Exploration Center (JSEC)

Top-down missions

JAXA

ISAS

PS: Project Scientist
AS: Archive Scientist
SGS: Science Ground Segment

Akatsuki ... PS, SGS, AS
Hisaki ... PS, SGS, AS
Hayabusa2 ... PS, SGS, AS
BepiColombo ... PS, SGS, AS
Hayabusa ... AS
SELENE ... AS

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Japanese organization for data archives (Time)

- JAXA
- ISAS

Program Director
- Senior Chief Officer of Fundamental Technology for Space Science

Projects
- Science Satellite Operation and Data Archive Unit (C-SODA)
- Lunar and Planetary Exploration Data Analysis Group (JLPEDA)

Current
- Past
- Future

Space Exploration Center (JSEC)
Publication of Scientific Data

Planetary Exploration Data is available on the Internet

Major sites:
JAXA DARTS  https://darts.jaxa.jp/
NASA PDS  https://pds.nasa.gov/
ESA PSA  https://www.rssd.esa.int/index.php?project=PSA
ISRO ISDA  https://www.issdc.gov.in/isda.htm
Chinese missions  https://moon.bao.ac.cn/ceweb/datasrv/dmsce3.jsp
IPDA  https://planetarydata.org
Summary

• Japanese lunar and planetary missions are continuously performed.
• The ground station has also been established: MDSS.
• The flow of data from an on-board instrument to the ground system was shown, and the technologies required for each system were different.
• The ideal(mature) form of data archives is shown. In particular, the standards used in the space development are CCSDS, PDS, and SPICE.
• The organization for data archivings in JAXA was also shown.
• The final output, scientific datasets, is available from the web site: DARTS for JAXA.
Enjoy the planetary data