SpaceOps-2023

17th International Conference on Space Operations, 6-10 March 2023, Dubai, United Arab Emirates

EVALUATING THE NEW CCSDS MISSION PLANNING AND SCHEDULING STANDARD: HOW TGO AND ENMAP COULD HAVE BENEFITTED FROM AN INTEROPERABILITY STANDARD FOR THE EXCHANGE OF MISSION PLANNING AND SCHEDULING INFORMATION

SpaceOps-2023,#334

Peter van der Plas

ESA ESTEC

09/03/2023

Acknowledgement

CCSDS Mission Planning and Scheduling Working Group

Peter van der Plas (ESA/ESTEC)

Guillermo Buenadicha (ESA/ESAC)

David Frew (ESA/ESAC)

Maria Wörle (DLR)

Christoph Lenzen (DLR)

Marc Duhaze (CNES)

Lea Dubreil (ESA/ESOC)

Vladimir Zelenevskiy (Telespazio Germany)

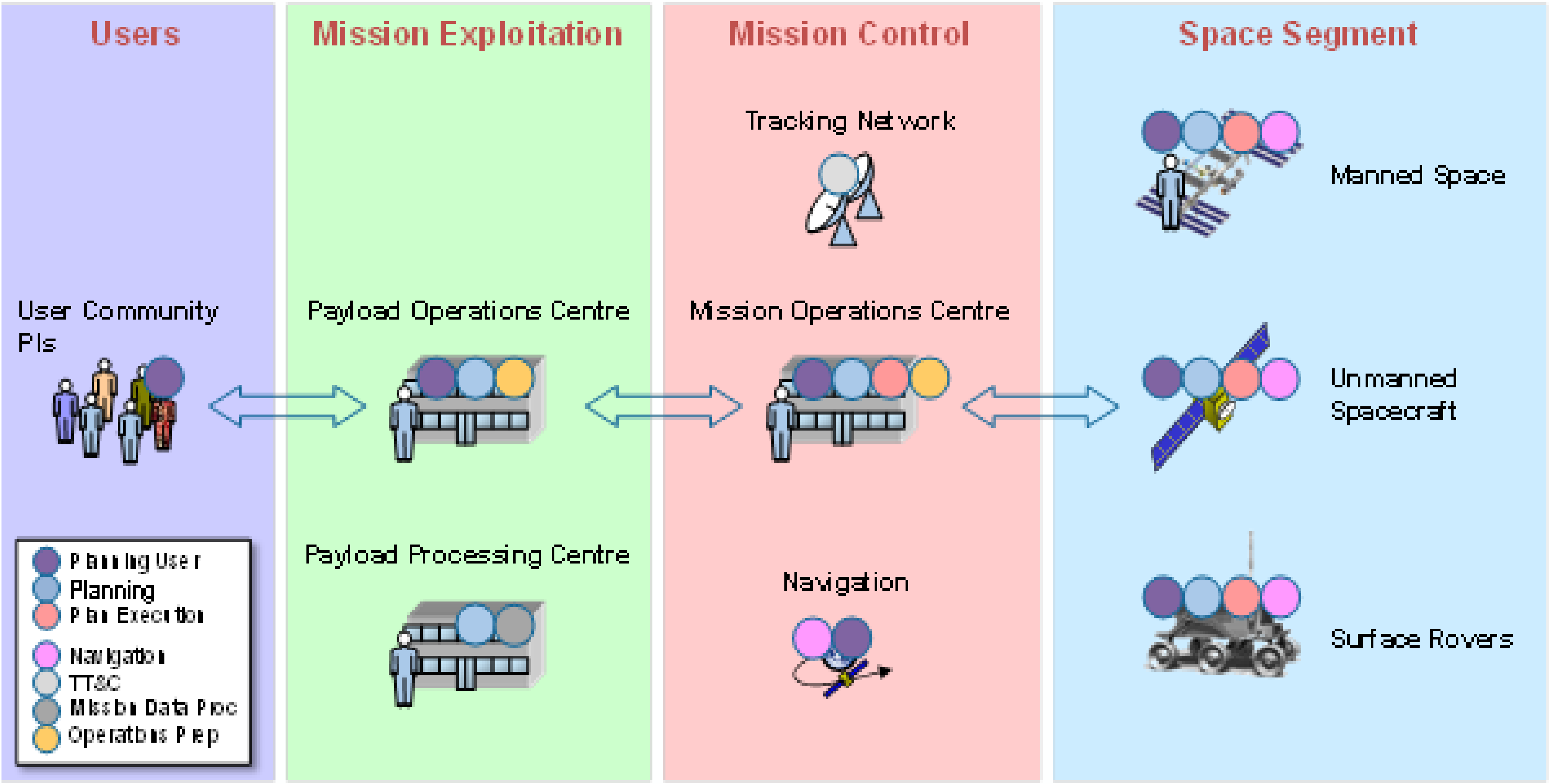
Outline

- Background and objectives
- Overview of the MPS standard
- Evaluation of the draft standard using:
  - ESA's ExoMars TGO mission
  - DLR's EnMAP mission
  - ESA's OPS-SAT mission
- Next steps
- Conclusions

Background

