The Extreme UV Imager telescope on-board the Solar Orbiter mission – Overview of phase C and D

J.-P. Halain[a]*, P. Rochus[a], E. Renotte[a], A. Hermans[a], L. Jacques[a], F. Auchère[b], D. Berghmans[g], L. Harra[e], U. Schühle[d], W. Schmutz[f], A. Zhukov[g], R. Aznar Cuadrado[d], F. Delmotte[c], C. Dumesnil[b], M. Gyo[f], T. Kennedy[e], P. Smith[e], J. Tandy[e], R. Mercier[c], C. Verbeeck[g]

[a]Centre Spatial de Liège, Université de Liège, Liege Science Park, 4013 Angleur, Belgium
[b]Institut d'Astrophysique Spatiale, Orsay, France
[c]Institut d'optique, Orsay, France
[d]Max-Planck-Institut für Sonnensystemforschung, Göttingen, Germany
[e]Mullard Space Science Laboratory, Surrey, UK
[f] Physikalisch-Meteorologisches Observatorium Davos and World Radiation Center, Switzerland
[g]Royal Observatory of Belgium, Avenue Circulaire, Brussels, Belgium

ABSTRACT

The Solar Orbiter mission is composed of ten scientific instruments dedicated to the observation of the Sun's atmosphere and its heliosphere, taking advantage of an out-of ecliptic orbit and at perihelion reaching a proximity close to 0.28 A.U.

On board Solar Orbiter, the Extreme Ultraviolet Imager (EUI) will provide full-Sun image sequences of the solar corona in the extreme ultraviolet (17.1 nm and 30.4 nm), and high-resolution image sequences of the solar disk in the extreme ultraviolet (17.1 nm) and in the vacuum ultraviolet (121.6 nm).

The EUI concept uses heritage from previous similar extreme ultraviolet instrument. Additional constraints from the specific orbit (thermal and radiation environment, limited telemetry download) however required dedicated technologies to achieve the scientific objectives of the mission.

The development phase C of the instrument and its sub-systems has been successfully completed, including thermo-mechanical and electrical design validations with the Structural Thermal Model (STM) and the Engineering Model (EM).

The instrument STM and EM units have been integrated on the respective spacecraft models and will undergo the system level tests. In parallel, the Phase D has been started with the sub-system qualifications and the flight parts manufacturing.

The next steps of the EUI development will be the instrument Qualification Model (QM) integration and qualification tests. The Flight Model (FM) instrument activities will then follow with the acceptance tests and calibration campaigns.

Keywords: Extreme Ultraviolet Telescope, Solar Orbiter, Engineering Model, Structural-Thermal Model, Qualification Model, Flight Model

1. INTRODUCTION

The Solar Orbiter mission embarks ten scientific instruments dedicated to the observation of the Sun's atmosphere and heliosphere, taking advantage of an out-of-ecliptic orbit and at perihelion reaching a proximity close to 0.28 A.U. [1],[2],[3] [15]. The Solar Orbiter mission is planned to be launched in October 2018.

The Extreme Ultraviolet Imager (EUI) instrument will provide full-Sun image sequences of the solar corona in the extreme ultraviolet and high-resolution image sequences of the solar disk in the extreme ultraviolet and in the vacuum ultraviolet. The EUI instrument is thus composed of:

- A High Resolution Imager (1 pixel = 100 km) at the hydrogen Lyman-α line[12] (HRI_{Lya} channel),
- A High Resolution Imager (1 pixel = 100 km) at the extreme ultra-violet (EUV) 174 Å line (HRI_{EUV} channel),
- A Full Sun Imager (1 pixel = 900 km) at alternatively the EUV 174 Å and 304 Å lines[7],[8] (FSI channel).

The EUI instrument takes heritage from previous similar extreme ultraviolet instruments. Additional constraints from the specific orbit (thermal and radiation environment, limited telemetry download) however required dedicated technologies to achieve the scientific objectives of the mission (CMOS-APS detectors, high reflectivity mirror coatings, heat pipe and highly efficient heat-rejection entrance baffles, data compression and prioritization, and re-closable door mechanisms)[9][13][16][17].

The EUI instrument is composed of two units, based on a passive thermo-mechanical design (Figure 1). The Optical Bench System (OBS) holds the three telescope channels (with mirrors, cameras, filter wheels, filters and door mechanisms). The Common Electrical Box (CEB) unit operates the instrument and provides the data handling (processing and compression) and electrical interfaces with the spacecraft [9].

