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A virtual appliance as proxy pipeline for the Solar Orbiter/Metis coronagraph

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ABSTRACT

Metis is the coronagraph on board Solar Orbiter, the ESA mission devoted to the study of the Sun that will be launched in October 2018. Metis is designed to perform imaging of the solar corona in the UV at 121.6 nm and in the visible range where it will accomplish polarimetry studies thanks to a variable retarder plate. Due to mission constraints, the telemetry downlink on the spacecraft will be limited and data will be downloaded with delays that could reach, in the worst case, several months. In order to have a quick overview on the ongoing operations and to check the safety of the 10 instruments on board, a high-priority downlink channel has been foreseen to download a restricted amount of data. These so-called Low Latency Data will be downloaded daily and, since they could trigger possible actions, they have to be quickly processed on ground as soon as they are delivered. To do so, a proper processing pipeline has to be developed by each instrument. This tool will then be integrated in a single system at the ESA Science Operation Center that will receive the downloaded data by the Mission Operation Center. This paper will provide a brief overview of the on board processing and data produced by Metis and it will describe the proxy-pipeline currently under development to deal with the Metis low-latency data.

Keywords: Solar Orbiter, solar corona, image processing, data analysis, space astronomy.

1. INTRODUCTION

Since Galileo Galilei observed the sun spots on the solar surface, the knowledge on how our star works has enormously improved, nevertheless some important aspects remains nowadays still unclear to the modern solar physic. It is not a case in fact if one of the main questions that drive the ESA's long-term planning for space science missions, the Cosmic Vision program, concerns the study of the Sun and its interaction with the Earth and the solar system. ESA, in fact, adopted Solar Orbiter [1], a heliophysic experiment, as the first medium class mission in the competition carried out in 2011. The Solar Orbiter mission should fly in 2018 and it has been conceived to address the central question of heliophysics: How does the Sun create and control the heliosphere? It was proposed by the European Solar Scientific Community with the aim of exploring the circumsolar region with a highly innovative approach studied to obtain unique almost helio-synchronous observations and to perform the first out-of-ecliptic imaging and spectroscopic observations of the solar poles and the equatorial corona from high latitudes.

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One of the key points of the mission consists in its powerful suite of six remote-sensing and four in-situ instruments that will work in synergy carrying out simultaneous observation of the investigated science objective. While the in-situ instruments will operate continuously during normal operations, the remote-sensing instruments will acquire data in three 10-day intervals centered around perihelion and either maximum latitude or maximum co-rotation passages.

Solar Orbiter has been thought as a long-term solar observatory foreseeing an overall mission life cycle of 10 years (7 nominal plus 3 years as extended mission) but, unlike other space observatories orbiting around the Earth that have, more or less, the same field of view on the investigated target, the point of view of the instruments on board Solar Orbiter will vary greatly during each orbit. Furthermore every orbit, having different characteristics (solar latitude, perihelion, etc.), will provide the opportunity to focus on specific scientific aspects that could be better studied in particular orbits rather than others. Science and operations planning is therefore crucial to fully exploit the investigating potential of the mission and dedicated tools have to be foreseen to support this strategic activity.

1.1 Low Latency Data

The Solar Orbiter, from the commanding point of view, is similar to a deep-space mission where the payload operations are planned in advance and the control of the whole system is not possible in real-time. Therefore the instruments will be operated off-line using a timeline of telecommands that will be uploaded to the S/C several days before those operations start. The in-situ instruments will produce scientific data continuously with a data generation rate roughly constant over the entire orbit but the generated volume will greatly increase during the 3 ten-day observing windows when also the remote-sensing instruments will operate. As the mission profile shows strong oscillations in spacecraft-Earth distance, also the telecommunications bandwidth will vary substantially, approximately by a factor 25, causing a variation on the data downlink capability of the platform.

In order to accommodate both fluctuations in data generation and in download capacity, the spacecraft is equipped with a Solid State Mass Memory (SSMM) that can store up to 532 Gbits in its nominal, two-unit configuration. Simulations of the downlink profile over the mission [2], show that we are likely to reach the maximum capacity of the SSMM several times during the mission, with latencies in data retrieval that can exceed, in some cases, also 100 days.

