Ground data processing for spacecraft operations and science

Yukio Yamamoto[1,2] and Hiroshi Ishikawa[2]

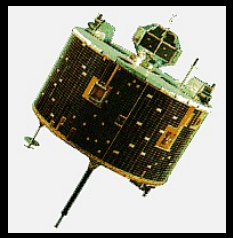
[1] Japan Aerospace Exploration Agency

[2] Tokyo Metropolitan University

Lunar and Planetary explorations in Japan

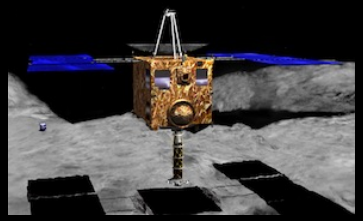
1985.01.08
Sakigake(MS-T5)
Halley's Comet

1990.01.24
Hiten (MUSES-A)
Moon Swing-by



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

2003.05.09
Hayabusa (MUSES-C)
Asteroid Sample
Return

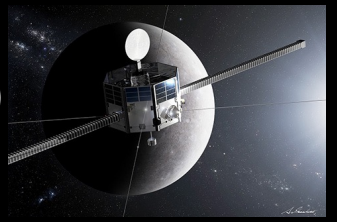


2007.09.14
Kaguya (SELENE)
Lunar Orbiter

2010.05.20
Akatsuki (PLANET-C)
Venus Climate
Orbiter

2014.12.03
Hayabusa2 (Hayabusa2)
