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WSO-UV: the challenge of the Russia-Spain shared operations

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Abstract

The ground segment of the WSO-UV mission is under developement by Russia and Spain. Both countries will have a complete ground segment and a ground station for the mission and will share the responsability of the spacecraft and scientific operations. This paper presents the ground segment architecture and the main aspects of the operational organisation.

1 Introduction

The World Space Observatory – Ultraviolet (WSO-UV) is an international space observatory for observation in UV spectral range (100–350 nm). The WSO-UV Ground Segment (GS) is under development by Spain and Russia and both countries will coordinate the mission and scientific operations and will provide the satellite tracking stations for the project. Aiming to maximize the scientific return along such a long lifetime, the ground segment architecture is to be based in a modular approach, relying in a common framework able to run together different subsystems developed from different agencies and institutes, which may be fully upgraded and even replaced along the years. More information about the WSO-UV mission and its scientific goals are presented in [1].

The WSO-UV GS is comprised of all the infrastructure and facilities involved in the preparation and execution of the WSO-UV mission operations, which typically encompass real-time monitoring and control of the spacecraft, telescope and instruments as well as reception, processing and storage of the scientific data. In principle, there will be two complete ground segment systems, the Russian one will be located in Moscow (Lavochkin Association and Institute of Astronomy RAS), and the Spanish one will be sited at Madrid (*Universidad*

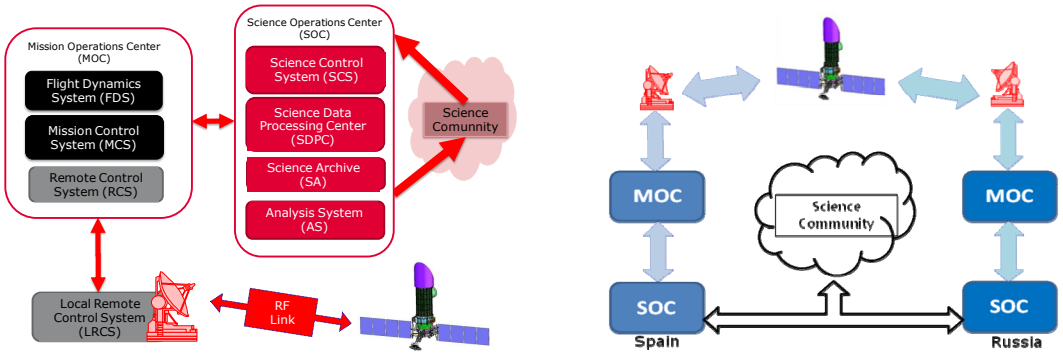

Figure 1: WSO-UV Ground Segment description and shared operations

Complutense de Madrid, UCM). The satellite operations will be shared between both ground control centers transferring the mission control from one center to the other on a regular basis. The Ground Segment development is based as much as possible on GMV's existing products for telemetry and telecommand systems, flight dynamics and science processing. One of the main challenges on GS development is the management of shared information between both centers and the alignment of all the operational data (telemetry, telecommand and planning) according to the operational shifts.

Another key point for successful operations is to adopt a very flexible approach for the scientific processing of data within the WSO-UV Ground Segment. Both ground control centers could be fully configured in order to process the science products independently and in parallel or in a more distributed approach depending on the project needs, even allowing the participation of new partner processing centers.

2 Ground Segment description

The Ground Segment major components have been defined in Fig. 1, and the activities associated to each component are briefly described herein after.

The Mission Control System (MCS) is in charge of providing the services for monitoring, commanding and control procedure execution for the platform, the payload and the ground segment, and other services related with performance evaluation, mission planning, on-board software and operational database management and control procedures generation.

The Flight Dynamics System (FDS) is linked to the spacecraft orbit and attitude maintenance. The FDS is an off-line system is not running all the time and their processes are run only at certain points of the operational loop. Some of the tasks performed by the Flight Dynamics are orbit and attitude determination, manoeuvre computation and monitoring, computation of products needed for the scientific planning and validation of the scientific observation plan.

The purpose of the Remote Control System (RCS) is to allow operation of all the

WSO/UV ground stations from a single operator position located in the MOC, even if local operation is still possible. The main aim of the RCS is to continuously monitor the status of the G/S equipment, record all important events during operations and support the station engineers in analysing problems.

