# An Operational History for Space Missions: Application to Planck

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12th September 2013


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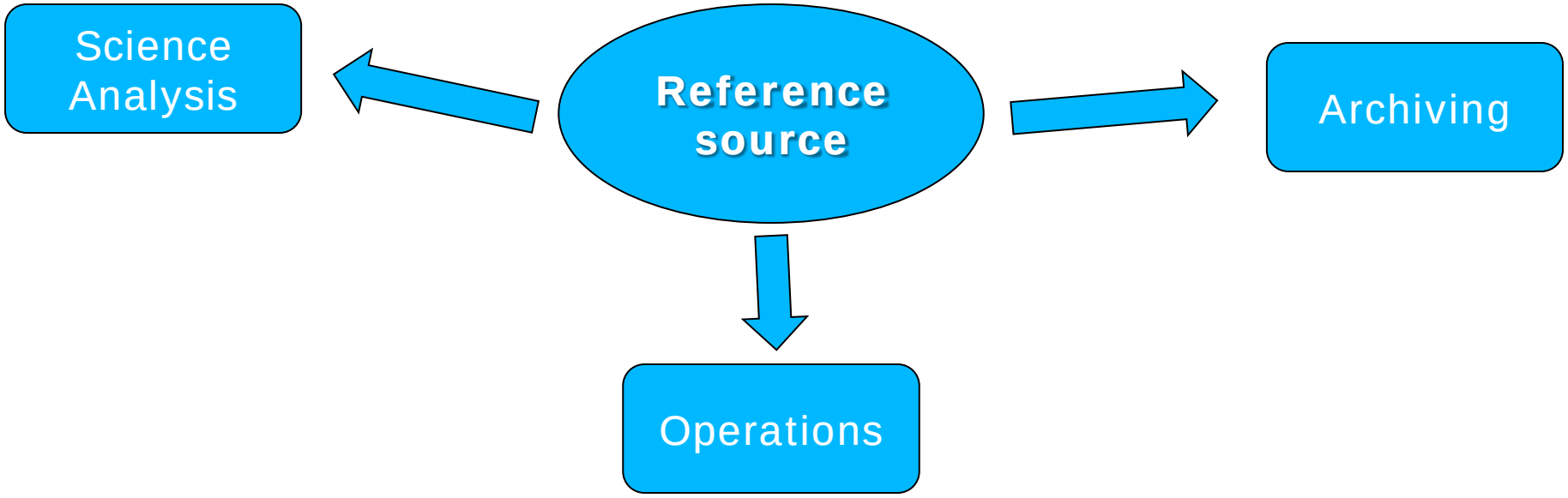
# Outline

- Motivation
- Difficulties of data collection
- Application to Planck
- Distribution
- Potential applications to other missions
- Lessons Learned / Summary