Asteroid Sample
Return

2018.October
Mio(BepiColombo-MMO)
Mercury Orbiter



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

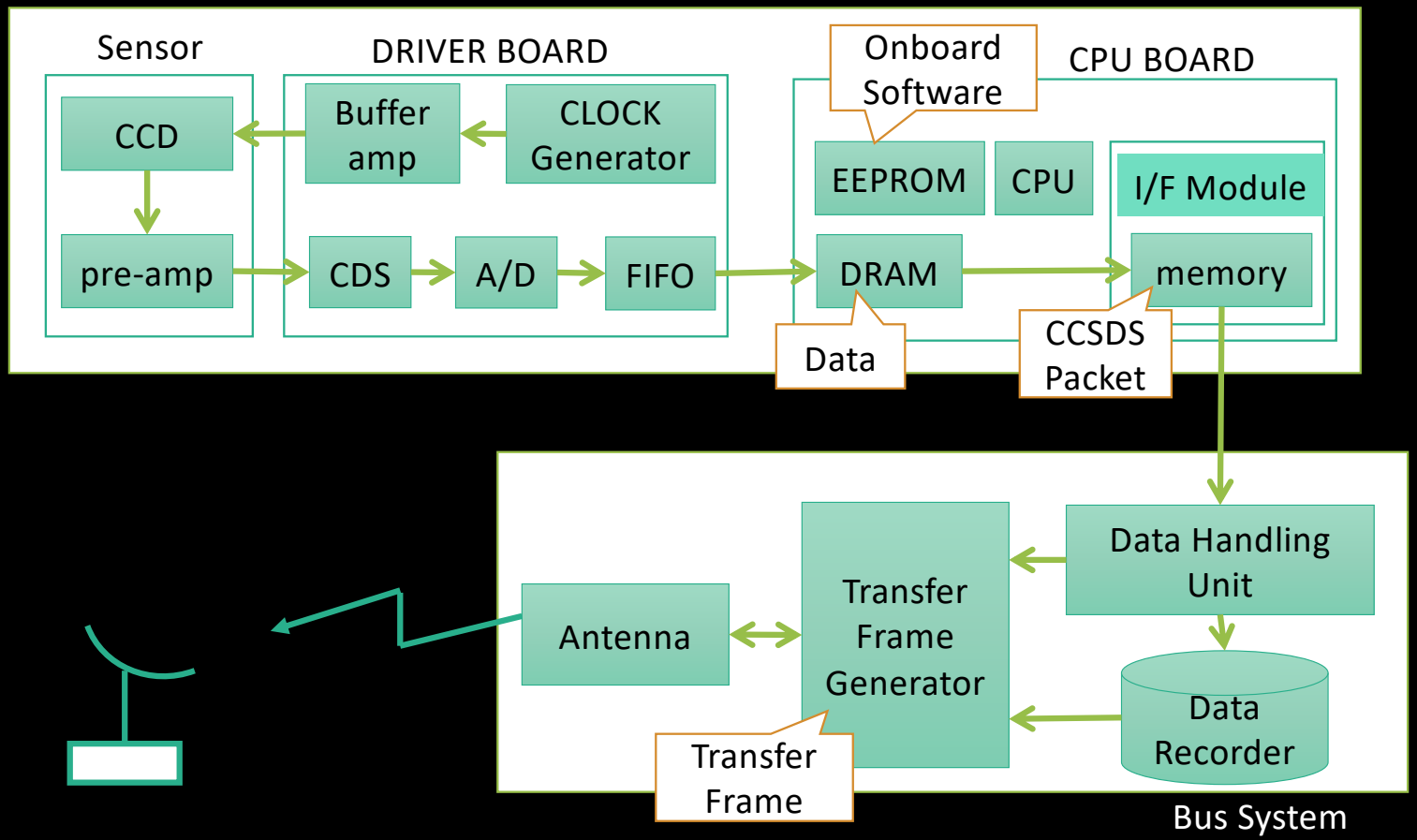
2024 MMX
Phobos sample return

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

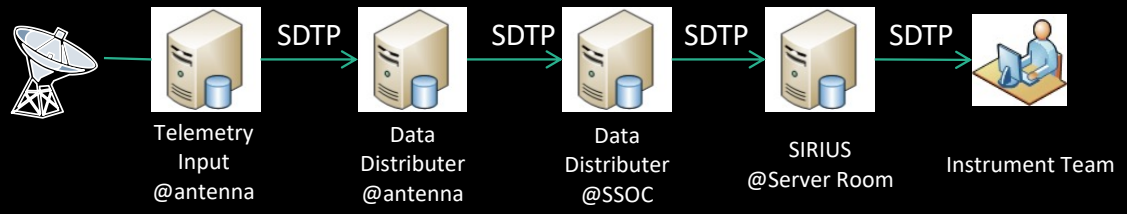
Typical On-board Camera example



Data flow in ground data systems

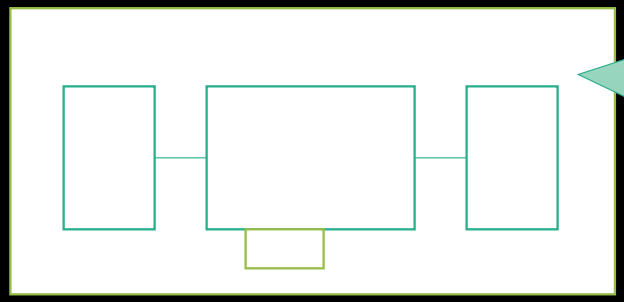
Communication Protocol: SDTP

- 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

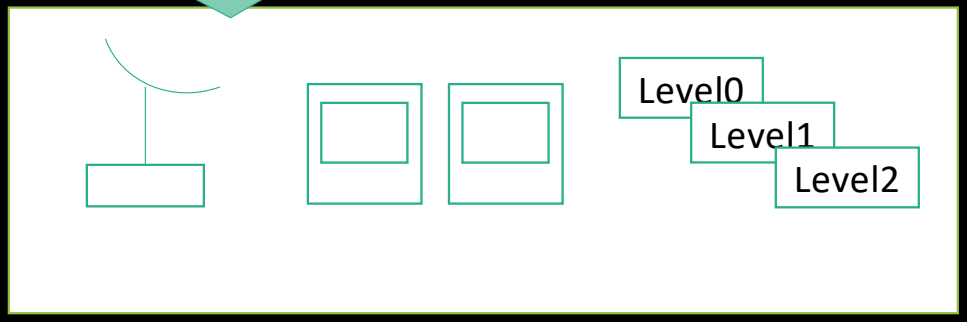


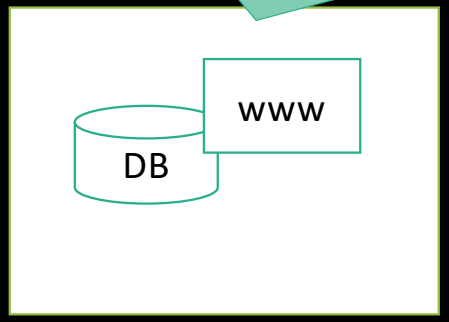
Embedded System
OS: None, Real-time OS
Know.: Hardware/Satellite
Lang.: Assembler/C