The Science Control System (SCS) is in charge of the instrument and data operations mainly in two areas. Regarding the monitoring capabilities, it will be in charge of the acquisition of both housekeeping telemetry on the platform and the instruments, and also all science data generated on-board. Regarding the science capabilities, the SCS will allow the pre-processing of science telemetry for use by quick look analysis and level L0/L1 processors.

The Scientific Data Processing Center (SDPC) is in charge of providing the end users of the mission with both the mission products and all data required for their utilization. The SDPC may be centralized in one single physical location or distributed along several locations or may be formed by several instances cloned among them. But logically, it forms a single entity. The SDPC is in charge of running the pipeline processing system (PPS). In addition, the SDPC will be in charge of undertaking the programme for systematic identification of sources detected serendipitously during observations and the creation of mission catalogue of such sources.

The Science Archive (SA) is responsible for providing secure and persistent storage for data belonging to the WSO/UV mission, and allowing authorized users to access to this data in a fast and reliable way. But more importantly, it is the mission legacy that guarantees that the mission products will be usable by future users well beyond the spacecraft operations ended.

The Analysis System (AS) is the responsible for calibrating the observations, verifying and processing the scientific data. Note that this system is not in charge of the pipeline (automatic) processing, but it is intended for the manual and/or preliminary SCS products processing. It is expected that the PPS will make use strong reuse of the AS developments. The Analysis System (AS) is the set of facilities and tasks required for offline WSO-UV data processing.

3 Ground Segment team

The Ground Segment team will be responsible for the implementation of the operational concept of the mission and running smooth conduction of the WSO-UV operations. It is lead by the ground segment manager. The Ground Segment manager will be responsible for defining ground segment implementation requirements based on overall mission and project requirements, establishing a ground segment system and operations concept and architecture of support facilities, managing the programmatic aspects of the ground segment including all cost and schedule matters, assuring the implementation, integration and validation of the ground segment system and directing flight operations in the early mission phases.

The Ground Segment team is split in the MOC and SOC team. The Mission Operations Center (MOC) is in charge of monitoring and commanding (platform, payload and ground segment), on-board software management and maintenance, orbit and attitude determina-

tion, orbit and attitude manoeuvres computation and monitoring, spacecraft monitoring and reporting, etc. So, the MOC team is responsible for the safe operation for the spacecraft. It is leaded by the Spacecraft Operations Manager (SOM). From a functional point of view, the MOC is divided in the following areas:

- The Mission Control System (MCS) that is mainly in charge of the uplink and execution of the telecommand corresponding to the platform and science operations and the space monitoring, by processing of received housekeeping telemetry. So, in this frame, are defined several user roles: spacecraft controllers, timeline planners, telescope engineers and platform engineers
- The Flight Dynamics System (FDS) that is mainly in charge of orbit determination, attitude re-constitution, and orbit control manoeuvres in an optimal way to maximize the duration of the scientific observations. For controlling this system the following user roles are identified: flight dynamics operators, flight dynamics engineers and flight dynamics administrators.
- The Remote Control System (RCS) that is in charge of continuous monitoring of the status of the Ground Station equipment and the providing of some basic scheduling and automation for the routine operations. The main role identified is the communication controller.

The Science Operations Centre (SOC) is responsible for the scientific operations of the WSO-UV satellite and for the provision of adequate scientific scheduling to the MOC. The SOC team is leaded by the Science Operations Manager. It includes the following subsystems:

- The Science Control System (SCS) will be responsible of the reception, distribution and processing in various levels (L0 and L1) of the scientific data received from the MCS. On the other hand, during nominal operations the SCS will be also responsible of collecting all the proposals from the scientific community, and process them in order to generate the schedule of the science activities to be performed by the observatory. In this frame, the roles identified are the following: instrument controllers, scientific planners and instrument engineers.
- The Analysis System (AS), provides the single and common infrastructure dedicated to provide, store and manage the AS software. The roles defined in the AS are the following: AS administrator and AS committee.
- The Scientific Data Processing Centre (SDPC) in charge of L1 data product processing providing the final science products, ready for scientific utilisation. The roles identified are the following: pipeline configuration manager,pipeline controller engineers and pipeline scientists.
- The Science Archive (SA) in charge of L1 data product processing. It provides the end users mission with the mission final science products. The next user roles have been identified: archive operators and archive administrators.