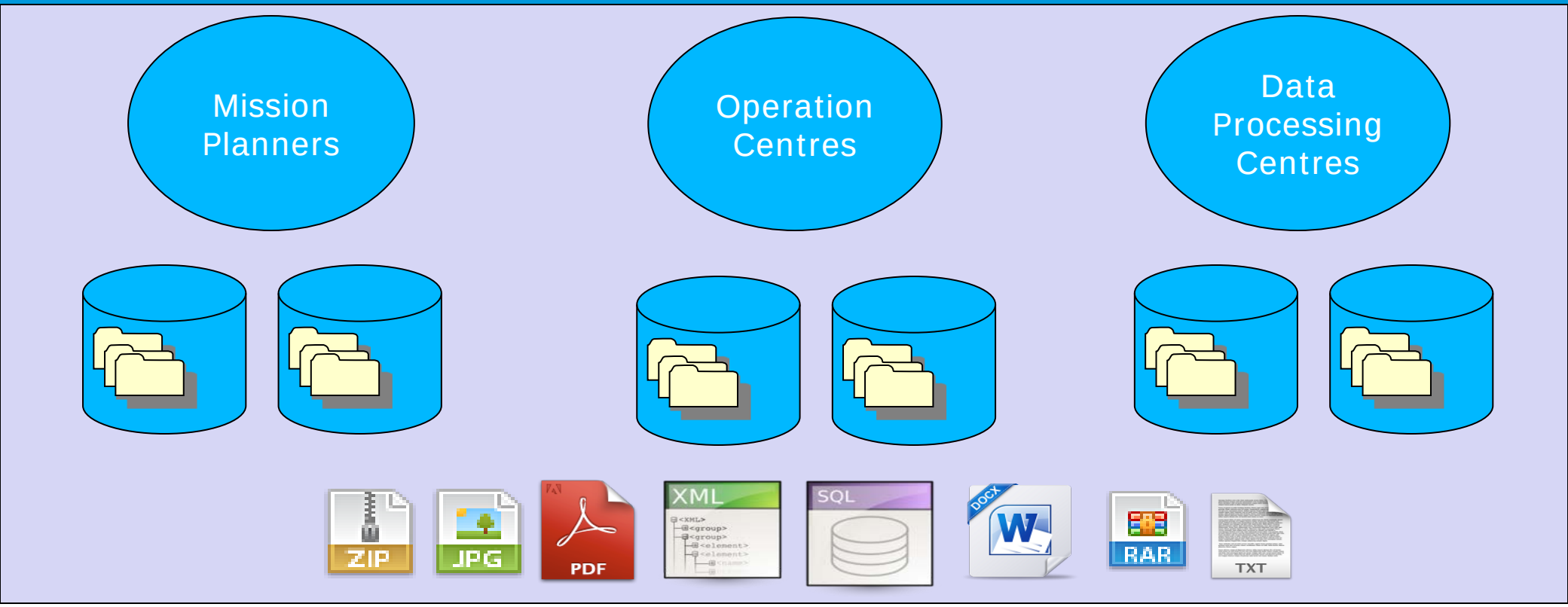
# Operational History Motivation

**From the point of view of meeting the scientific objectives (i.e. survey completion), it is required to be able to categorise the operational state of the satellite at any time...**

