



The THESEUS Ground Segment

Enrico Bozzo University of Geneva Switzerland







For the THESEUS ESA M5 proposal, a sketch of the GS organization has been prepared based on the experience gained in previous running missions and on M3/M4 projects.

A revised and refined GS structure and organization will be achieved at the end of the assessment phase.

The current sketch of the THESEUS ground segment has been **designed to maximize the** science return of the mission and taking into account that:

- GRBs, transient sources, and ToOs are the key ingredients of the mission → QLA concept and data processing strategy
- The position of GRBs and transient sources will be communicated rapidly (<30 s) to the ground. Prompt diffusion of these information to the science community at large are of paramount importance \rightarrow integration of the TBAGS in the THESEUS SGS





Data products

Raw telemetry: science telemetry + (preliminary) auxiliary data. Few Gbit per orbit are expected.

Level 0: binary FITS files for each instrument. On-board calibrations are applied to all instrument data.

Level 1: all corrections (such as aspect correction, time calibration, barycentric corrections) and instrument-specific calibrations (such as detector gains and good-timing information) are applied to level 0 data to obtain cleaned event files.

Level 2: pre-defined science products (NOTE: level 2 products are also used for the QLA).

Level 3: enhanced, higher level, scientific products derived from Level 2 data





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Operational Ground Segment

- Ground Stations: Malindi, Kourou as backup
- Mission Operation Center (MOC):
 - commanding of the spacecraft and instruments
 - ensuring the spacecraft safety and health
 - provision of Flight Dynamics support
 - all communications with the satellite through the ground stations (upload of the platform and payload telecommands, reception of telemetry)
 - $\circ~$ collecting the science data and the transmission to the SOC
 - $\circ~$ providing the raw telemetry, housekeeping and auxiliary data to the SOC
 - Providing the telecommand history and other auxiliary data (including attitude history, time calibrations and barycentric corrections) to the SOC





- Science Operation Center
- Instrument Operation Centers
- Science Data Center
- THESEUS Burst Alert Ground Segment (TBAGS)
- Science Operation Center (SOC):
 - Mission planning and proposals handling (IRT GO program, PS decides on external triggers)
 - Automatically process lower level data (Raw to Level 0 data processing)
 - Science Data Archive (data and software distribution to the users + cloud analysis ESA DataLabs)
 - Observation and performance simulator
 - User Support and mission outreach (in collaboration with SDC and IOCs)





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- Science Operation Center
- Instrument Operation Centers
- Science Data Center
- THESEUS Burst Alert Ground Segment (TBAGS)
- Instrument Operations Centers (IOCs, one per instrument):
 - through national funding
 - deep expertise of the payload
 - support to ESA for payload system integration on the spacecraft, maintenance, operations and calibration
 - characterize and calibrate the instrument responses (provide calibration data)
 - monitor the science performance of the instruments, long-term trend analysis of instrument performance
 - maintain the on-board software (OBSW)
 - maintain the on-board database
 - o raise anomaly reports
 - support the investigations of anomalies





- Science Operation Center
- Instrument Operation Centers
- Science Data Center
- THESEUS Burst Alert Ground Segment (TBAGS)
- Science Data Center (SDC):
 - established through national funding and built as a consortium of institute with a leading agency
 - providing interactive and pipeline data analysis software, Quick-Look Analysis (QLA) software, pre-processing software
 - perform pipeline processing of higher level data (Level 0 to 3)
 - o lead the data processing software maintenance task
 - o perform sky monitoring and provide the publicly available results to the community
 - \circ $\,$ support the IOC in the instrument calibration activities
 - User support related to analysis software, data processing and quality
 - o workshops for training in data analysis and software usage
 - o contributes to the testing and validation of the overall SGS operational system





- Science Operation Center
- Instrument Operation Centers
- Science Data Center
- THESEUS Burst alert Ground Segment (TBAGS): LAC+VHF stations
- TBAGS:
 - Subset ~40 VHF SVOM ground stations concentrated around the equator
 - THESEUS Alert Center (TAC): personnel monitoring the on-board generated alerts and support/feedback to the community.





The VHF system of ground antennas



The VHF network foreseen for SVOM.





An example of the old HETE 2 VHF equipment: antenna + workstation.





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Data latency (details well explained in SciRD appendix)

| THS-LAT-R-015 | Science data latency (Level 0 Data Products) | | | | | |
|---------------|--|----------------|-----------------|-------|---------------|--|
| Definition | The THESEUS ground segment shall make available Level 0 Data Products, including | | | | | |
| | Flight Dynamics information, for off-line analysis within 2 working days from the end of | | | | | |
| | the time interval when the data were obtained for 75% of the time. | | | | | |
| Synopsis | Value | Units | Condition | Owner | Parent | |
| | | | | | Requirements | |
| | 2 | (working) days | 75% of the time | ESA | THS-SCI-R-101 | |
| | | | | | THS-SCI-R-103 | |
| | | | | | THS-SCI-R-110 | |

| THS-LAT-R-020 | Instrument data latency (normal operation phase in case of contingencies) | | | | | | |
|---------------|---|---------------|-----------------|-------|---------------|--|--|
| Definition | The THESEUS ground segment shall make available instrument data (auxiliary and | | | | | | |
| | housekeeping data) to the instrument teams for off-line analysis within 1 working day | | | | | | |
| | from the end of the time interval when the data were obtained for 95% of the time during | | | | | | |
| | the normal operational phase in case of contingency (according to the definition given in | | | | | | |
| | [AD3]) | | | | | | |
| Synopsis | Value | Units | Condition | Owner | Parent | | |
| | | | | | Requirements | | |
| | 1 | (working) day | 95% of the time | ESA | THS-SCI-R-101 | | |
| | | | | | THS-SCI-R-103 | | |
| | | | | | THS-SCI-R-110 | | |





Data products

| THS-DPR-R-005 | THESEUS data products | | | | | | |
|---------------|---|-------|--------------------------|-------|--------------------------------|--|--|
| Definition | THESEUS mission shall be able to produce the following data products: X-rays/γ-rays event lists, histograms of X/gamma events (images, light curves, and spectra) over reconfigurable bin boundaries; IR images, IR low-resolution spectra; IR high-resolution spectra | | | | | | |
| Synopsis | Value | Units | Condition | Owner | Parent Requirements | | |
| | Event lists | | 0.3-5 keV energy band | SXI | THS-SCI-R-130 THS-SCI-R-170 | | |
| | Event lists | | >50 keV energy band | XGIS | THS-SCI-R-200 THS-SCI-R-240 | | |
| | Event lists integrated in 32 second histograms on a pixel-by-pixel | | 3-30 keV energy band | | | | |
| | Images | | H, J, Z, Y bands | IRT | | | |
| | Low-resolution spectra | | | | | | |
| | High-resolution | | | IRT | | | |
| | spectra | | | IRT | | | |





IRT GO programme and external triggers

- The IRT will have a GO programme with proposals submitted to SOC and peer review organized to shape the programme.

- A consortium board composed by consortium members and chaired by the Project Scientist (ESA) will screen and select the external triggers ToOs to be implemented, ensuring the core science targets for THESEUS are achieved.





Overview

- Relatively standard ground segment and SGS operations.
- Based on the heritage of previous missions
- Optimized shared of tasks between ESA and the THESEUS Consortium
- Relatively small data rate (for the late 2030 scenario) and manageable data products