Welcome to ESAC

SCIENCE OPERATIONS 2013

"Working Together in Support of Science"
European Space Astronomy Centre: History and Current Activities

- 1978: Villafranca Satellite Tracking Station, VilSpa,
- 1970s, 1980s, 1990s: Support astronomy missions,
- Early 2000s: Expansion to planetary missions,
- 2008: VilSpa renamed ESAC.

- ESAC activities now include:
  - Satellite Communications & Tracking,
  - SMOS Data Processing Ground Segment,  
    (SMOS = Soil Moisture and Ocean Salinity)
  - Space Situational Awareness (SSA),
  - Communication and Education,
  - Centro de Astrobiologia (CAB ESAC) Lab.

- Science Operations Centres for astronomy and planetary missions,
- Science Archives.
SCIENCE OPERATIONS 2013

"Working Together in Support of Science"

Conference Purpose

M. Kessler, ESA
pp. Organisers
Common Challenges in Science Operations

Ground-Based / Space-Based

- Working at the interface of Science, Engineering, Operations & Management
- Lack of focus on Science Operations especially during early project phases
- Heterogeneous repository of concepts, tools, processes and terminology
- Strong institutional competition
Dynamic Common Challenges in Science Operations

Ground-Based / Space-Based

- Larger, more complex and expensive infrastructures & instrumentation
- Growing expectations in terms of optimized deliveries and services
- Wider spectrum of communities to be served
- Increased demand on usability of combined results in science
General Common Interest in Science Operations

Ground-Based / Space-Based

- Increased awareness for science operations as key to enabling science
- Improvements by transferring experience and harmonization
- A vision for the future

Science Operations 2013, ESAC Madrid, Sept. 10-13
Objectives for a Joint Look at Science Operations

The objective of SCIOPS 2013 is to present and discuss the various approaches to science operations in spacecraft missions and ground-based facilities for Astronomy and Solar System Science by:

- Comparing and improving our processes and approaches
- Fostering innovations
- Enabling a more efficient use of our resources
- Establishing and intensifying collaborations
SCIENCE OPERATIONS 2013

"Working Together in Support of Science"

The Space Perspective

M. Kessler, ESA
ESA’s Science Operations

Currently involved in ~25 missions
  - assessment to long-term archiving
Most people located at ESAC (~200),
  - also at ESTEC, STScI and GSFC
  - mix of scientists and engineers.
<table>
<thead>
<tr>
<th>Year</th>
<th>Mission Name</th>
</tr>
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<tbody>
<tr>
<td>1990</td>
<td>Hubble Space Telescope (ESA SciOps at STScI)</td>
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<td>1999</td>
<td>XMM-Newton</td>
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<td>2002</td>
<td>INTEGRAL</td>
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<td>2009</td>
<td>Herschel Space Observatory</td>
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<td>2009</td>
<td>Planck</td>
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<td>2013</td>
<td>Gaia</td>
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<td>2015</td>
<td>LISA Pathfinder</td>
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<td>2018</td>
<td>James Webb Space Telescope (ESA SciOps at STScI)</td>
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<tr>
<td>2020</td>
<td>Euclid</td>
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</tbody>
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New missions under study: EChO, LOFT, Plato, STE-QUEST
<table>
<thead>
<tr>
<th>Year</th>
<th>Mission Description</th>
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<tbody>
<tr>
<td>1995</td>
<td>Solar and Heliospheric Observatory (SOHO)</td>
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<tr>
<td>2000</td>
<td>Cluster</td>
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<td>2003</td>
<td>Mars Express</td>
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<td>2004</td>
<td>Rosetta</td>
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<td>2005</td>
<td>Venus Express</td>
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<td>2006</td>
<td>Hinode (Japanese-led Solar observatory)</td>
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<td>2009</td>
<td>PROBA-2</td>
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<td>2015</td>
<td>BepiColombo</td>
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<tr>
<td>2017</td>
<td>Solar Orbiter</td>
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<td>2022</td>
<td>JUICE</td>
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New missions under study: Marco-Polo R
ESA’s Science Operations

- Currently involved in ~25 missions
  - assessment to long-term archiving
- Most people located at ESAC (~200),
  - also at ESTEC, STScI and GSFC
  - mix of scientists and engineers.

- Provides some/all of following elements:
  - **Interfaces to users:**
    - calls for proposals, information, workshops, training, helpdesk,…
  - **Payload operations:**
    - scientific scheduling and optimisation, payload monitoring, quick-look data analysis, …
  - **Payload data acquisition, processing, distribution, and archiving:**
    - payload calibration and cross-calibration, data processing (interactive tools and pipelines), archive development, population and maintenance,…
Science Operations Development Elements (a modular approach)

**Mission Science Data and Products**

**Mission Management after in-orbit-commissioning**

**Science Operations Visibility, Reporting & Knowledge Management**

**Coordination with Science Communities for Operations & User (Science) Support**

- **Science Operations Systems Studies, Design & Requirements**
  - Translation of mission and science scenarios into requirements. Identification of most efficient system architecture and processes.

- **Science Operations Planning**
  - Generation of conflict-free and optimised science instrument operations plan, timelines and command sequences in close cooperation with instrument teams.

- **Science Instrument Handling**
  - Preparation, calibration and operations of science instruments and/or support to these activities.

- **Science Data Processing**
  - Provision of automatic and/or interactive data processing capabilities and generation of science products incl. quick look analysis products.