*Ref: Planck Science Operations Routine Phase Plan*



# Operational Data Collection




Mission Milestones

Definitions
e.g. Operational Days

Anomalous Events

# Application To Planck: Structure

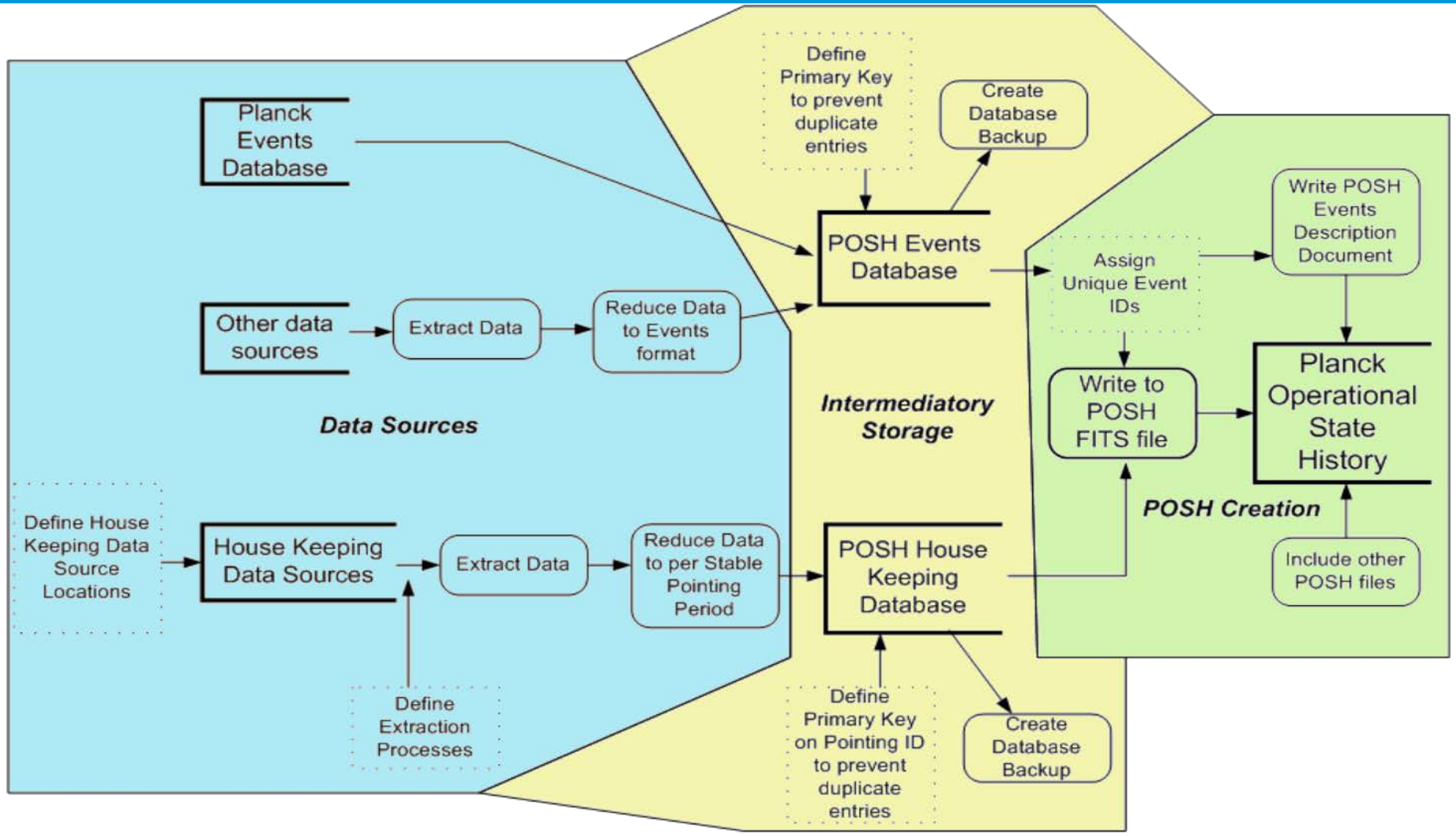
## Events

| *Event_ID* | *Start_Time_UTC* | *Start_Time* | *End_Time_UTC* | *End_Time* | *Title* | *EventType* | *SubType* |
|---|---|---|---|---|---|---|---|
| Unique identification of event | Start of event as a String | Start of event as a number | End of event as a String | End of event as a number | Brief description of event | Number representing event type | Binary number representing the event's subtype |
| 7-digit number iinnnnn | yyyy-mm-dd hh:mm:ss | In seconds since launch of Planck | yyyy-mm-dd hh:mm:ss | In seconds since launch of Planck | | 2-digit number ii | 8-bits 00000010 |

## Instrument & Spacecraft states – House keeping summary

| *PREF* | *Start_Time_UTC* | *Start_Time* | *End_Time_UTC* | *End_Time* | *House_Keeping_Data* |
|---|---|---|---|---|---|
| Pointing reference number | Start of stable pointing as a String | Start of stable pointing as a number | End of stable pointing as a String | End of stable pointing as a number | Columns of house keeping parameters |
| 8-digit number | yyyy-mm-dd hh:mm:ss | In seconds since launch of Planck | yyyy-mm-dd hh:mm:ss | In seconds since launch of Planck | |

# Application To Planck: Pipeline

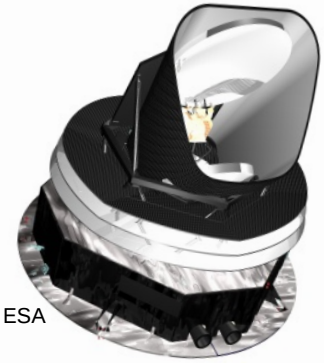


# Application To Planck: Format

- Easily accessible
  - Easy to query
  - Easy to distribute
  - Easy to read

- FITS file format
  - Widely used format within the Astrophysical community
  - Contains multiple tables and metadata in one file
  - FITS Standard ensures universal readability
  - Free software available to read it
- PDF
  - Containing detailed event descriptions
  - Preserves text formatting
  - Allows internal links

# Potential Application To Other Missions: Survey Missions



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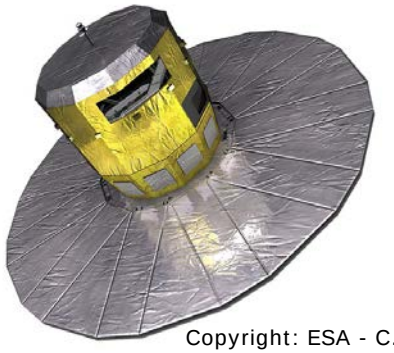
**Planck**