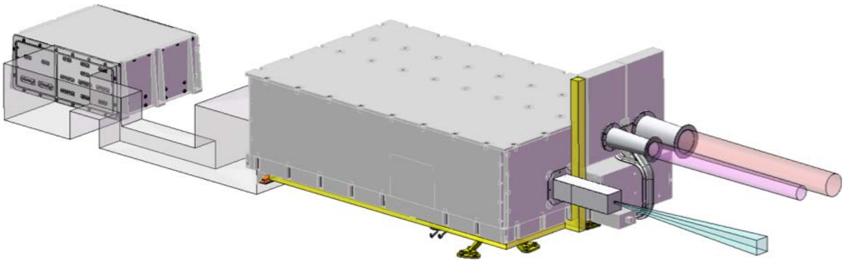

Figure 1 – The two units of EUI: CEB (left) and OBS (right), with the interconnecting harness

2. INSTRUMENT PHASE C

The EUI instrument design had been previously described [9][13][16][17], and its Phase C has now been completed by the sub-systems and instrument critical design reviews (CDR).

As shown in Figure 2, for some sub-systems (door, cameras and detectors, software and bench structure), the CDR was completed after the instrument CDR (ICDR).

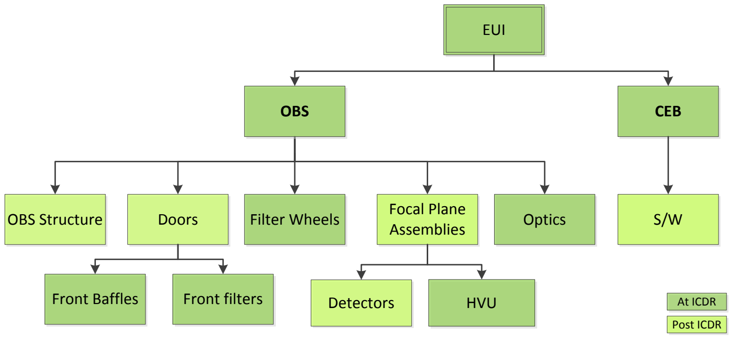

Figure 2 – Overview of the EUI instrument and sub-systems CDR

2.1 Instrument CDR

The instrument CDR was held end of 2013 achieving the following objectives:

- The instrument performances, supported by analyses and/or tests, meet both the scientific and the system functional requirements.
- The instrument detailed design is robust, with adequate margins and compliant with the set of functional, performance, design, interface and product assurance requirements.
- External interfaces are defined and documented in the relevant configuration-controlled Interface Control Documents, as input for the S/C CDR process (that was held on the first half of 2015).
- The instrument verification and test plans, including on-ground instrument calibration and characterisation plans, are realistic and adequate to demonstrate compliance with all requirements and that they are supported by consolidated tests. In addition, the verification and traceability matrices from system to subsystems requirements are complete and coherent.
- The instrument qualification plan is complete, satisfactory and coherent with the subsystems qualification plans.
- The schedule is realistic with adequate margin and contingencies.
- The identified risks are thoroughly assessed with clearly defined mitigation plans and actions.
- The operations concept and the instrument operability are well developed, described in the User Manual and in line with the flight software architecture and design.

- The commanding and control of the instrument is properly defined in the flight software documentation and the flight software design reflects the needs of commanding and operations.
- The critical technologies have been identified and full performance demonstrated.

Some sub-systems (door, cameras and detectors, software and bench structure) were however not mature enough at the time of the ICDR to be properly reviewed and dedicated sub-system CDRs were therefore performed in the following 18 months.

2.2 Sub-systems CDR

Software

The EUI on-board software CDR was decoupled from the instrument critical design review, in order to guarantee the high level of documentation required for such project. The software CDR has thus been successfully been held at mid-2014 and is currently under validation on the CEB Engineering Model (EM) [18].

OBS structure

The mechanical analysis results being not available on time of the ICDR, the carbon-based structure of the OBS unit was also reviewed at end-2014.

In the meantime, the OBS and CEB Structural and Thermal Model (STM) were tested. The OBS structure design has been slightly enhanced to take into account the lessons learned from this STM test campaign [18].

For instance some reinforcement to reduce thermo-elastic effect on mirror positions over the operational thermal range (back panel thickness increase by 10mm).

The OBS structure has also been adapted following some late S/C modification and requests (additional reference cube, increased thermal interface contact area), and to take into account the updated door design (described hereafter).

Figure 3 shows the CDR-level OBS unit structure with the three entrance baffles and door mechanisms.

