FLEX LOW RESOLUTION SPECTROMETER BREADBOARD ACTIVITIES

A. Altbauer(1), P. Sandri(1), D.A. Lang(1), L. Pettinato(2), R. Gabrieli(2), P. Coppo(2), M. Taccola(3), D. Nuzzi(4)

(1) OHB System AG - Manfred-Fuchs-Str. 1, D-82234 Weßling, Germany, (2) Leonardo - SpA Via delle Officine Galileo 1, Campi Bisenzio (FI), 50013, Italy, (3) European Space Agency - European Space Research and Technology Center, Noordwijk, The Netherlands, (4) Altran Italia SpA Via Guglielmo Marconi 30, 50131 Firenze - Italy (c/o Leonardo)

1. INTRODUCTION

The FLEX Space Segment consists of a single satellite carrying the FLuORescence Imaging Spectrometer (FLORIS) operating in the 500-780 nm spectral band [1]. FLEX will fly in tandem with Copernicus Sentinel-3 working in combination with the Ocean and Land Color Instrument (OLCI) [2] and the Sea and Land Surface Temperature Radiometer (SLSTR) [3,4]. FLEX will provide important additional information regarding the vegetation fluorescence signal and a more accurate atmospheric corrections, which are essential for a quantitative evaluation of the status of health of vegetation. The FLORIS instrument [5] is composed of a High (HRS) and a Low Resolution Spectrometer (LRS), with a spectral sampling and resolution respectively of 0.1 and 0.3 nm (HRS), and 0.6 and 1.8 nm (LRS). A flight representative breadboard of the High Resolution Spectrometer was developed by Leonardo and testing results can be found in reference [6]. OHB is responsible of the Low Resolution Spectrometer and another breadboard was designed, manufactured, integrated, aligned and tested at OHB premises. This paper presents the results of the breadboard campaign for the LRS and shows the derived Flight Model (FM) alignment strategy.

2. OPTICAL LAYOUT OF THE BREADBOARD LRSPE

The optical layout of the Breadboard of the Low Resolution Spectrometer of FLEX relies on a 1x Magnification Offner Relay (Figure 1), presenting a first order effective focal length of 3168.663mm and achieving the theoretical diffraction limit (Figure **2**, Figure **3**) in the spectral range [500; 740] nm, for a rectangular Field of View with dimensions ± 0.042 mm (slit width in X-direction) times ± 22.05 mm (slit length in Y-direction). The spectrometer works with F/6.5 and the grating generated by holographic recording presents a saw-tooth profile with 500 lines/mm.

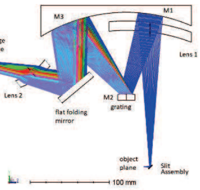


Figure 1: BB layout of the FLEX LRSPE.

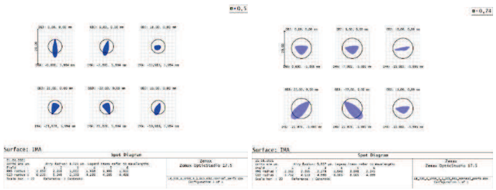


Figure 2. Theoretical spot diagrams of the BB of the FLEX LRSPE

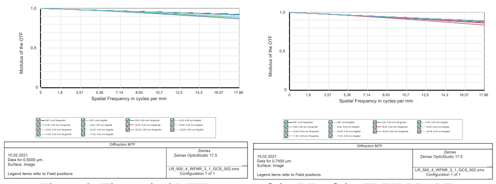
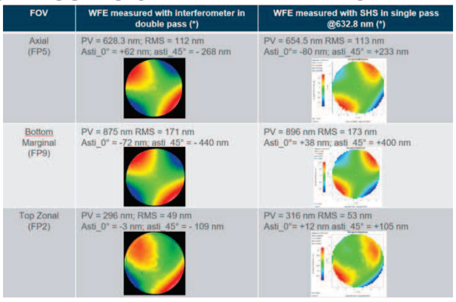


Figure 3. Theoretical MTF curves of the BB of the FLEX LRSPE.

3. ALIGNMENT CONCEPT TESTED IN BB

The instrument internal alignment strategy for the BB consists in the identification of the optimal position of the mirror M1+M3 in the LRSPE Housing guaranteeing the compliance for the WFE, which is the first image quality parameter to be measured. After the successful position optimization of the mirror M1+M3, the FISLI (slit-simulator) was installed and the Wave Front Error (WFE) and Modulation Transfer Function (MTF) for all field points and all wavelengths was measured (Figure 4, Figure 9). Finally, an auxiliary camera, precisely aligned on the image plane, enabled minimization of the keystone, achieved by clocking the grating groves along the optical axis wrt the FISLI (Figure 6). This alignment strategy resulted successful (Sect. 4).