- The Mission Planning and Scheduling (MPS) Working Group
  - Is under the Consultative Committee for Space Data Systems (CCSDS)
  - Is tasked with specifying generic and interoperable mission planning services
  - Its work will result in a CCSDS Recommended Standard (Blue Book)
- Objectives and Use Cases for the MPS standard
  - To support interoperability between space agencies
  - Based on generic planning concepts and representative missions
  - An analysis been published in a CCSDS Informational Report (Green Book)

Mission Planning Entities



Objectives

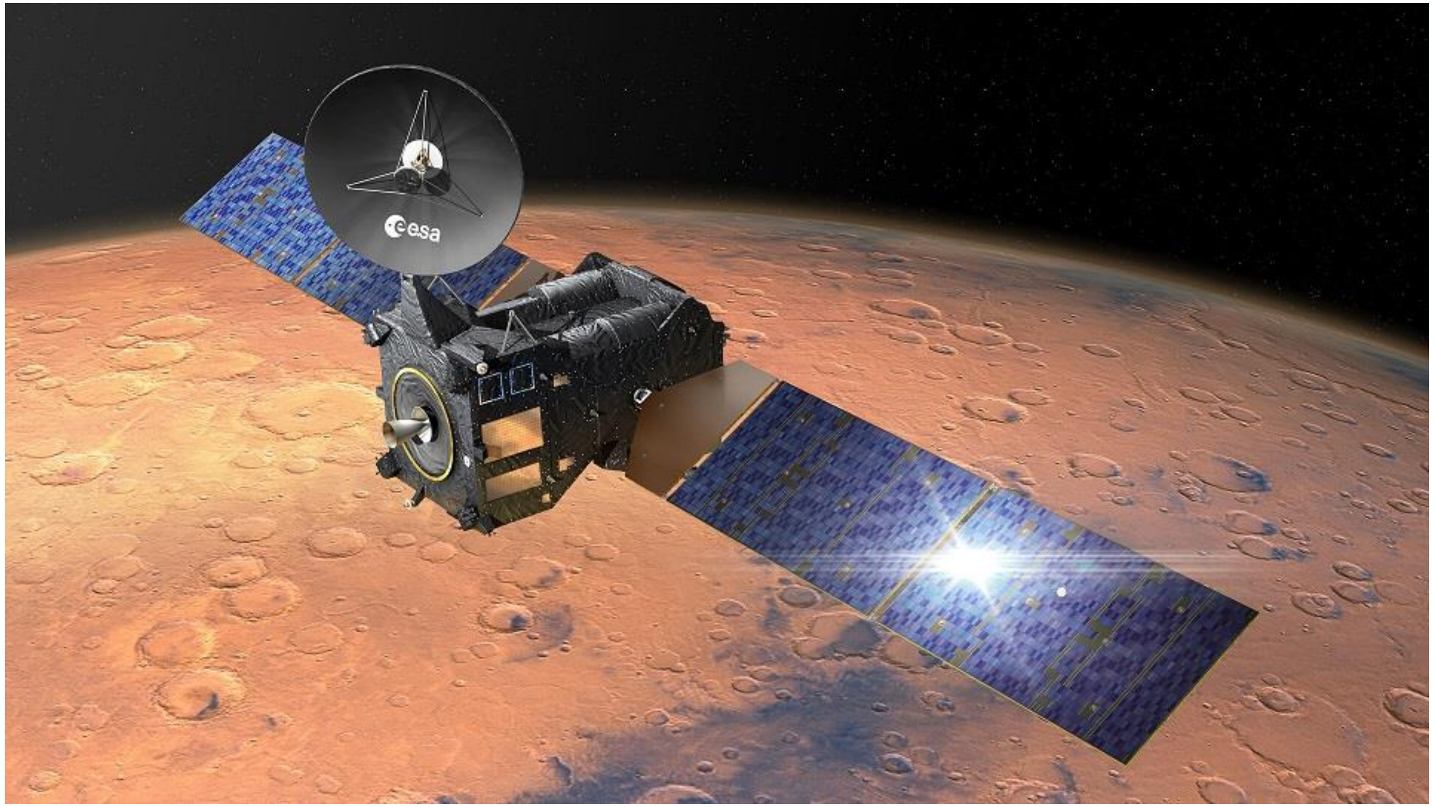
- The objectives of the paper have been to:
  - Evaluate the current draft of the MPS standard
  - Based on missions in operations (TGO, EnMAP, OPS-SAT)
  - Demonstrate its viability in representative space missions
  - Showcase the use of service-oriented architectures
- In anticipation of the publication of the MPS standard