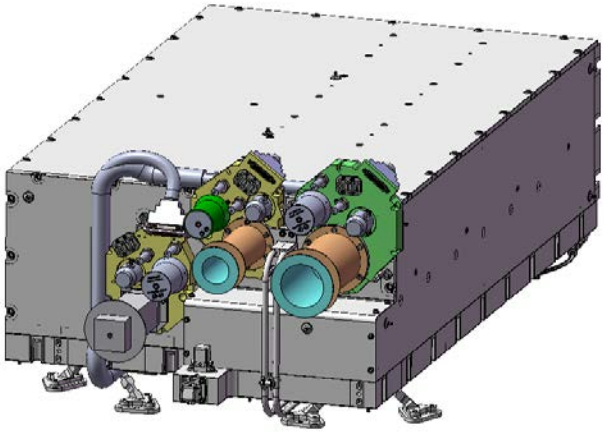

Figure 3 – EUI OBS unit after OBS and door CDR

Detectors and cameras

The detector [16][18] and camera[18] sub-systems were not at CDR level when the instrument CDR has been passed. For that reason, these two sub-systems have continued to be designed and analysed before successfully passing their dedicated CDR.

Door

The EUI doors have three main purposes:

- Protect the entrance filters against launch acoustic vibration and against contamination.
- Protect the instrument against contamination during AIV, launch and in-orbit.
- Provide instrument protection from solar UV light and particle irradiation in non-operational flight periods.

Moreover, the FSI door mechanism also provides an intermediate ‘occulter’ position, to observe the corona by obscuration of the solar disk.

The EUI doors design was updated between instrument CDR and door CDR. The design is inherited from the JUNO scan mirror mechanism [17]. This mechanism uses the same motor, and the same reed switches end position sensors.

All three door concepts (shown in Figure 4) are now based on a rotating lid directly mounted onto the motor shaft, with reed switches used as open/closed position indicators and a pin puller to keep the door closed during launch (launch lock) in conjunction with a spring mechanism to maintain the lid against the end-stop. Two magnets, one at each end position (open and closed) are used to maintain the final position with the motor OFF and avoid lid movement due to external disturbing torques (e.g. S/C manoeuvers).

A labyrinth around the lid in the closed position provides the contamination protection and purge outlet, and a venting labyrinth by-pass around the entrance filters limits the pressure gradient across the filters during ascent depressurization and purging.

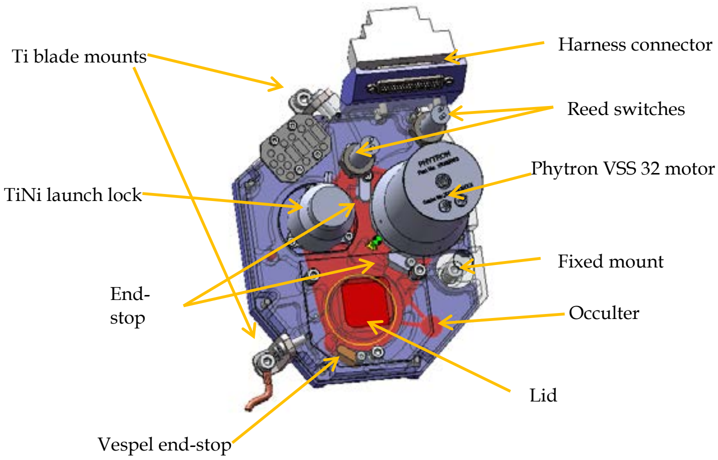

Figure 4 – EUI door design at CDR level

The door aluminum housing is fixed via one rigid and two flexible mounts in titanium onto the OBS front panel.

The new door design has passed the CDR and the qualification activities have started by the manufacture of three doors for the QM instrument.

2.3 Test matrix

The EUI instrument verification strategy is summarized in the test matrix of Table 1, where ultimate verification methods are indicated for each requirement.

Table 1 – EUI unit test matrix

Test	Model				
	STM	EM	QM	FM	FS
Physical properties(1)	**A, T**	-	**A, T**	**A, T**	-
Functional & performance(2)	-	**T**	**T**	**T**	**T**
Static load	-	-	-	**A**	-
Sinusoidal and random vibration	**T_Q**	-	**T_Q**	**T_A**	-
Acoustic	(tested at spacecraft level)				
Shock	-	-	**T**	-	-
Thermal balance(3)	**T**	-	**T**	**T**	-
Thermal vacuum cycling	-	-	**T_Q**	**T_A**	-
Corona & arcing	-	-	**T**	-	-
EMC/ESD(4), DC magnetic properties	-	**T**	**T**	**T**	-
Life	Tested at equipment level: doors and filter wheel				

R = Review of design; **A** = Analysis; **I** = Inspection; **T** = Test; **T_Q** = Test at qualification level; **T_A** = Test at acceptance level

(1) CoG and Inertias verified by analysis only
(2) Functional and health checks at ambient. Includes electrical interfaces and HW/SW compatibility. Geometrical performance (image quality) verified with visible source (w/o EUV filters). Radiometric & spectral performances are also verified (with EUV filters).
(3) Thermal balance and cycling are combined in a single vacuum sequence, except for STM where only thermal balance is performed. A thermal Validation test (thermal balance with dedicated solar simulator) is also performed on the OBS STM/QM
(4) Radiated Emission and susceptibility, Bonding / isolation tests. CE/CS on one redundant half only. Only conductive EMC tests. CEB STM housing and CEB EM boards will be used for shock and ESD qualification tests of CEB

The STM and EM activities have been completed [17] at instrument level and are being tested with the respective equivalent spacecraft models, the S/C STM and S/C Electrical Test Bench (ETB).