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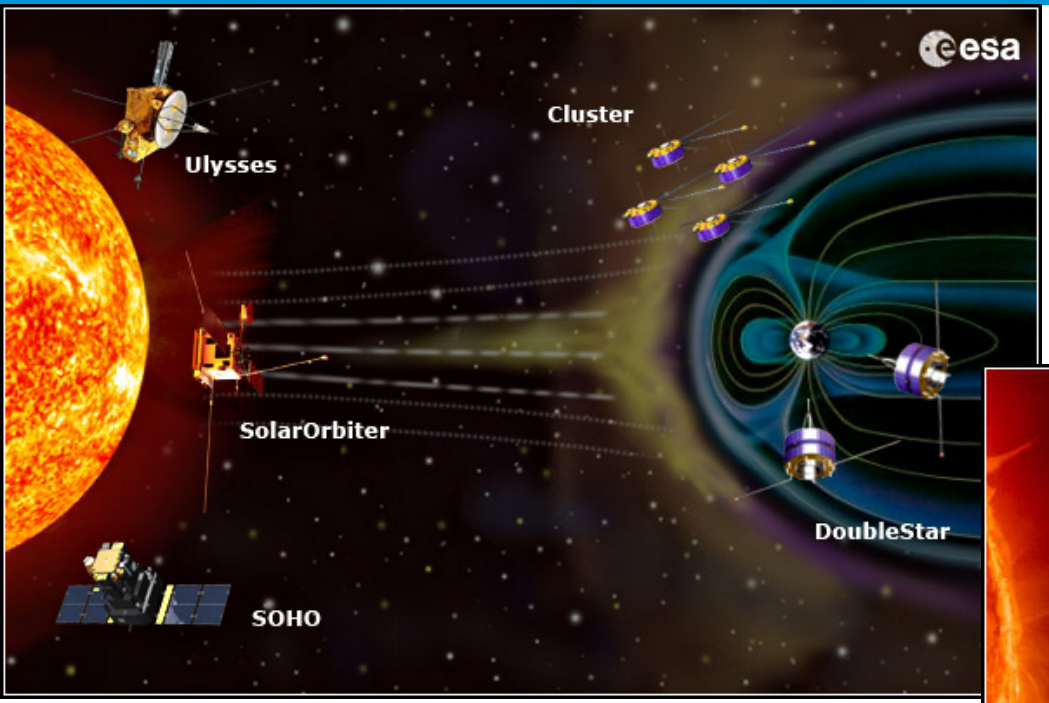
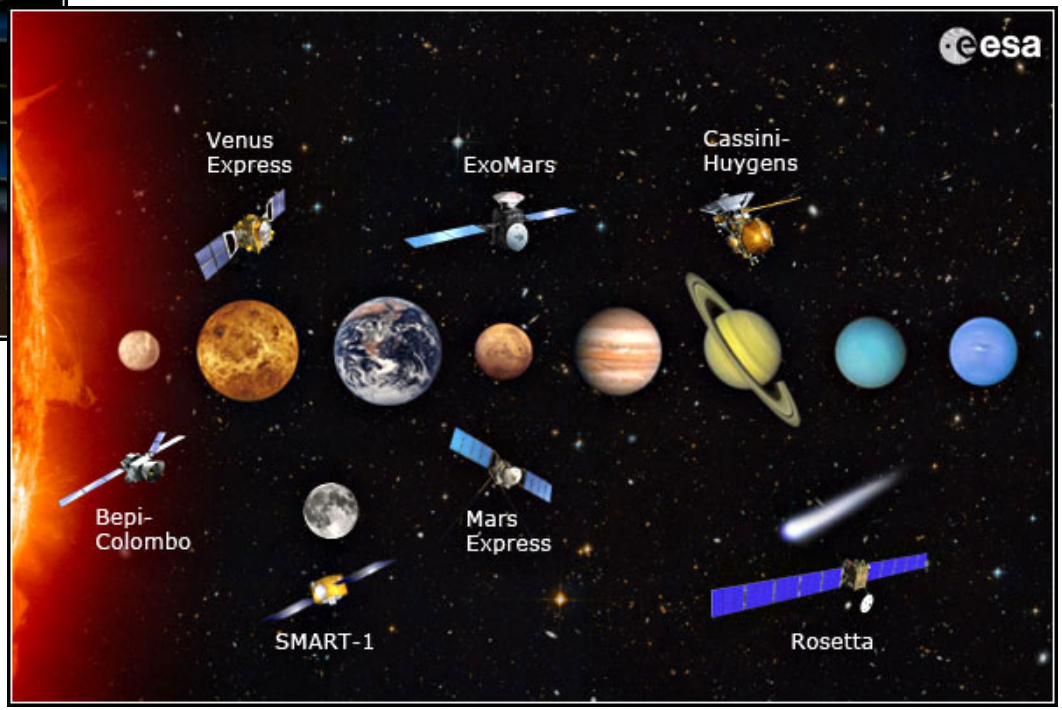
**GAIA**