Overview of the MPS standard

- Information Model
  - Planning Requests, Plans
  - Planning Events, Planning Activities, Planning Resources
  - Expressions, Arguments, Constraints, Triggers, Repetitions
- Services Specification
  - Planning Request Service, Plan Distribution Services
  - Plan Execution Control Service, Plan Information Management Service, Plan Edit Service
- File Based Exchange
  - XML Schemas limited to Planning Requests and Plans
- Tailoring of the standard
  - Optional services, optional operations (by means of capability sets), optional data types

ESA’s ExoMars TGO mission

- ExoMars Trace Gas Orbiter (TGO)
  - 400km orbit around Mars
  - Performing scientific observations
  - Providing relay support
- Ground segment
  - Mission Operations Center (MOC) at ESOC Darmstadt
  - Science Operations Center (SOC) at ESAC Madrid
  - Instrument science teams



ESA's ExoMars TGO mission

- Mission planning concepts
  - Repetitive survey with repeating science observations
  - Interleaved with exclusion windows for relay operations
  - Medium Term Planning (MTP) baseline schedule for avoiding conflicts
  - Short Term Planning (STP) detailed schedule for instrument commanding
- Planning system interfaces
  - File-based exchange of information between planning entities
  - Using event files, bitrate files, pointing request files and commanding files

ESA’s ExoMars TGO mission

- Mapping planning interfaces to the MPS standard
  - Relay slots, communication passes and Flight Dynamics events → MPS plan files / planned events
  - Bitrate files → MPS plan files / resource profiles
  - Pointing requests → MPS planning requests / pointing constraints (NAV PRM)
  - Commanding files → MPS plan files / planned activities
- Migration to MPS services could be considered
- Potential benefits and limitations
  - \+ Service-based information exchange will shorten lead times
  - \- The synchronization of planning configuration data is not (yet) supported