- The OBS and CEB STM units have been tested in vibrations and in thermal at unit level. The OBS STM was then delivered and integrated on the S/C STM (Figure 5) for S/C mechanical tests (acoustic and shock) and then thermal tests. The CEB housing being re-used for the CEB QM, it has been replaced by a Mass Thermal Dummy (MTD) for the S/C STM tests.
- The OBS EM and CEB EM have been individually tested and then coupled to validate electrical interfaces and EMC. The OBS and CEB EM units before being delivered to S/C ETB to perform all electrical and software validations (including EMC).

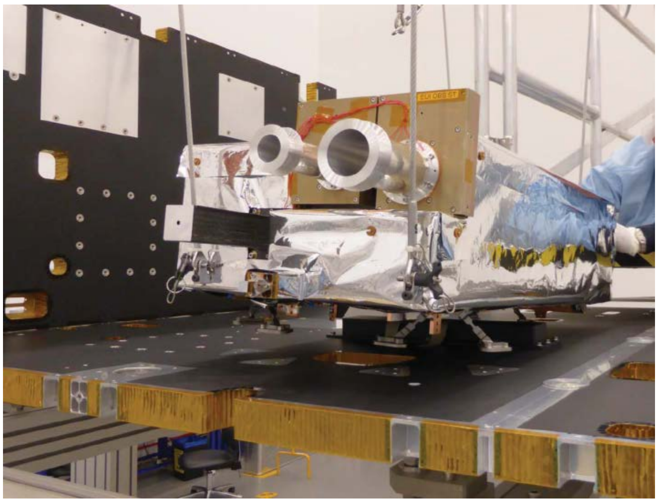

Figure 5 – EUI OBS STM unit integration on the Solar Orbiter spacecraft STM (credit: Airbus)

The next steps in the EUI development are the qualification and flight models manufacturing, assembly and tests, as described in the following paragraphs.

3. INSTRUMENT PHASE D - QUALIFICATION ACTIVITIES

The manufacturing of the sub-systems Qualification Models (QM) has been initiated according to the CDR design, taking into account the lessons learned from the STM units [17]. The EUI qualification will be accomplished at sub-system and at unit/instrument levels with dedicated test activities.

3.1 Sub-systems qualification

The EUI OBS sub-systems [17] are qualified before being integrated on the OBS structure, according to the test matrix of Table 2. A short description of each of these tests is presented in the following, for sub-systems and for unit /instrument.

Table 2 – EUI sub-system qualification matrix

Tests	Cameras	Doors	Detectors	Filter wheels	Mirrors	HVU	Structure
Optical properties		Prototype	Prototype QM, FM	QM	STM, QM, FM, FS		
Physical properties	STM, QM, FM, FS	STM, QM, FM, FS	STM, QM, FM, FS	STM, QM, FM, FS	STM, QM, FM, FS	STM, EM, QM, FM, FS	STM, QM, FM
Electrical	STM, QM, FM, FS	STM, QM, FM, FS	EM, QM, FM, FS	EM, QM, FM, FS		EM, QM, FM, FS	
Mechanical	STM, QM, FM, FS	QM, FM, FS		STM, QM, FM, FS	STM, QM, FM, FS	QM, FM, FS	
Bake-out	STM, QM, FM, FS	STM, QM, FM, FS		STM, QM, FM, FS	STM, QM, FM, FS	STM, QM, FM, FS	STM, QM, FM
TVAC	QM, FM, FS	QM, FM, FS		QM, FM, FS		QM, FM, FS	
TBAL	STM, QM,FM, FS	STM, QM, FM, FS		QM, FM, FS		QM	
EMC	EM, QM	QM		QM		EM, QM, FM, FS	
Calibration			QM, FM, FS			QM, FM, FS	
Radiations	QM		QM	QM		QM	
Functional/Performance	EM, QM, FM, FS	QM, FM, FS	EM, QM, FM	EM, QM, FM		EM, QM, FM, FS	

Optical properties

At sub-system level, optical properties refer to mirrors, filters and entrance baffle optical surfaces. For each part, the following measurements are performed.

- Mirrors:
    - Wave-Front-Error (WFE) of the optical surfaces, to determine the optical quality of the mirrors (in mounts), including mounting/heating effect. The adjustment stability after heating/vibration is performed on mirror/mounts.
    - Reflectivity at Ly-α / EUV wavelengths.
- Filters:
    - Thermo-optical properties and spectral transmission are measured w.r.t. temperature, including number of pinholes in EUV filters
    - Ageing of filter.
- Entrance baffles:
    - Thermo-optical properties of the reflective coating (stability of the coating vs. ageing is quantified on samples).