This has a direct consequence on the capability to correctly plan the following forthcoming operations but it also represents a potential risk for each instrument and for the science produced by the whole mission. In fact, if something unexpected occurs in the nominal operation that causes a degradation of the performance of an instrument, we could have visibility of the problem only several months later with a huge impact on the science data products.

In order to minimize the effect of the data latency on instrument operations planning and instrument performance checks, the payload-generated data on-board are categorized in different downlink priorities. In general, the following broad types of payload data will be transferred to the storage mass memory of the spacecraft to await downlink as telemetry:

- Housekeeping (HK) data.
- Science & context data.

The payload data with highest priority are the instrument HK data. At each ground contact, after all platform data have been received, the payload HK will be the first type of data to be received on ground, typically once per day covering the previous 24 hours.

An extra priority has been introduced to make sure that a subset of the recently acquired payload data will be downlinked at each ground contact. This dataset is called Low-Latency data. Its main aim is to give an overview of the acquired data since the last ground contact, to ensure daily visibility on on-going operations and to allow changes to future operations in case it is necessary.

As a goal, all Low-Latency (LL) data should be downloaded at each ground contact with the spacecraft. Therefore to guarantee the daily delivery of both HK and LL data, the total LL data volume is limited to 12 MB per day, corresponding to roughly 1 MB/day per instrument. Once on ground these data have to be quickly analyzed in order to check the instrument performance and, if necessary, trigger recovery actions.

1.2 The adopted software framework: virtual appliances

Once acquired by the instruments, the data will be transferred to the platform that will store and then downlink them to ground. The data retrieval from the spacecraft is controlled by the ESA Mission Operation Center (MOC) that will forward the received telemetry to the Science Operation Center (SOC) where data will be analyzed and distributed to the instrument PIs.

Each of the 10 instruments on board Solar Orbiter carries out a peculiar investigation producing data that are specific of that instrument. Furthermore the instruments are constructed by different teams therefore each of them will need dedicated software to properly calibrate and decode the data products. Usually the instrument providers develop in-house their own dedicated data processing pipeline software system and analyze data at their premises with no particular time constraints. However, for what concerns the Low-Latency Data instead the prompt reaction needed in response to a possible unexpected problem requires an immediate analysis of the received data and therefore processing pipeline software has to be installed directly at SOC.

While the development of each processing pipeline is still to the responsibility of the team supporting each instrument, the SOC will host the ten pipelines and will also perform centralised post-processing of output products. In order to simplify the management of such different processing pipelines, the different teams involved in Solar Orbiter and ESA agreed to adopt a common framework to develop their own software. The idea is to develop each Low-Latency pipeline as a virtual-machine image loadable into system virtualization software. This mechanism, where an operating system is bundled alongside an application for distribution, is known as a Software Appliance and in the virtualization context, as a Virtual Appliance. Such a system involves a guest operating system which runs inside a virtual machine created and managed by a hypervisor – the core virtualisation software – which itself (often) runs under the control of a host operating system. A Virtual Machine (VM) is an appliance (and so a virtual appliance) when it encompasses and is dedicated to a single software application as is the case for the Low-Latency pipelines. This common approach enables SOC to use the same kind of software interface for every instrument while it provides complete flexibility to each team to freely develop their own pipeline using their favorite software tools. Furthermore the virtual appliance mechanism minimizes the software integration task on the operational systems, eliminating the usual problems related to the software environment such as: available libraries, directories in which the software is installed, conflicting configuration with other installed applications and so on. This environment is in fact largely delivered along with the virtual appliance itself.

SOC will therefore provide the machine operating as hypervisor that will emulate multiple (at least ten) virtual hardware platforms that will be isolated from each other. Each team/instrument will release its own virtual machine running their specific processing pipeline on the preferred guest operating system. However, to reduce the complexity of the entire system and to minimize the range of possible peculiarities in the guest operating systems' interactions with the environment, all teams agreed on adopting one of the Linux distributions as the operating system for their VM.

2. THE METIS CORONAGRAPH

Metis is one of the six remote-sensing instruments of the Solar Orbiter scientific payload, it is a coronagraph that can simultaneously image the visible and ultraviolet emission of the solar corona and diagnose, with unprecedented temporal coverage and spatial sampling element (down to about 4000 km), the structure and dynamics of the full corona in the range from 1.6 to 3.0 solar radii at minimum perihelion (0.28 AU), and from 2.8 to 5.5 R at 0.5 AU. This region is crucial in linking the solar atmosphere phenomena to their evolution in the inner heliosphere, and the study of its properties is very important in meeting the Solar Orbiter fundamental science goals.