4. RESULTS OF THE BB CAMPAIGN



FOV	WFE measured with interferometer in double pass (*)	WFE measured with SHS in single pass @632.8 nm (*)
Axial (FP5)	PV = 628.3 nm; RMS = 112 nm Asti_0° = +62 nm; asti_45° = - 268 nm	PV = 654.5 nm RMS = 113 nm Asti_0°= -80 nm; asti_45° = +233 nm
Bottom Marginal (FP9)	PV = 875 nm RMS = 171 nm Asti_0° = -72 nm; asti_45° = - 440 nm	PV = 896 nm RMS = 173 nm Asti_0°= +38 nm; asti_45° = +400 nm
Top Zonal (FP2)	PV = 296 nm; RMS = 49 nm Asti_0° = -3 nm; asti_45° = - 109 nm	PV = 316 nm RMS = 53 nm Asti_0°= +12 nm asti_45° = +105 nm

Figure **4**. WFE measurements - double pass vs. single pass.

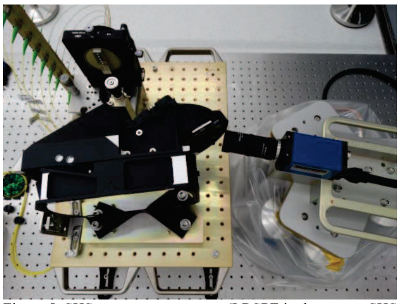


Figure 5: SHS measurement set-up (LRSPE in the center, SHS on the right, FISLI at the top)

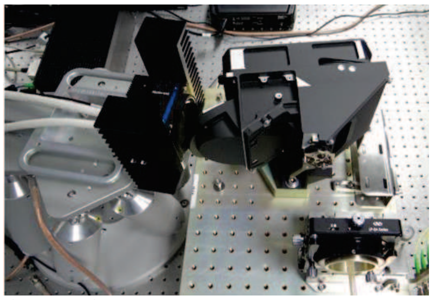


Figure 6: Service Detector measurement set-up

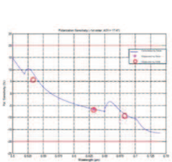


Figure 7: Pol. Sensitivity

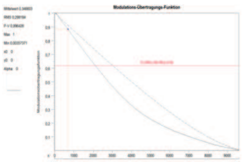


Figure 8: MTF measurement.

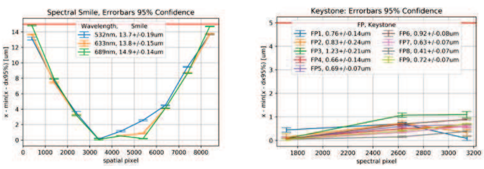


Figure 9: Smile and keystone results

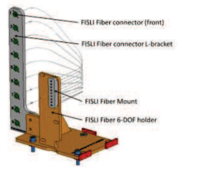


Figure 10: Fibre-based slit assembly FISLI .

5. LAYOUT OF THE FM LRSPE AND UPDATED ALIGNMENT CONCEPT FOR FM

The optical design was reviewed in order to cover a working spectral range extending up to 758 nm and in order to fulfill tighter requirements for MTF both along and across track, Spectral Sampling Interval (SSI), stray-light and spectral resolution (SR). Furthermore, the need to withstand high mechanical loads pushed the opto-mechanical design to a light-weighted metal M1/M2 mirror concept. To identify a suitable criterion that could be implemented in the AIT phases, an analysis was performed on the population of the Monte Carlo Trails generated for the Tolerance Analysis, focusing attention on following parameters: WFE_{rms} for axial FoV, $||Z_6^{St}|_0 - |Z_5^{St}|_0|$, WFE_{rms} for marginal FoV, $||Z_6^{St}|_{-22} - |Z_5^{St}|_{+22}|$.

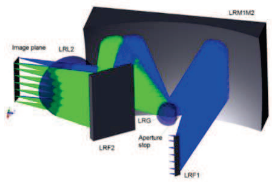


Figure 11: Optical layout of the FM FLEX Low Resolution Spectrometer.

6. CONCLUSION

The BB campaign has proven that the theoretical developed alignment concept could be directly applied to the BB Instrument. The BB resulted compliant to all the optical performances. For Flight LRSPE the established updated alignment concept will be validated during the FM campaign. The necessary update of the different OGSE is already implemented. The flight optical and mechanical parts are currently in the manufacturing phase and some parts, as the flight lens and the flight flat mirror, are already in OHB. The assembly, alignment and testing is planned to be performed in 2021. The delivery of the flight LRSPE is foreseen for end of 2021.

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