At instrument level, optical properties refer to

- The optical alignment and co-alignment of the channels.
- An end-to-end optical performances (image quality, straylight…) during functional and performance tests

Physical properties

The following physical properties are measured and their conformity is checked with the mechanical interface drawings:

- External and critical dimensions
- Mass
- Planeity, location and characteristics of fixation points/connectors (interfaces)

The Moments of Inertia (MoI) and Centre of Gravity (CoG) are determined by analysis. On the OBS STM unit, however it has also been measured (Figure 6) and confirmed the model.

Figure 6 – EUI OBS STM MoI and CoG measurement

Electrical

The following measurements are performed as part of the electrical verifications:

- Position / type / orientation of electrical interfaces (connector)
- Isolation of pins from shields / structure / backshell
- Grounding
- Ohmic resistance between selected lines (electrical continuity checks)
- Electrical continuity across structure

Mechanical

Classical mechanical tests are conducted to validate the mechanical design:

- Low level sine sweeps (0.5 g, 2 octaves/minute) are performed in the range 5 - 2000 Hz to identify instrument eigen-frequencies, correlate the mechanical model and check that no mechanical anomaly occurred during the high-level vibration runs.

- The Sine Vibration test is conducted to demonstrate that the instrument can withstand the mechanical environment of the low frequency (< 100 Hz) sine and transient vibrations.
- The Random Vibration test is conducted in the range 20 - 2000 Hz to demonstrate that the instrument can withstand the mechanical load expected during launch.

A shock test is also conducted on the STM and on the QM units in the range 100 - 10000 Hz to demonstrate that the instrument can withstand the various shock events which may occur during the life time.

For the filters, a delta-pressure test is performed as mechanical tests verification of the capability to sustain pressure differentials during launch.

Bake-out

Due to very high molecular cleanliness requirements, all parts, sub-systems and units are baked-out to deplete any volatile materials prior to on-orbit operations.

The bake-out is performed at parts and components level in a vacuum oven with gas purging by applying the highest temperature compatible with the material. The assembled instrument will be baked out again at high vacuum with a thermally controlled Quartz Crystal Microbalance (TQCM) monitoring the bake-out process. This bake-out is nominally performed by heating to a temperature of 80° C during a minimum of 72 hours.

TVAC/TBAL

A typical thermal test sequence usually combines both thermal cycling and thermal balance in a single vacuum sequence.

- The thermal vacuum cycling test (TVAC) is conducted under vacuum to verify that the instrument can withstand thermal cycles between extreme temperatures without degradation of its performance.
- The thermal balance (TBAL) test simulates the radiative and conductive environment and is used to verify the thermal equilibrium temperatures predicted by the thermal model. A correlation of the results with the thermal model including uncertainty calculation is performed after the test.

In addition to the thermal cycling and balance tests, a thermal qualification of the EUI OBS was conducted on the STM (and will be repeated with the EQM). The TVAC test is performed during the same vacuum sequence as the thermal balance test. The objectives are to validate the thermal interfaces with the feedthroughs of the spacecraft sun shield and ensure the unit can sustain the impact of thirteen solar constants irradiance.

EMC

EMC tests are performed to verify that the EUI instrument is compliant with the requirements of the Solar Orbiter payload according to a dedicated test plan. It includes in particular:

- Bonding and isolation test
- Grounding test and conductivity test of space exposed surfaces
- EMC Conducted Emission / Susceptibility test
- ESD susceptibility tests
- DC and AC Magnetic Properties test

Calibration

In order to build a radiometric model of the instrument, a calibration at Ly-a and EUV wavelengths is performed for the detectors, the filters and the mirror coatings, in advance of the OBS unit end-to-end calibration.

Radiations

Radiation tests are performed to verify that critical components of the EUI instrument can survive the radiation environment of the mission, if they are not qualified for the specified environment. These tests are performed at component level only and mostly concern the detector.

Functional/Performance

Functional tests are intended to check the instrument / sub-system health and are conducted during each major environmental test, before and after the vibration test and during the thermal cycles of the TVAC test.

A functional test of the EUI instrument suite, including OBS, CEB and harness is also performed under representative thermal environment to demonstrate the correct functional working of EUI (so-called "integrated test").

Functional tests include testing of mechanisms and in particular at sub-system level it includes life-time testing of mechanisms. The detectors functional and performance tests are performed before and after radiation tests.

3.2 Units and Instrument qualification

The instrument qualification activities involve the two OBS and CEB units, individually tested and then combined as listed in Table 1.

The EUI units and instrument QM test flow is shown on Figure 7.