In addition, Metis can contribute to the study of the properties and evolution of Sungrazing comets.

2.1 The Metis instrument

The instrument is constituted by an optical bench hosting the coronagraph and by several electronics subsystems that allow the thermal control of the entire system and the acquisition of the data produced by the 2 detectors: the Visible

Light and the UltraViolet Detector Assemblies (respectively VLDA and UVDA). The coronagraph is constituted by an on-axis Gregorian telescope that uses an innovative design to minimize the thermal load induced by the solar disk radiation. The Metis entrance aperture has not the classical annular shape of a coronagraph but it is constituted by a reduced circular aperture on the spacecraft (S/C) thermal shield. A spherical mirror (M0) positioned inside the coronagraph boom, acts as occulter by reflecting back the focused solar disk light through the entrance aperture itself. Metis is the first space coronagraph adopting such design using a so-called inverted external occulter configuration [3].

While the solar disk is filtered out by M0, two annular mirrors (M1 and M2) drive the remaining coronal radiation first through an interference filter and then focus the two resulting light beams onto the two focal planes: the visible (580 – 640 nm) and the UV (121.6 nm) one. Actually the visible radiation passes through a Polarimetric Module Package (PMP) before reaching the detector providing Metis with the capability to perform polarimetric imaging in this range.

From the electrical point of view, the 2 Active Pixel Sensors (APS) are connected to three electrical units, the Camera Power Converter (CPC) and the High Voltage Unit (HVU) that provide the voltages needed to the sensor assemblies and to the Main Processing and Power Unit (MPPU) in charge of handling the communication between the detectors and the on-board computer on the platform. The MPPU runs the instrument Application Software (ASW) and it controls the several sub-systems and the overall data acquisition process.

The detector assemblies are provided by the Max-Planck-Institut für Sonnensystemforschung (MPS) of Gottingen, Germany, with a contribution of the Istituto di Astrofisica Spaziale e Fisica cosmica (IASF) in Milan for the development of the electronics and the software of the photon counting algorithm [4] of the UV detector. The UVDA sensor is a 1k x 1k, 15 μm pitch Star1000 device (by Cypress) that is optically coupled via fiber optic taper to a microchannel plate (MCP) that works as UV intensifier. The detector can be operated in analog mode or in photon counting mode depending on the intensifier gain set through the external HVU.

The Visible Light Detector Assembly (VLDA) is based on the same sensor adopted by the Solar Orbiter Polarimetric and Helioseismic Imager (PHI) instrument [5] and developed by CMOSIS [6] and MPS. The detector is a 2k x2k APS with a 10 μm pixel size @14 bits and it will be operated together with the Liquid-Crystal-based PMP polarimeter assembly in order to provide broadband linearly polarized images.

A detailed description of the Metis instrument can be found in more specific papers [7], [8].

2.2 Metis processing & data products

In most of the cases, the VLDA and UVDA will be operated simultaneously creating two concurrent data streams that will be handled by the MPPU, processed and later on sent to the S/C SSMM for temporary storage. Whereas the UVDA has two main possible operational modes, analog and photon counting, the VLDA foresees only the analog mode. In analog (or integration) mode, both detectors collect the charge created by the incoming photons over the set integration time. In photon counting mode, the intensifier of the UVDA will be operated at high gain and the APS will be read out in rolling shutter mode at 12 frames per second. This rate is sufficient to discriminate every single photon hitting a single pixel per read frame hence allowing the detection of each photo-event on the sensor and producing a list of events coordinates (x, y and energy). The UVDA photon counting mode is compliant with the case of low UV photons fluxes, in case of higher fluxes the on-board software will automatically switch to the accumulation mode where a stacked matrix (the *Photon Matrix* in **Figure 1**) containing the number of photons detected per pixel along with the integrated energy amplitude profile, will be produced instead of the normal list.

When the detectors are operated in analog mode, the produced frames undergo a similar on board processing, see **Figure 1**.