- **Science Data Archiving**
  - Provision of mission data archive with interfaces, services and tools for optimised science generation, science operations and long-term preservation.
ESA’s Approach to Science Operations

- Top-level requirements per mission defined in ‘Science Management Plans’, approved by Member States at Science Programme Committee (SPC)
- We carry knowledge, experience and expertise from project to project
- Act as interface between “industrial/agency” and “university” cultures
- ESA-provided elements usually “embedded” in a larger cooperation with multiple Member State entities on Science Ground Segment.

**ESA’s Science Operations Centre** together with Member State Partners (Instrument Centres, Processing Centres, etc.) form a Science Ground Segment (SGS).
Task distribution between ESA and Member States is mission specific

Member States usually contribute bulk of resources

ESA provides overall coordination (rather than direct management)

ESA has overall responsibility for scientific outputs of the mission
Herschel Science Ground Segment

Distributed system.

200 active developers worldwide (mostly Europe, USA, Canada, China)

~4 million lines Java code

~15-20 year lifetime

Science Operations 2013, ESAC Madrid, Sept. 10-13

Working Together in Support of Science
Euclid Science Ground Segment

ESA responsibilities:
- SGS overall design
- Interface to mission operations
- Payload operations coordination
- Archive and community support

National contributions:
- Science data production
- Pipeline/Infrastructure development
- Data processing facilities
- Management (IT) and engineering support (FR)

Science Ground Segment Manpower Distribution
The European Space Astronomy Centre (ESAC) hosts most of ESA astronomy and planetary missions’ archives. This currently includes:

- Herschel Science Archive → Herschel Mission
- XMM-Newton Science Archive → XMM-Newton Mission
- ESA Hubble Science Archive → HST Mission
- Planck Legacy Archive → Planck Mission
- ISO Data Archive → ISO Mission
- ESA’s Planetary Science Archive → (regrouping data from Rosetta, Mars Express, Venus Express, Huygens, Smart-1 and Giotto for the time being)
- SOHO Science Archive → SOHO Mission
- Ulysses Final Archive → Ulysses Mission
- INTEGRAL Science Data Archive → INTEGRAL Mission
- EXOSAT Science Archive → EXOSAT Mission

In the future, Cluster, Gaia, BepiColombo, Solar Orbiter and Euclid will also have their archives located at ESAC.

Within the Science Operations Department of ESA’s Directorate of Science and Robotic Exploration, all these archives are designed, developed, maintained and operated by the Science Archives Team at ESAC, using common, modular and flexible 3-tier architecture, where the data storage is clearly separated from the data presentation. This ensures automatic operations as well as long-term maintainability and evolution. Through easy-to-use graphical user interfaces or through powerful machine and Virtual Observatory interfaces, they provide instant access to ESA scientific mission data for the science operations centres at ESAC and to the scientific community worldwide.
ESAC Archives Long-Term Plan

- Large set of science archives co-located at ESAC are a major research asset for community
- Need to be kept readily available for future users and novel uses

Thus, must plan now for next 5–20+ years

Planning based around 3 major goals:
- Enable maximum scientific exploitation of data sets
- Enable efficient long-term preservation of data, software and knowledge, using modern technology
- Enable cost-effective archive production by integration in, and across, projects
Enable maximum scientific exploitation of data sets

- A key objective is to provide the scientific community with the best possible means to exploit the results obtained from ESA’s scientific missions.

- We plan to:
  - Develop a powerful multi-mission, multi-instrument, multi-wavelength archive interface to enable the scientific exploitation of the results in the ESAC archives by expert and novice users alike.
  - Ensure that our archives are fully-interoperable with those of our partners (including any ground-based facilities) by adopting or developing the necessary, protocols, products and tools to facilitate the broadest possible exploitation of ESA scientific data.
  - Provide high-quality user science support (“helpdesk”) services by pooling internal and external science experts.
  - Stimulate scientific utilisation of the ESAC archives, together with European partners, to ensure the maximum benefit from added value services.
Efficient long-term preservation of data, software and knowledge

- Key objective to ensure the long term preservation and accessibility of the ESA mission science “Legacy”.

- Contributing to build up of European Legacy of Space Science Data by preserving all mission data (uplink, raw, processed and associated metadata), together with associated software and knowledge and up to date archive access services to enable continued exploitation of ESA science data in the long term.

- Implement European partnerships for Long Term Preservation (data, software and knowledge, Archive Technology development).

- Contribute to VO evolution with other Data Centres, PI teams and Community.

- Ensure archive technology awareness and motivation for technology migration every 5-7 years to ensure efficient ESA science archives services.
Cost effective archive production by integration with projects

- **Archive integration into Science Operations projects:**
  - Archive as a project component which provides crucial feedback into other science operations components of the project
  - Archive can incorporate the full operational context of a project
  - Allows archive development without duplications and avoids deficiencies due to late implementation

- **Archive horizontal integration into ESAC Archives:**
  - Exploitation of economy of scale as part of ESAC Archives’ operations
  - Convenient access to multi-mission ESAC Archive contents
  - Archive harmonisation across projects e.g. through common approach to metadata
PROBA-2: June 2012 Transit of Venus
Views from Mars Express
Herschel and Other Views of the Eagle Nebula (M16)

- Far Infrared
- Visible
- Far Infrared & X-rays
- Near Infrared
- X-rays
- Visible & Infrared & X-rays
- Mid-Infrared