- It starts from sub-systems manufacturing up to instrument integrated tests of the two OBS and CEB units.
- The flow includes a series of Key Inspection Points (KIP) and Mandatory Inspection Points (MIP) dedicated to assess the status of the previous steps before proceeding to the next ones.
- The overall flow ends up with the qualification review, which drives the start of the flight model Assembly Integration and Tests (AIT).

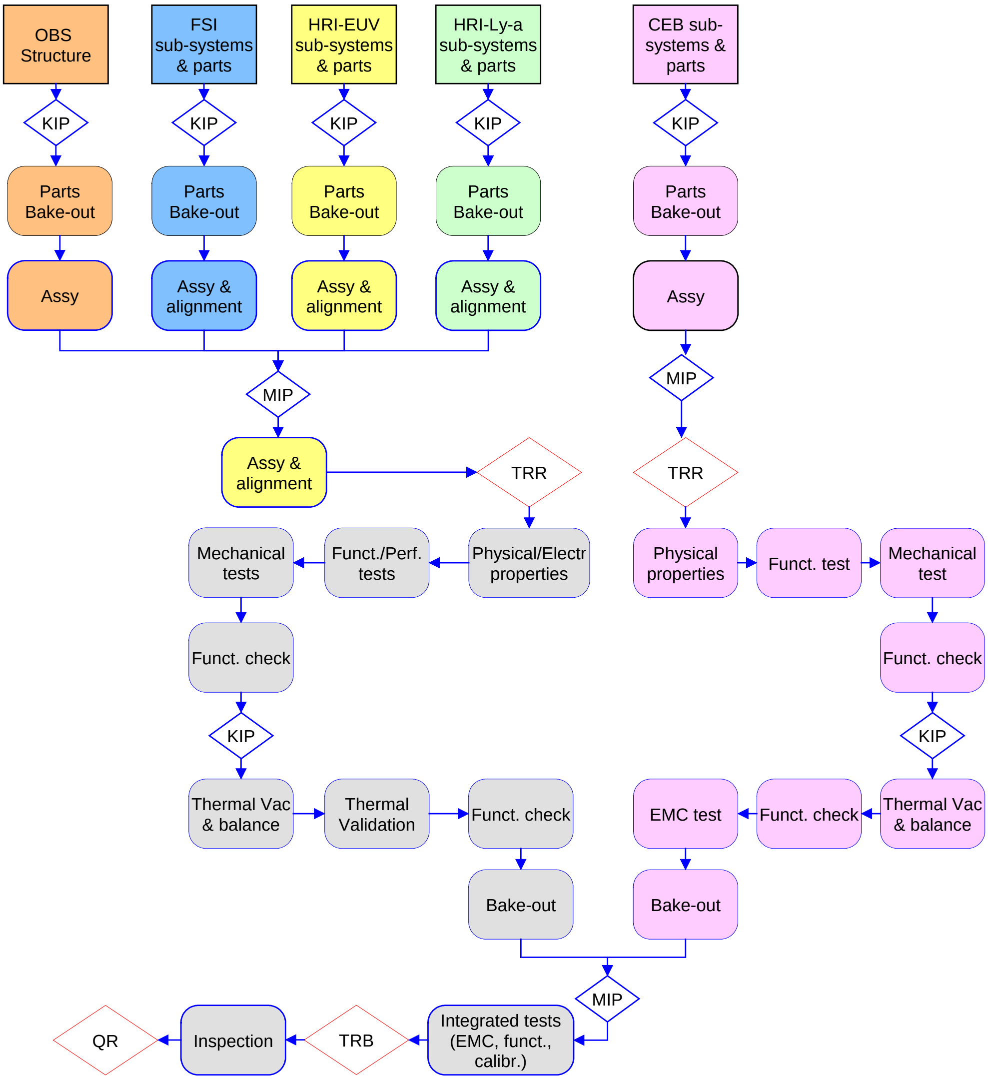

Figure 7 – EUI units and instrument QM test flow

The objectives of the instrument QM are the following:

- **Assembly**: check all sub-systems properly fit within the OBS structure.
- **Optical**: verification and repetition of integration and alignment, and an end-to-end verification of optical paths.
- **Electrical**: verification of electrical performances, incl. EMC tests, validation of on-board software and functional interfaces.
- **Mechanical**: qualification at unit level using qualification levels.
- **Thermal**: qualification at unit level (the test setup developed for the OBS STM [17] will be re-used) using qualification levels.
- **Performances**: on-ground calibration preparation.

The parts used for the OBS QM are not necessarily all hi-rel./rad.-hard but will be of the same type being used for the flight units.