4 Science team

Since the primary users of WSO-UV will be scientists, the operational approach for WSO-UV needs to be simple and transparent to end users. The interaction of astronomers with WSO-UV will follow steps that are very similar to those of other space-based astronomy missions.

The WSO-UV scientific team will issue a Call for Proposals periodically following strict public policies and procedures. Proposal acceptance process will be split in three phases: AO-phase 1 where the astronomer will only be required to enter the portions of a complete observing proposal that are required for scientific and technical assessment of it, proposal selection where TAC (Time Allocation Committee) will prioritize and rank them according to their scientific relevance for the mission goals and the AO-phase 2 where the astronomer will submit detailed information for accepted proposals.

Then, after observation scheduling process has been performed and it has been commanded to the spacecraft, the observation plan will be conducted and data will be brought to the ground segment, then it will be started the archiving process. As part of the archiving process the Ground Segment will process the science data in order to assess the quality of the observations using the calibration files available at the time of the observations, to populate the database of observations, and to make an initial version of the science data available to the science team. The WSO-UV archive will contain the data stored there in its raw form, the calibration files necessary to calibrate the data, and databases that describe the data.

Science Users will request data from the archive using web-based tools similar to those that have been developed for other missions. Although there will be some users who will want their data on physical media, most will retrieve data directly via internet. This will be quicker for them, and since no physical handling is required. Science users, instruments manufacturers, etc will be able also to provide documents and algorithms to be used in the processing of data products in the ground segment.

5 Operations

The baseline operational scenario currently under discussion is the operation of the WSO/UV mission based in a sharing of the operations between the so-called Russian and Spanish observatories as shown in Fig. 1. The mission baseline may be formed then by two observatories, meaning in broad sense two centers with commanding capabilities. At a given time, only one MCS will carry out the operation of the satellite, with the other one, ready for taking over the responsibility of the operations at the designated time, and vice-versa. The observatory concept may include the MCS functionality, and very likely, the SCS functionality as well. It must be noted that the advantages of having a single SDPC for the mission are kept in this dual scenario.

Routine WSO-UV operation encompasses the following main group of tasks:

- Planning processes: these include the planning and scheduling of space and ground segment operations: science user requests management, space segment routine operations,

ground segment maintenance requests, constraints management, resources management (space and ground), conflict resolution, space segment operations scheduling, ground segment operations scheduling and commanding preparation of the observing plan.

- Operations execution processes: these cover the implementation of scheduled operations for the space and ground segment: schedule execution, procedure execution, manual commanding, command pre-transmission validation and uplink management, command verification, schedule and command history archiving, space and ground segment health monitoring and failure detection, isolation and recovery.

- Evaluation processes: these include the evaluating the success of executed operations and for monitoring the performance of the space segment that is: data analysis processes (trend analysis, forecasts), monitoring of resource availability and utilization with provision of feedback to the planning processes described earlier, report production (automated report production, routine operations reporting, anomaly reporting).

- Mission exploitation processes: these processes are related to the generation, archiving and delivery of mission products to the end-users in a timely manner: data transmission between ground entities, data processing on ground, data archiving, cataloguing and retrieval, data delivery to the end-user, data archiving, cataloguing and retrieval and feedback to mission planning.

- Support processes: they cover all other activities performed in support of operations that are not covered by any of the above categories: orbit and attitude determination and maintenance, orbital and geometric events prediction, ground station coverage predictions, monitoring and control database maintenance, ground software maintenance, on-board software maintenance, scientific SW support and Analysis System (instrument SW, documentation, calibration data, etc).

6 Conclusions

The WSO-UV mission is progressing and the ground segment concept is also approaching the final design and implementation of the required support for mission and science operations. A part from the particularities associated to a science mission, this new mission will be affected by a new concept of observations management, trying to maximize the scientific return of this mission, and the shared operations between the two observatories located in Spain and Russia. A demonstration of the ground segment concept, has been successfully carried-out on February 12th 2010, with a complete participation of the Spanish and Russian operations teams.

References

[1] Gomez de Castro, A. I., et al. 2011, these proceedings