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

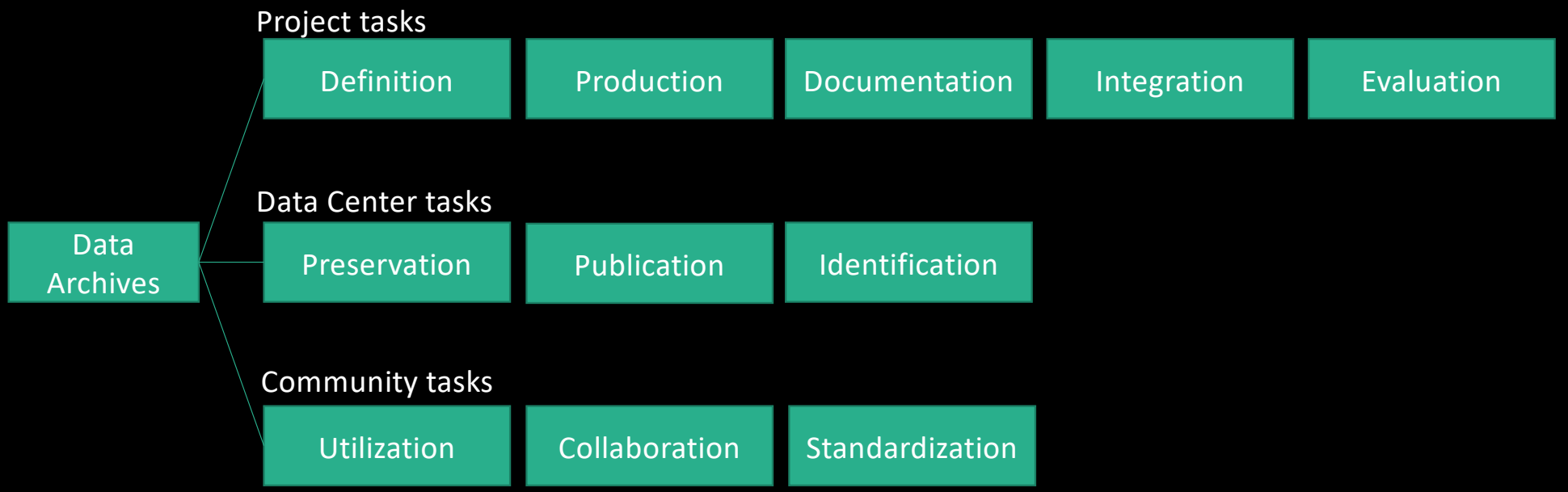
Ground System





Publication System

Mature form of Data Archiving



Standards in space

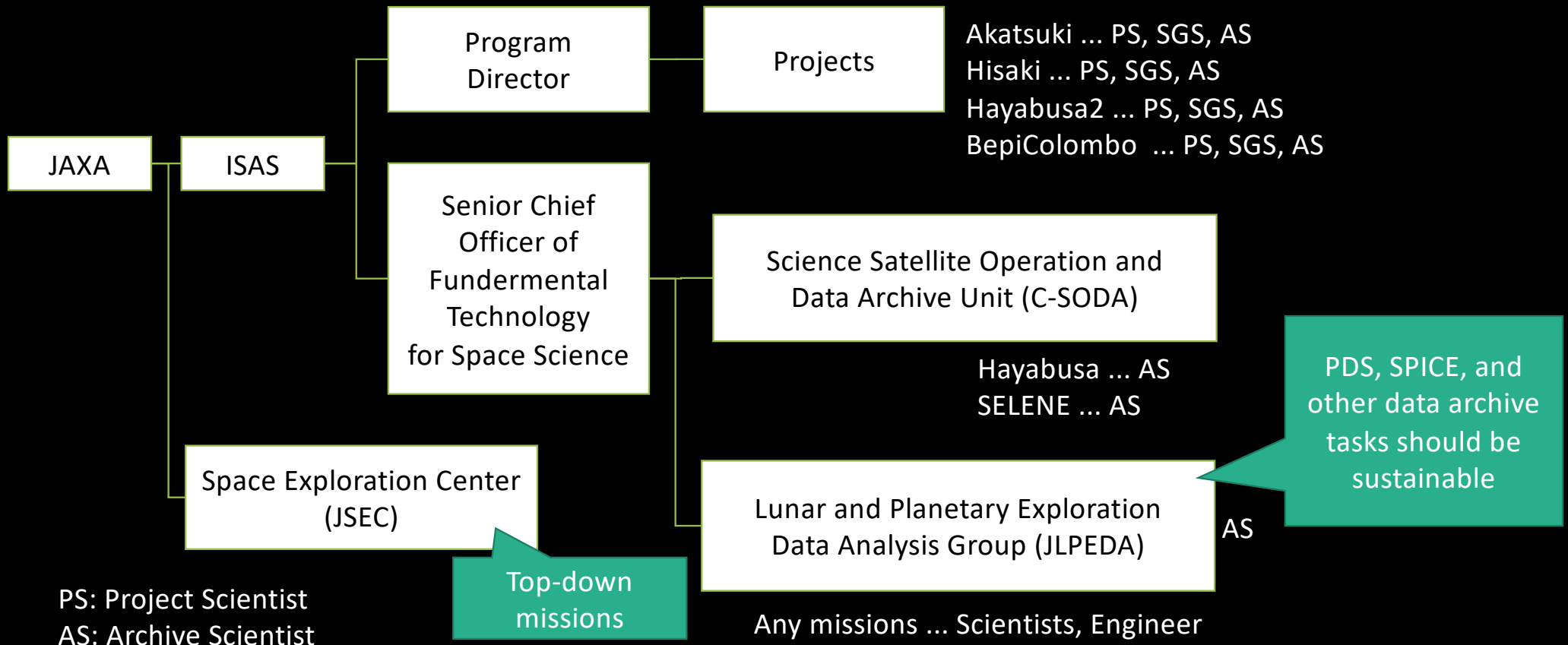
Spacecraft design and operations

- 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

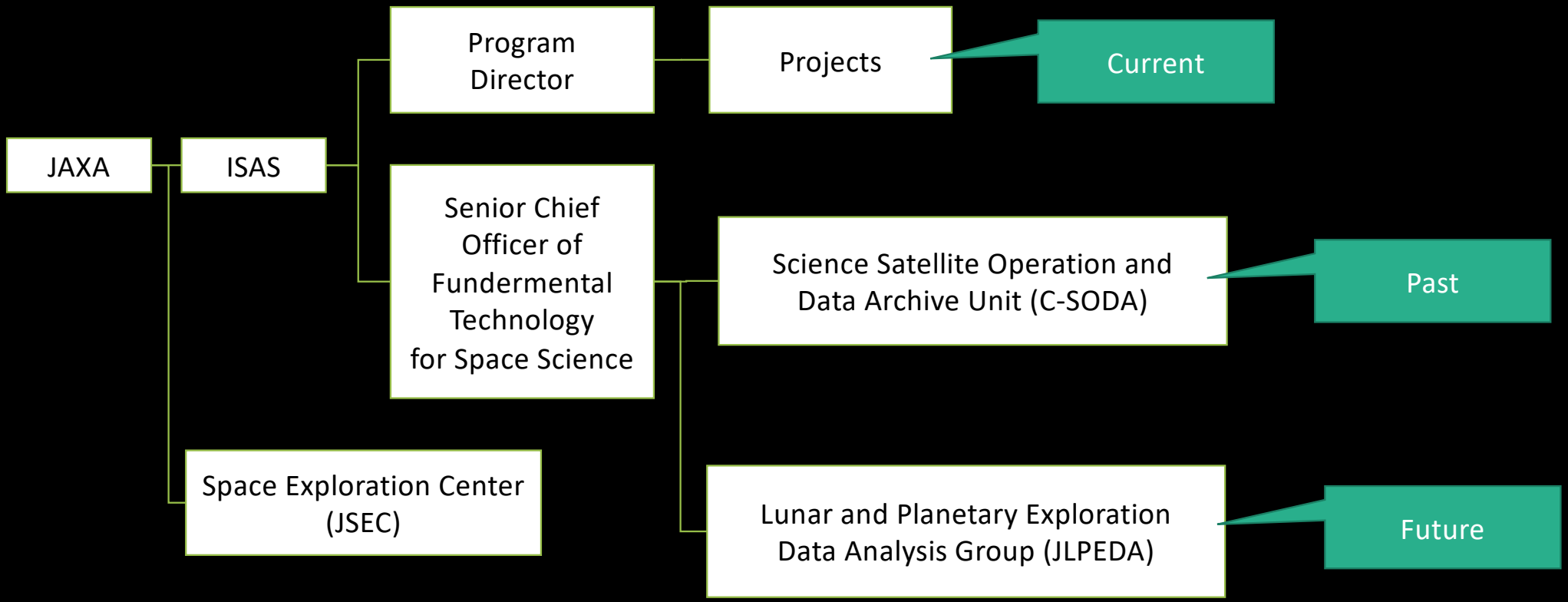
- PDS
  - Planetary Data System
  - Found: 1990's
  - Provide Scientific data standards with peer-review
  - Quality that withstands scientific analysis
- SPICE
  - Define ancillary data such as time, trajectory, attitude, etc.
  - Provide fundamental data such as planetary ephemeris, axis, etc.
  - 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)



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

Japanese organization for data archives (Time)



Publication of Scientific Data

Planetary Exploration Data is available on the Internet

JAXA/DARTS

NASA/PDS

ESA/PSA

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