Coordinated science observations with Solar Orbiter

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Solar Orbiter: Linking Sun & Heliosphere

How does the Sun create and control the Heliosphere – and why does solar activity change with time?

- What drives the solar wind and where does the coronal magnetic field originate?
- How do solar transients drive heliospheric variability?
- How do solar eruptions produce energetic particle radiation that fills the heliosphere?
- How does the solar dynamo work and drive connections between the Sun and the heliosphere?

First M-class mission of ESA’s Cosmic Vision 2015-2025 (collaboration NASA)
Solar Orbiter: The mission

Mission Profile (10 years long)
Launch scheduled for Feb 2019

- Elliptical orbits between 0.28 and 1 AU
- Inclination out-of-ecliptic up to >30°
- 4 in-situ & 6 remote-sensing instruments
  - Sun in UV, X-rays, polarized WL, spectra...
  - Plasma particles, fields & waves
Solar Orbiter: A different solar mission

PREVIOUS MISSIONS

- Focus on in-situ **plasma** OR remote-sensing **solar** data
- **Stable** viewpoint or distance
- Quasi-**continuous** observations
- **Flexible** commanding
- **Quick data** availability to whole community
Solar Orbiter: A different solar mission

- Combines 2 worlds: in-situ + remote-sensing observations
Solar Orbiter: A different solar mission

**SOLAR ORBITER**

- Combines 2 worlds: *in-situ* + *remote-sensing* observations
- **Variable** viewpoint, distance from Sun and from Earth: data **latency** up to 6m

*Constrained & variable downlink*
Solar Orbiter: A different solar mission

Solar Orbiter

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Solar Orbiter: A different solar mission

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- **Offline Commanding**: limited opportunity to respond to changing Sun + shared pointing!
Solar Orbiter: A different solar mission

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Most scientific objectives need coordinated observations with whole payload, at specific + coordination with ground (DKIST, ...)

WE NEED A COORDINATED PLAN!
Science Ground Segment

- Instrument Operations Requests
- Science data Processing

Science Planning Coordination
- Pointing Requests
- Low-Latency science data visualisation
- Auxiliary data processing
- Data Archive
Solar Orbiter’s Science Activity Plan

- Strategic plan covering the science we are going to do and when over the whole mission (Science Working Team + SOC).
- How?

  Detailed science objectives
  Group objectives that require similar, coordinated observations

  Set of SolO Observing Plans (SOOPs)
  Find best opportunities for each SOOP in typical trajectories.

  SOOP scheduling strategy
  Schedule all SOOPs in given trajectory

Science Activity Plan for particular trajectory
Solar Orbiter’s Science Activity Plan

- Solar Orbiter’s SAP lives on the online Wiki pages, so that all involved scientists have visibility and can take part in mission planning process

- Orbit Plots
- Instruments: observables, modes and operational constraints
- SAP-related work
  - Solar Orbiter detailed science objectives
  - SOOP pages
    - General Planning strategy for first version SAP v0
    - Planning periods Option E (LTP/MTP)
Solar Orbiter’s Planning Cycles

- Mission-level Planning *(now)* -> **SAP**
  Science Operations Working Group schedules SOOPs in more detail. Covers 6 months.

- Long-Term Planning *(6-12m ahead)*
  Detailed commanding per instrument over 6 months, validated against mission constraints.

- Medium-Term Planning *(1m ahead)*
  Covers 1 week, last call for changes in instrument modes

- Short-Term Planning *(1-2w ahead)*
  
- Very-Short-Term Planning *(2-3 days)*
  - p-VSTP: adjust S/C pointing to solar activity
  - i-VSTP: limited instrument fine-tuning (resource-neutral)

Planning coordination & high-level constraint checking

Instrument commanding & detailed constraint checking

Adapting to the changing Sun
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Adapting to the changing Sun
LTP: Coordinated SOOP scheduling

10 instrument suites with specific limitations
+ variable operations restrictions
+ changing orbits
+ mission goals need payload-wide datasets
= need for coordinated planning of common Observing Campaigns (SOOPs)

Solar Orbiter’s Long Term Planning takes place during an SOWG meeting

We need a visual and interactive planning tool: SOOP Kitchen
Instrumen\nt suites

SOOP Kitchen

6 months
SOOP Kitchen: Multi-user planning tool

Web-based GUI, linked to planning database

Full configuration control

High-Level constraint checking

Exports dataset for full planning simulation & commanding
VSTP: How to react to changing Sun?

All instruments share the same pointing!

FOVs at perihelion
VSTP: How to react to changing Sun?

- Remote-sensing windows: update S/C fine-pointing to track features
  - Fine-pointing can be updated daily, but takes ~3 days to execute!
- Based upon
  - **Low-Latency data**: minimal set of science data, downlinked daily
  - **Modelling** Sun-S/C connection (magnetic field)
Conclusions

• Solar Orbiter is a heliophysics mission which is very different from previous ones.
• Mission science depends on datasets combining data from up to 10 instrument suites (both remote-sensing and in-situ).
• This need + changing opportunities + limited and variable resources ask for a high level of coordination in science planning and resource simulations.
• We prepare new planning tools and perform planning exercises with the instrument teams to get ready for this exciting mission.

www.cosmos.esa.int/web/solar-orbiter/home