For the VLDA a first step concerns a reordering routine that reconstructs the correct sequences of pixel of the acquired frame. The frames are then processed to remove artefacts due to cosmic rays (CRs) or Solar Energetic Particles (SEPs) hits. More specifically, a variation of the "two image scrub" algorithm adopted in the STEREO mission is implemented on board [9]. This CR&SEP algorithm compares the current frame with the previous one (having the same polarization angle) on a pixel-by-pixel basis. If the difference between the comparing pixels values exceeds a set parameterized threshold (that depends on the estimated noise), the pixel with the higher value is replaced with the value of the other one. Only two images at the time need to be processed. The spikes-free frames are then passed to two concurrent procedures: the first one computes the mean value of the pixels belonging to a selectable annular region split in 8 sectors as those shown in **Figure 2**; such 8 values provide a rough estimate of the brightness of the corona the instrument is observing and if and how it is changing. A time series of these data constitute the so-called Light Curves and will be periodically sent to ground as Low Latency Data for monitoring purposes. The same data will be also monitored on board Metis to catch possible arising of transient events on the solar corona (solar eruption, like CMEs) comparing the averaged brightness values of the 8 sectors of consecutive frames [10] and triggering a transition mode of the instrument into a sort of high cadence mode (CME Observing Mode).

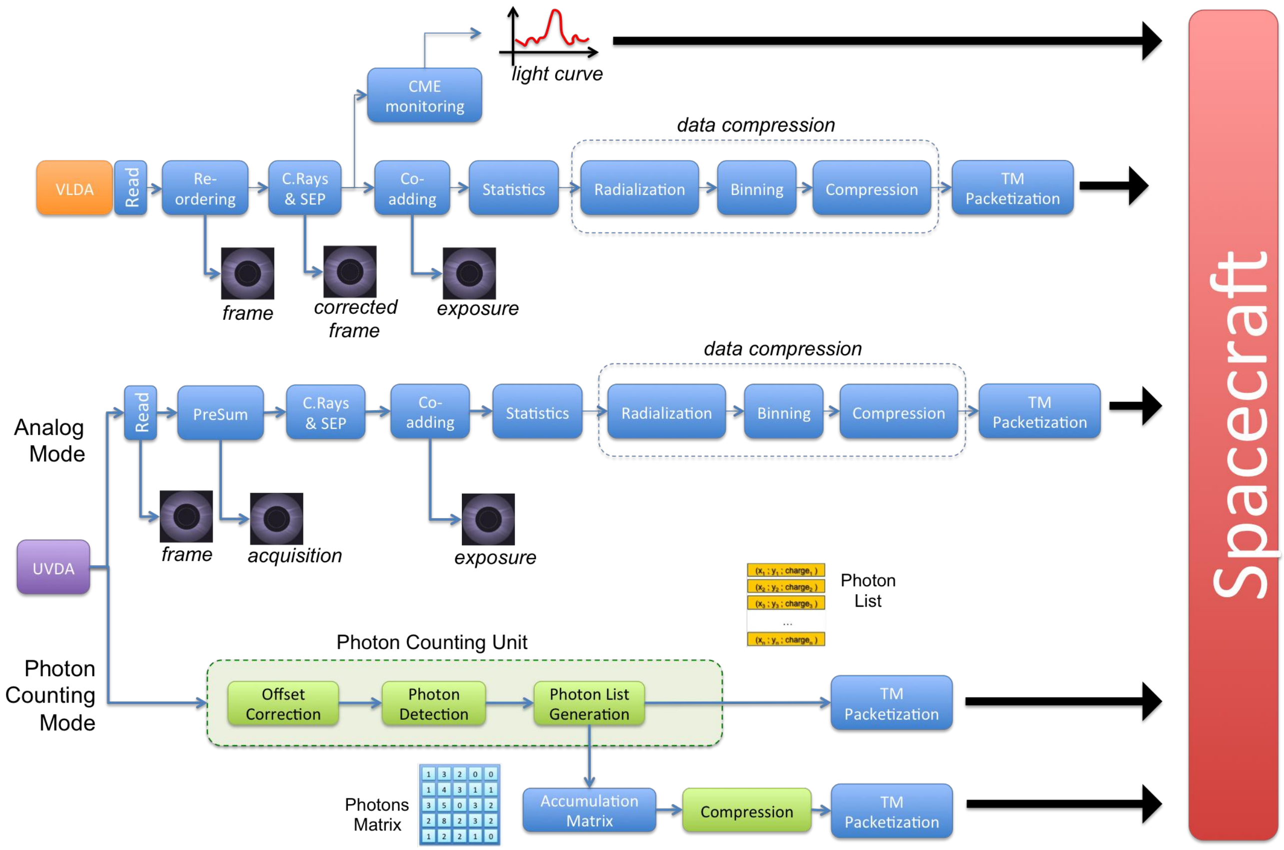


Figure 1: Metis on board processing overview. Each box in represents a processing step performed on the data coming out from the detector assemblies. The black arrows in the right part of the picture correspond to the data products sent to the S/C and to ground.