- Scanning / Continuous data acquirement

# Potential Application To Other Missions: Planetary / Orbital Missions

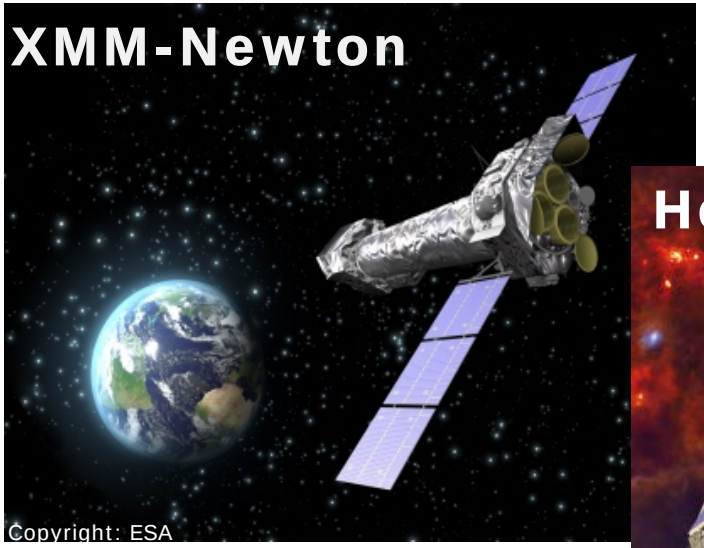


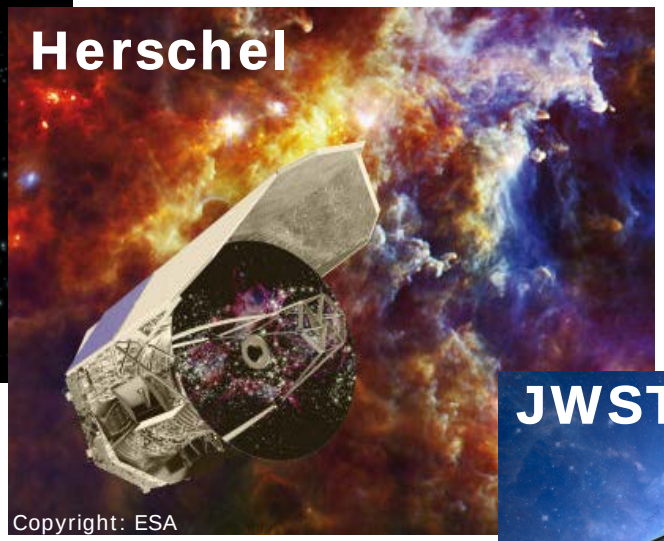

- Multiple instruments
- Different experiment types

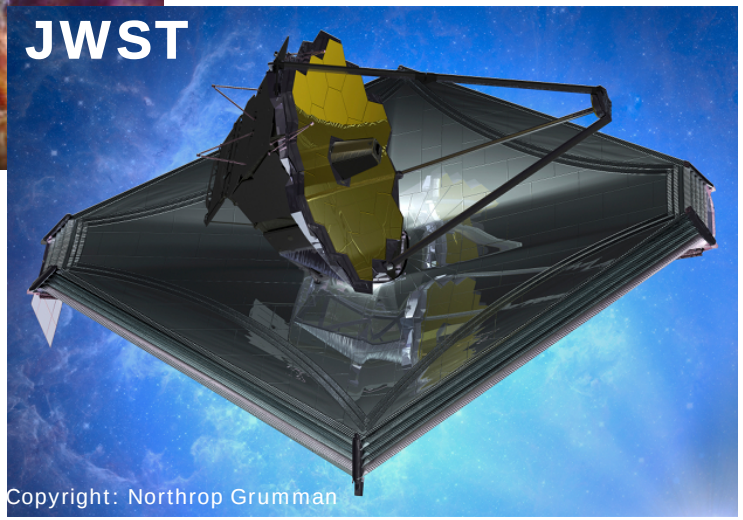



- Help to correlate events and status between instrument teams

# Potential Application To Other Missions: Observation Missions



# Lessons Learned / Summary

- Plan early – before operations begin
  - Can reduce development and maintenance costs
  - Can be included in operational pipelines
  - Allows operational history to be used to full potential
  - Could be useful during planning stages of a mission