DLR’s EnMAP mission

- EnMAP
  - 640km low-Earth orbit, resolution 30m
  - A single hyper-spectral instrument
  - Monitoring Earth “in more than three colors”
- Ground segment
  - Mission Operations Segment (MOS)
    - Mission Planning System (MPS)
    - FOS, FDS, GDS
  - Payload Ground Segment (PGS)
    - Data Information Management System (DIMS)
    - NSG, Instrument Planning, External Data Sources

DLR’s EnMAP mission

- Mission planning concepts
  - Acquisition requests from the user community via DIMS
  - Reactive planning framework from GSOC
  - Considering cloud data, both archived and forecasted
  - Incremental planning, maintaining an up-to-date timeline
- Planning system interfaces
  - Service-based exchange of information between systems

DLR’s EnMAP mission

- Mapping planning interfaces to the MPS standard
  - Acquisition Request (Submit, Cancel, Close)
  - Status Request
  - Acquisition Request Status (Signal)
  - Others: Uplink/Downlink Station Interfaces, Flight Dynamics Events/Orbit, Cloud Data, …
- Potential benefits and limitations
  - \+ Standardized interfaces would be beneficial when having new interface partners
  - = The MPS constraint model is not needed, as the constraints are embedded in the planning system → however, the MPS standard allows for tailoring to the specific mission needs
  - \- CCSDS standards do not (yet) provide the full range of required services, for example: navigation events and orbit data messages are currently only file based

ESA's OPS-SAT mission

- OPS-SAT
  - 3U CubeSat
  - Full set of sensors and actuators
  - Software and firmware experiments
- Ground segment
  - Operated from ESOC Darmstadt
  - Accessible to European industry, institutions and individuals

ESA's OPS-SAT mission

- Mission planning concepts
  - Experiment-centered approach (currently 236 registered experimenters)
  - The operational concept depends on rudimentary FDIR, robustness of the flight model and a reliable and "safe" safe mode
  - The planning process is complex due to the multiplicity of experiments
  - Short planning span (1-4 days) and frequent re-planning is required
- Planning system interfaces
  - File-based planning using the Mission AuTomatIon System (MATIS) tool

ESA's OPS-SAT mission

- Mapping planning interfaces to the MPS standard
  - Only a small subset of the MPS standard would be required
  - OPS-SAT MPSS does not provide service-oriented interfaces
  - The current system is very centered around manual actions by the operator
- Potential benefits and limitations
  - \+ MPS can provide the mission with rich, formalized interfaces for interactions across the system, both manual and automated
  - \+ If the entire planning cycle becomes MPS-compatible, it could easily integrate not only the core operations planning, but also payload application planning
  - = The system design would require a very in-depth study of the book to derive a sensible application, here OPS-SAT-2 could potentially become a good validation environment

Next steps

- Currently the MPS standard is ready for CCSDS “Agencies Review”
  - Feedback from the evaluations have already been incorporated
- Possible validation using additional missions (from other Agencies)
  - A detailed validation of the File Formats and Information Model should be considered
- The prototyping of the standard by ESA and DLR is progressing well
- The publication of the MPS standard (Blue Book) is expected by end-2023
- After publication, a pilot implementation in an actual mission (existing or new) would be essential in promoting the wider adoption of the standard

Conclusions

- There is a clear benefit of a service-oriented standard over a file-based approach
  - Allowing for automation and a shortening of the planning cycles
- Using a set of standardized services will in particular benefit missions with multiple independent or distributed entities in the ground segment
- The current MPS services and related information model is quite extensive
  - However, many parts of the standard are optional
- A current shortcoming of the CCSDS architecture is that beyond the use of the MPS standard, other interfaces are not (yet) based on services
- The MPS standard does not provide (yet) a means to disseminate the mission planning configuration data in an automated manner

Contact

End of the presentation…

Contact: Peter.van.der.Plas@esa.int