The output frames of the CR&SEP algorithm are also managed in parallel by a co-adding function that provides an averaged exposure starting from a certain number of input frames. Some statistical computations will be then performed on the obtained exposure to assess the image spatial noise. The data will be finally compressed, packetized and sent to the S/C.

For the UVDA a first procedure of frames co-addition is performed in order to produce a so-called acquisition (see figure above). The same CR&SEP algorithm used for the VL frames is then applied to clean the pixel array from possible Cosmic Rays and Solar Energetic Particles tracks that otherwise would cause a deterioration of the data. In the UVDA processing chain there is neither the light curves computation nor the CME monitoring but only a second co-adding stage that produces the final ‘exposure’ and the same statistical computations foreseen for the VL channel. The computed exposure is finally processed using the same compression algorithm as the VL data, packetized and sent to the platform.

The METIS compression algorithm is based on the CCSDS 123.0-B-1 standard and it has been adapted to be suitable for its specific purpose. The standard specifies a lossless predictive coding algorithm. For METIS this algorithm has been extended to near-lossless compression, in which the absolute reconstruction error can be limited to a user-defined maximum bound. A further "radialization" algorithm has been developed ad-hoc for Metis, consisting in a re-mapping of the original image for the purpose of enhancing the compression exploiting the geometry of the observed target. The radialization algorithm consists in fact in rearranging the positions of the pixels, switching from a Cartesian coordinates system to a polar one. It has been thought by analyzing the geometry of solar acquisitions adapted to a prediction-based compression algorithm; In prediction-based technique a mathematical model is used to predict a pixel given the knowledge of the adjacent pixels that have been already processed. Then, the prediction residual is encoded to the compressed file. More similar are the values of the comparing pixels the higher is the compression ratio achieved. The geometry of the solar corona is clearly radial, therefore it is more advantageous for the predictor to have adjacent pixels (expecting to have similar values) as linear neighbors rather than spread over circles in the image.

A more detailed description of how the algorithm works and the adaptation adopted for METIS can be found in [11].

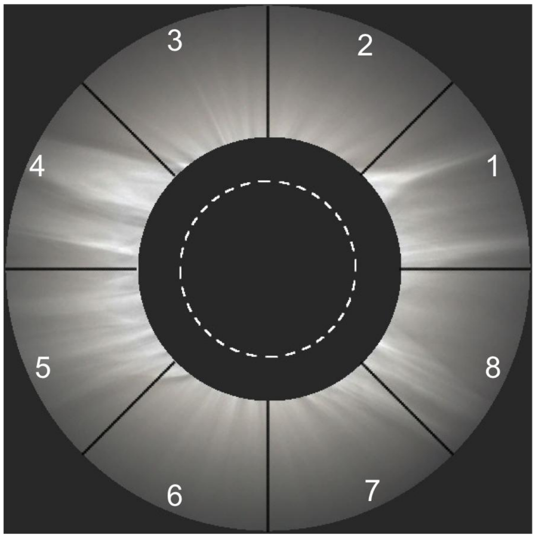


Figure 2: the 8 radial sectors splitting the Metis field of view used to compute the mean values that produce the Light Curves data products. The same sectors are also used to monitor the occurrence of solar transient events. The dashed circle in the center of the image represents the Sun disk dimensions @ 0.28 AU

Once the data has been compressed the last step is performed by an internal routine that splits the data in several telemetry packets following the CCSDS ESA standard. In particular the protocol prescribes a maximum size for the generated packets of 4112 bytes, for Metis this limit is actually reduced to 4088 bytes due the dimension of the internal buffer used by the Spacewire communication link. With this constraint an uncompressed raw image is split in 517 TM packets for the UV detector and 2065 for the VL.