- Planck Operational State History publicly released March 2013

Planck Legacy Archive (PLA) – http://archives.esac.esa.int/pla

# Events

| | |
|---|---|
| Anomalous Data Acquisition Status | LFI Not Routine Operations |
| Calibration Sources | Mission Events |
| Cryo Chain Anomaly | OD Boundaries |
| Deviations to Nominal Scanning Law | Orbit Maintenance Manoeuvres |
| DTCP Period | Other Events |
| Environmental | RF Periods |
| HFI Instrument Anomaly | Satellite Special Activities |
| HFI Not Routine Operations | SCS Operations |
| Instrument Special Activities | Slew Events |
| LFI Instrument Anomaly | SVM Anomaly |

# House Keeping Parameters

| Parameter (from AHFs/Orbit file) | Units |
|---|---|
| Stable Pointing Reference | |
| Start time of stable pointing | UTC |
| Number of seconds since Planck launch | Seconds |
| End time of stable pointing | UTC |
| Number of seconds since Planck launch | Seconds |
| Duration of stable pointing | Seconds |
| Executed Longitude at start of stable pointing from 0 to 360 degrees | Degrees |
| Executed Latitude at start of stable pointing from -90 to 90 degrees | Degrees |
| Longitudinal error at start of stable pointing | Degrees |
| Latitudinal error at start of stable pointing | Degrees |
| Average drift rate over a stable pointing | Arcsec/Hour |
| Distance from Sun at start of stable pointing | Kilometres |
| X-Coord of Planck in Earth-Moon barycentric co-rotating frame | Kilometres |
| Y-Coord of Planck in Earth-Moon barycentric co-rotating frame | Kilometres |
| Z-Coord of Planck in Earth-Moon barycentric co-rotating frame | Kilometres |
| Maximum anti-Sun angle over stable pointing from 0 to 180 degrees | Degrees |
| Maximum anti-Earth angle over stable pointing from 0 to 180 degrees | Degrees |
| Maximum anti-Moon angle over stable pointing from 0 to 180 degrees | Degrees |
| Maximum Principal Axis Tilt 1 from -100 to 100 arcmin | Arcmin |
| Maximum Principal Axis Tilt 2 from -100 to 100 arcmin | Arcmin |
| Maximum nutation angle over stable pointing from 0 to 1000 arcmin | Arcmin |
| Maximum spin rate over stable pointing | Degrees/Second |

| Parameter (from MUST/SREM calibrated data) | Units |
|---|---|
| 0.1K Bolometer Plate Temperature: HD271280 | Kelvin |
| 1.6K Thermometer: HD497280 | Kelvin |
| 4K Box: HD494280 | Kelvin |
| 4K Shield Horn Entry Plate: HD281280 | Kelvin |
| 30&44GHz reference load temperature: HD282280 | Kelvin |
| 50K V-Groove Final pre-cooling stage: SM022540 | Kelvin |
| Flight Model 1 Focal Plane - Cold Plate Far Left: LM205332 | Kelvin |
| Flight Model 1 Focal Plane - Cone Right Part Left: LM302332 | Kelvin |
| Flight Model 2 Focal Plane - Cone Left Part Left: LM206332 | Kelvin |
| Flight Model 2 Focal Plane - Right Bottom: LM301332 | Kelvin |
| HFI JFET Box: HD497280 | Kelvin |
| Primary Reflector: DM119187 | Kelvin |
| Secondary Reflector: DM122187 | Kelvin |
| HFI Sorption Cooler Subsystem Liquid Vapour Hear eXchanger: SM018540 | Kelvin |
| LFI Sorption Cooler Subsystem Liquid Vapour Hear eXchanger: SM019540 | Kelvin |
| Temperature Stabilisation Assembly: SM020540 | Kelvin |
| Standard Radiation Environment Monitor Proton Detector | Kelvin |
| Standard Radiation Environment Monitor Electron Detector | Kelvin |
| Proton Counter TC1 | MeV |
| Electron Counter TC3 | MeV |