The CEB QM, on the other hand, is the flight spare unit that will not be refurbished and is thus fully flight-like

4. INSTRUMENT PHASE D – FLIGHT MODEL

4.1 Manufacturing Readiness Reviews

The flight model manufacturing shall ideally be started after the qualification review, after the successful completion of all qualification activities. Due to planning constraints, the EUI flight model instrument must be delivered before end of 2016 to be on time for the October 2018 launch, the long lead procurement flight hardware (cameras and CEB electronic components, door motors and launch locks, structure panels) have been ordered and will be available before the end of the QM campaign.

Dedicated Manufacturing Readiness Reviews (MRR) is performed for each sub-system. Such review aim to check the design status at the time of manufacturing

4.2 AIT

The assembly and test flow of the flight model units is very similar to the qualification model (Figure 7), except that acceptance levels are applied (i.e. 3dB/5°K lower than the qualification levels).

After the unit tests, the EUI flight model will be integrated and tested on the S/C. Apart classical thermal and mechanical (acoustic) tests, the following S/C functional tests will also be performed to check the instrument / sub-system health:

- At delivery (short functional tests – typically < 1 hour duration):
    - Dark images and images with internal LED lamps (door closed), acquisition and processing with data transfer to the S/C on-board memory.
    - Switch-on of detector annealing and decontamination heaters, and check temperature increases (stop after 10 °C increase).
    - Functional tests of the Intensifier and High Voltage Unit (HVU), at the lowest possible HV level (no LED images on Ly-a channel).
- After S/C vibrations and TBAL tests (full functional tests – typically < 8 hour duration):
    - The same sequence of dark and LED images (door closed) acquisition and processing with data transfer to the S/C on-board memory.
    - Switch-on of detector annealing and decontamination heaters, and check of temperature increases (stop after 10 °C increase)
    - Door opening and closing (full cycle) and filter wheel rotations
    - Functional tests of the Intensifier-HVU (HV when chamber pressure is < 10-4 mbar and Ly-a LED images at TBD voltage; lowest possible HV level in ambient).
    - Check co-alignment with other remote sensing instruments.

4.3 Flight spare

The Flight Spare (FS) is intended for the replacement of failed or damaged equipment of the FM during instrument and spacecraft AIT.

All critical parts (moving parts, electrical components, optical parts…) of the OBS unit are replaced by FS kits. Structural parts are refurbished (i.e. cleaned, metrology and integrity check, re-assembly) if not subject to a major issue occurring during QM AIV

The OBS FS is thus composed of the following parts:

- FS optical bench structure, with FS mounts
- Refurbished QM camera housing with FS detector and FS electronic boards and components (including LEDs)
- Refurbished QM HVU housing with FS board and components
- FS mirrors and mounts
- Refurbished QM doors housing with FS motors, micro-switches, launch-lock
- Refurbished QM filter wheels frame with FS filters, motor, bearing and coupling parts
- Refurbished QM entrance baffles, with FS entrance filters

The CEB QM unit will be the FS with minimum refurbishment.

5. CONCLUSIONS

The detailed design achieved for the instrument CDR releases the manufacturing of the qualification model and flight model sub-systems and parts.

The QM will serve to qualify the instrument units and sub-units, in advance of the flight part assembly and acceptance tests. The flight model will then undergo a complete on-ground calibration that will serve as reference for in-flight operations, before integration on the Solar Orbiter spacecraft.

In the meantime, the OBS STM and the OBS and CEB EM will have been integrated and tested on the respective spacecraft STM and ETB, and submitted to the respective test campaigns at spacecraft level. The results of these spacecraft activities, being too late for the instrument QM and FM development will mainly be used as feedback for the QM and FM test activities.

ACKNOWLEDGEMENTS

The EUI instrument is developed in a collaboration which includes the Centre Spatial de Liège (Belgium), the Institut d'Astrophysique Spatiale and the Institut d’Optique (France), the UCL Mullard Space Science Laboratory (UK), the Max Planck Institute for Solar System Research (Germany), the Physikalisch-Meteorologisches Observatorium Davos (Switzerland), and the Royal Observatory of Belgium (Belgium).

The Belgian institutes are funded by Belgian Federal Science Policy Office (BELPSO); the French institutes by Centre National d'Etudes Spatiales (CNES); the UK institute by the UK Space Agency (UKSA); the German institute by Deutsche Zentrum für Luft- und Raumfahrt e.V. (DLR), and the Swiss institute by the Swiss Space Office (SSO).

REFERENCES

[1] Fleck B., Harrison R. A., Marsden R. G., Wimmer-Schweingruber R., “Summary of the Solar Orbiter payload working group activities, Telescopes and Instrumentation for Solar Astrophysics” Proc. SPIE 5171, 123-130, (2004).

[2] Marsden R.G., Marsch E. and the Solar Orbiter Science Definition Team, “Solar Orbiter Science Requirements Document” SCI-SH/2005/100/RGM, Issue 1 Revision 2 (2005).