3. METIS LOW LATENCY DATA PIPELINE

As explained above, Low-Latency data is a subset of science and context data that is promptly brought to ground allowing a quick overview of the instrument products. Metis plans to use this mechanism mainly to monitor the instrument performance and science data quality.

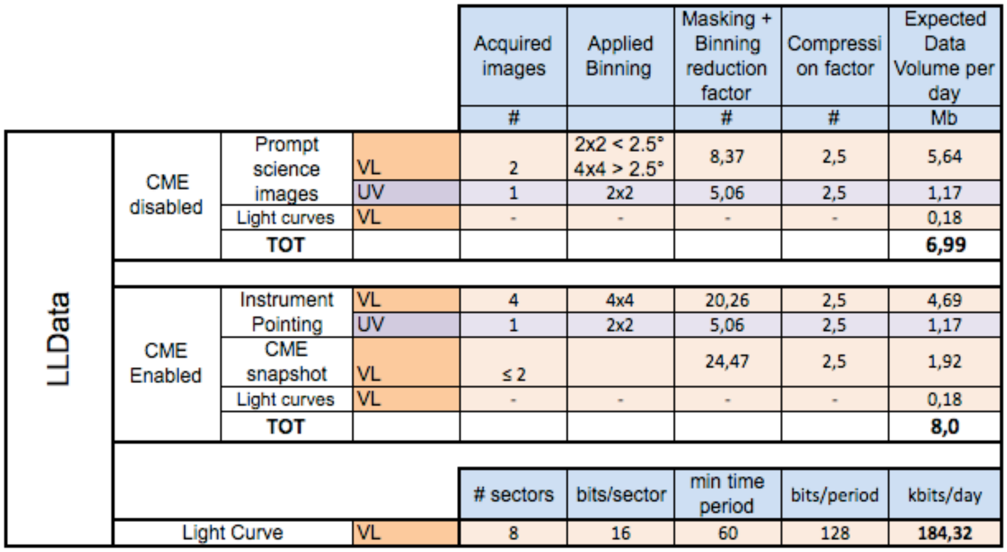
3.1 Metis Low Latency Data products

Due to the strict constraint on the total LL data volume available per instrument (~ 1MB/day), the data sent through this priority way has to be reduced and strongly compressed. A single uncompressed full frame image of the smaller Metis

UV detector would otherwise exceed twice this limit. A further aspect to be taken into account is that Metis can autonomously override the planned acquisition if the algorithm for the CME detection is enabled and a transient event occurs. In this case a series of high cadence acquisitions will replace the planned sequence and one of the images taken in this observing mode has to be sent as LLD in order to have a prompt feedback on the ongoing instrument operations.

These aspects brought us to define two different scenarios for the LLD products depending on the possibility that a snapshot is created due to a CME event. The table below summarizes the expected LL data products generated by Metis in case the CME detection algorithm is respectively active or not. A programmable software cap to the CME detection algorithm will be set to a maximum of 2 events per day to not exceed the available LL data volume.

Table 1: Expected Metis Low Latency Data products. The two scenarios take into account the possibility to produce a CME snapshot in case the CME detection algorithm is enabled. The Light Curves will be anyway sent as LLD.



				Acquired images	Applied Binning	Masking + Binning reduction factor	Compression factor	Expected Data Volume per day
				#		#	#	Mb
LLData	CME disabled	Prompt science images	VL	2	2x2 < 2.5° 4x4 > 2.5°	8,37	2,5	5,64
			UV	1	2x2	5,06	2,5	1,17
		Light curves	VL	-	-	-	-	0,18
		TOT						**6,99**
	CME Enabled	Instrument Pointing	VL	4	4x4	20,26	2,5	4,69
			UV	1	2x2	5,06	2,5	1,17
		CME snapshot	VL	≤ 2		24,47	2,5	1,92
		Light curves	VL	-	-	-	-	0,18
		TOT						**8,0**
				# sectors	bits/sector	min time period	bits/period	kbits/day
	Light Curve		VL	8	16	60	128	**184,32**

The above scenarios for Metis LL data both foresee a total data volume within the allocated 1 MB (i.e. 8 Mb). Standard on-board processing will be employed. Ground-based processing will instead employ a dedicated, proxy pipeline, since not all the calibration and other ancillary data may be immediately available for the main data processing pipeline because of their higher latency in downlink.

3.2 Metis Low Latency pipeline

As previously stated, each team supporting one of the ten payload instruments on board Solar Orbiter has to develop its own proxy pipeline to properly read the instrument data. In principle, each pipeline could be using its own Linux flavor and system set-up in which the pipeline software itself will operate. But this would mean that each team would have to spend resources on setting up, configuring and maintaining their own VM platform. So some of the instrument teams within the Solar Orbiter consortium have set up their virtual machines so that they can be used as a 'box' to be filled up with the proper processing code by other teams. This solution ensures that the other teams' programmers can focus their strengths on the instrument data and on how to process them instead of spending time on the software container.

Metis follows this strategy adopting the virtual machine developed by the SPICE team (Stein Haugan). The virtual machine is based on the Red Hat Enterprise Linux (RHEL) 6.6 distribution and it uses a series of bash-scripts to configure itself with respect to the environment according to the specifications defined by the SOC. In particular the systems mounts two remote folders (using the Network File System – NFS - protocol) one as input and the other one as output and then periodically checks if a processing request appears into the input folder. If a new request appears the software routine in charge of processing the data is executed and the results are then written into the output folder.

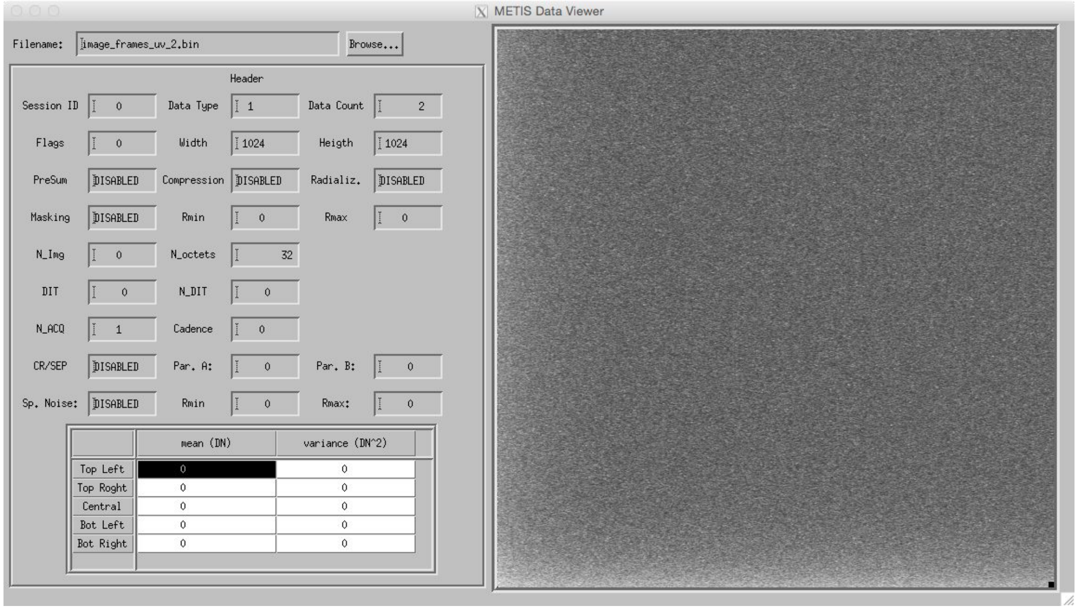
Actually, since the data coming from ESOC are wrapped into an xml structure, a procedure first parses the input files and extracts the real telemetry (TM) produced by the instrument. The list of TM packets is then presented to the core of the processing pipeline.

The Metis processing pipeline is currently under development, its main aim is to rebuild the scientific data from the received TM list, check that the auxiliary information of the image header are compliant with what is expected and then display the downloaded frame to allow to a user a quality check on the reconstructed image.

The current pipeline prototype is composed of several routines written in different programming languages. The first step concerns the collection of the TM packets related to the same scientific object. The platform in fact does not guarantee the packets will be delivered all at once and neither they will be ordered following their generation time, therefore a reordering routine is mandatory before processing the data. The current routine exploits some auxiliary information embedded in each Metis telemetry packet to rebuild the full set of generated information. In particular the first TM packet of each scientific product contains the overall size of the acquired data from which the total number (N_{EXP}) of the expected TM packets can be deduced. Every TM packet then reports a set of ID numbers that univocally identify it as belonging to a certain data product as well as an increasing counter that enables correct reordering of the entire list. Using this information we are able to rebuild the correct sequence of TM data that has been generated on board and to highlight if some packet were missing. In the latter case, the data will be still processed but the output frame might be recreated only partially and a “failed” processing will be pointed out in the output directory.