[3] Mc Coy D., and the Solar Orbiter assessment team, “Solar Orbiter Payload Definition Document” SCI-A/2004/175/AO, Issue 5 Revision 0 (2006).
[4] Auchere F., Song X., Rouesnel F., Appourchaux T., Fourmon J.-J., Le Clec'h J.-C., Berthe M., Defise J.-M., Mazy, E., Rochus P., Mercier R., Ravet M.-F., “Innovative designs for the imaging suite on Solar Orbiter, Solar Physics and Space Weather Instrumentation” Proc. SPIE 5901, 298-304, (2005).
[5] Vial J.-C., “Solar Orbiter: A unique opportunity for investigating small-scale physical processes at work in the magnetic solar atmosphere, Advances in Space Research” Advances in Space Research 36, 1375-1386 (2005).
[6] Young P. R., and the EUS Science Working Group, “Science With The Extreme Ultraviolet Spectrometer For Solar Orbiter” Proc. of The Second Solar Orbiter Workshop, 641 (2006).
[7] Rochus P., Halain J.P., Renotte E., Berghmans D., Zhukov A., Hochedez J.F., Appourchaux T., Auchère F., Harra L.K, Schühle U., Mercier R.., “The Extreme Ultraviolet Imager (EUI) on-board the Solar orbiter Mission” 60th International Astronautical Congress, (2009).
[8] Hochedez J.-F., Appourchaux T., Defise J.-M., Harra L. K., Schuehle U., Auchère F., Curdt W., Hancock B., Kretzschmar M., Lawrence G., Marsch E., Parenti S., Podladchikova E., Rochus P., Rodriguez L., Rouesnel F., Solanki S., Teriaca L., Van Driel L., Vial J.-C., Winter B., Zhukov A., “EUI, The Ultraviolet Imaging Telescopes of Solar Orbiter” The Second Solar Orbiter Workshop, (2006).
[9] Halain J.-P., Rochus P., Appourchaux T., Berghmans D., Harra L., Schühle U., Auchère F., Zhukov A., Renotte E., Defise J.-M., Rossi L., Fleury-Frenette K., Jacques L., Hochedez J.-F., Ben Moussa A., "The technical challenges of the Solar-Orbiter EUI instrument” Proc. SPIE 7732, 26 (2010)
[10] Halain J.-P. , Berghmans D., Defise J.-M., Renotte E., Thibert T., Mazy E., Rochus P., Nicula B., De Groof A., Seaton D., Schühle U., “The First light of SWAP on-board PROBA2” Proc. SPIE 7732, 24 (2010)
[11] Auchère F., et al., "HECOR, a HElium CORonagraph aboard the Herschel sounding rocket" Proc. SPIE 6689, (2007)
[12] Schühle U., Halain J., Meining S., Teriaca L., "The Lyman-alpha telescope of the extreme ultraviolet imager on Solar Orbiter" Proc. SPIE Solar Physics and Space Weather Instrumentation IV, 8148, (2011)
[13] Halain J.-P., Rochus P., Renotte E., Appourchaux T., Berghmans D., Harra L., Schühle U., Schmutz W., Auchère, F., Zhukov A., Dumesnil C., Kennedy, T., Mercier R., Pfiffner D., Rossi L., Tandy J., Smith P., “The EUI instrument on board the Solar Orbiter mission: from breadboard and prototypes to instrument model validation” Proc. SPIE 8443, (2012)
[14] Delmotte F., et al., “Development of multilayer coatings for Solar Orbiter EUV imaging telescopes” Proc. SPIE 8877, (2013)
[15] Fahmy S., Bagnasco G., Pacros A., Wirth K., “Solar Orbiter payload suite: a hotbed of innovation” 64th International Astronautical Congress, IAC-13-A3.5.2, (2013)
[16] Halain JP, Debaize A., Gillis JM., Jacques L., De Ridder T., Hermans L., Koch M., Meynant G., Schippers G., “The dual-gain 10 µm back-thinned 3k x 3k CMOS-APS detector of the Solar Orbiter Extreme UV Imager” Proc. SPIE, 9144, (2014)
[17] G. Randall Gladstone et al., “The Ultraviolet Spectrograph on NASA’s Juno Mission” Space Science Reviews, (2014)
[18] Halain JP, Rochus P, Renotte E, Auchère F, Berghmans D, Harra L, Schühle U, Schmutz W, Zhukov A, Aznar Cuadrado R, Delmotte F, Dumesnil C, Gyo M, Kennedy T, Mercier R, Verbeeck C, Thome M, Heerlein K, Hermans A, Jacques L, Mazzoli A, Meining S, Rossi L, Tandy J, Smith P, Winter B, “The Extreme UV Imager of Solar Orbiter – From detailed design to Flight Model” Proc SPIE, 9144, (2014)