If the TM sequence is complete, the scientific header is read and checked from the first TM packet and, if there are no problems on the values of the known parameters, the following data can be processed. As summarized in Table 1, LLD have to be highly reduced in order to fit inside the limited available data volume. Therefore the second processing step of the Metis pipeline is to apply the decompression algorithm to the received compressed data stream. This process uses further information coded in the first part of the first TM packet to rebuilt the original data or, actually, a good estimate of them, since the mechanism can use also a lossy compression algorithm.

The output of the decompression algorithm finally represents the data to be analyzed. Currently these data are just properly formatted and, if necessary, displayed on the screen to provide the user the ability to perform a quality and sanity check of the instrument operations and flag possible problems. A preliminary Graphical User Interface (GUI) has been developed using IDL (Interactive Data Language, by exelis), a powerful software tool that has been widely adopted by the solar community and that presents the great advantage of having available a rich astronomy library already developed and tested. The SPICE VM already provides the IDL language and a subset of the astronomy library.



Filename: image_frames_uv_2.bin

Session ID: 0
Data Type: 1
Data Count: 2
Flags: 0
Width: 1024
Heigth: 1024
PreSum: DISABLED
Compression: DISABLED
Radializ.: DISABLED
Masking: DISABLED
Rmin: 0
Rmax: 0
N_Img: 0
N_octets: 32
DIT: 0
N_DIT: 0
N_ACQ: 1
Cadence: 0
CR/SEP: DISABLED
Par. A: 0
Par. B: 0
Sp. Noise: DISABLED
Rmin: 0
Rmax: 0

	mean (DN)	variance (DN^2)
Top Left	0	0
Top Roght	0	0
Central	0	0
Bot Left	0	0
Bot Right	0	0

Figure 3: an overview of the developing Metis GUI interface to be used in the proxy pipeline. In the left panel of the GUI are shown the information extracted from the Metis scientific header; the right panel shows a ‘noisy’ image acquired by the UVDA detector (the Intensifier was off).

The prototype of the developing GUI has been recently tested during the Short and Full Functional Tests (SFT and FFT) on the Metis Engineering Model that are currently going on at the prime contractor premises in Milan. A screenshot of this GUI is shown in **Figure 3**.

Beyond the display of the data, the routine saves in the output folder the rebuilt frame as a FITS file [12]. These files will be gathered with the data coming from the other Solar Orbiter instruments and then analyzed and displayed together by the SOC to have an exhaustive view of the investigating target providing a powerful tool to support the instruments' short term observation plans and contributing to achieve the scientific success of the whole mission.

In future it is under study the possibility to provide the GUI with a wider set of analysis tools to extract information from the acquired data in support of the Metis measurement plan and contributing to properly designing also the instrument's forthcoming operations.

4. CONCLUSIONS

Due to mission constraint the Solar Orbiter's data retrieval can suffer a very long latency that, in the worst case, can span up to several months. In this scenario, the ongoing operation on board would be visible on ground much too late to foresee whatever kind of recovery action or re-targeting in case something unexpected occurs. The Low Latency Data provides instead a priority link to daily receive a small subset of scientific data coming from the observing instrument. These data have to be promptly processed to trigger possible reactions. Each teams supporting one of the ten payloads on board Solar Orbiter is thus developing a processing pipeline to deal with the LLD and Metis is working on its own proxy pipeline. The current prototype is based on an environment provided by a virtual machine set up by the SPICE team. In this 'software box' a suite of routines is currently under development and some of the basic tasks has been successfully tested during the test campaign carried out with the Metis engineering model. The pipeline in particular checks the format of the received data, provides basic image display capability and presents as output the processed frame saved as a FITS file. Exploiting this tool Metis will be able to provide a snapshot of the solar corona from the S/C point of view and, when the CME catching algorithm is enabled, to give a preview of what the instrument is observing. Therefore the pipeline will represent a fundamental tool not only to verify that the ongoing observation is proceeding correctly but also to address the forthcoming instrument observation plans and therefore achieve the scientific success of Metis and of the mission in general.

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