**ABSTRACT**

The XMM-Newton space observatory [1] is one of the “cornerstone” missions of the Horizon 2000 plan of the European Space Agency (ESA) [2], it was launched in December 1999 and, although it was originally planned to work for ten years, after almost 15 years in orbit it continues to operate almost like new.

Since the launch, the design and operation of the European Photon Imaging Camera (EPIC) [3], i.e. the telescope focal-plane detector, are continuously monitored using the flight Spare FPs (FS) units on the ground, one for each of the two on-board detectors: EPIC (S) and EPIC (P) [4]. Since such cameras are representative copies of the corresponding on-board instruments, ESA respond to keep them efficient, in order to make it possible the on-ground test of any change or update concerning the instrument SW, the TLM database or the commanding procedure. That possibility will be increasingly important in the future, since the expected instrument degradation and the aging processes may require substantial change in the instrument SW and database.

Both FS cameras are still operated through the same Electrical Ground Support Equipment (EGSE) which was used for this test before the satellite integration. It is based on the following items (Figure 1).

- The Interface Simulator Unit (ISU), which interfaces directly with the instrument Data Handling: it includes both the power L/F simulator, to power the instruments, and the front-end electronics, for the monitoring of the analog inputs and analog outputs, for the interface between the ISU and the spacecraft.
- The Central Check-Out Equipment (CCE) is the Master Test Processor used to operate the instrument, i.e. to send the TCs and to receive, display and archive the IFI.
- The EBHT (Electrical Break-Through Hardware Testing), the OBHT (Onboard Hardware Testing), the ISU-based CA and all other auxiliary items, which is now ready to be used by ESA. Here we report the status of the EGSE, the activity, the problems faced during the setup and the adaptations needed to use it.

**The new EGSE architecture**

The upgrade of the EPIC EGSE with the SXE has faced two main problems:

- ISUIA: it is a Mission Operations Control System developed by ESA to manage the routine operations of the flying missions from the Mission Operation Centre (MOC), which manages the instrument operations, and from the Science Control System (SCSS) of the Science Operation Centre (SOC) for the monitoring and archiving of the scientific data. In this scheme the direct interface with the instrument is still provided by the original ISU equipment, which, due to both technical and financial reasons, could not be replaced or modified.

**Project development**

The ISUIA development went through different phases:

1. ISUIA: it is a Mission Operations Control System developed by ESA to manage the routine operations of the flying missions from the Mission Operation Centre (MOC), which manages the instrument operations, and from the Science Control System (SCSS) of the Science Operation Centre (SOC) for the monitoring and archiving of the scientific data. In this scheme the direct interface with the instrument is still provided by the original ISU equipment, which, due to both technical and financial reasons, could not be replaced or modified.

2. Design generation of the ISUIA Software Design Document (SDD), inclusive of both the hardware architecture and the complete interface definition.
3. Coding & Debugging: coding of the ISUIA SW and test of single SW modules by using a SW debugger.
4. Integration & Acceptance: test of the ISUIA in connection with the ISU and the SW debugger in a configuration in which the instrument is simulated (by the ISU and the ISU-based simulation capabilities).
5. Commissioning: test of the ISUIA in connection with the ISU and the SXE OBDH, in a configuration in which a real instrument is present. After the SW Design, Coding and Debugging phase, we performed the first test L/F tests between EPIC/SXE and SXE ISUIA, in this case, since there was no interface with the real instrument, the SXE in the SXE OBDH simulation mode, receiving an incoming TM frame from the ISU (a string length of the frame trailer was assumed). This way was possible to send TCs from SXE to ISU and to receive TM PKTs from SXE and ISU SW in both cases, the test received TCs were correctly displayed in the TM/TC packet history at MOS/SOC local level. This proved that the communication L/F protocol provided by ISUIA was properly working.

The next step was the integration of the new SXE-based ISUIA with the real instrument (Figure 2 bottom). This was performed at the Leicester University, where the MOS FS camera is hosted from the XMM launch. With this configuration we performed three different test campaign.

1. During the first test, the whole SXE EGSE was interfaced with the MOS FS instrument. We managed to properly transfer single TC and TM PKTs between SXE and ISU, but not receive a continuous flow of TM data on ISUIA side (i.e. without a specific request from the ISU); this function, which is necessary for the test purpose and was ensured by the previous SXE EGSE configuration. This last version was fixed by setting a specific command at SXE level: it enables a loop sequence which can be used to test the SXE handling telemetry packets from the data chain, in the same way as before.

2. In the second test, the ISUIA protocol was successfully tested during a second test campaign.

3. On the third test campaign the final commissioning tests of the new SXE EGSE were performed. To this aim, we executed the following procedures, which were adapted from the flight operations used for the on-board campaigns:
   - Normal switch-on
   - Failure Wheel synchronization and rotation
   - Acquisition of Diagnostic images for each of the seven cameras
   - Generation of Scientific data in DeCon mode
   - Normal switch-off

These procedures were designed to be used with a fully operational camera cooled to operating temperature (100°C - 120°C), while during the commissioning tests the camera was used as a spare instrument, as a consequence, the CCD images were saturated and the analog chains were overloaded. However, all the operations were successfully performed, as expected, also taking into account the high operational temperature, therefore it was possible to assess that the system was properly working.

Finally, the spare chain system was successfully operated also with non-operating camera from the XMM-SOC.

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1. INAF - IASF, Milano (I)
2. Leicester University, Leicester (UK)
3. Thales Alenia Space Italia, Gorgonzola (I)
4. ESA - ESAC, Madrid (E)
5. ESA - ESOC, Darmstadt (D)

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**NEW SCOS-BASED EGSE**

- Instrument overview
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- Both FS cameras are still operated through the same Electrical Ground Support Equipment (EGSE) which was used for this test before the satellite integration. It is based on the following items (Figure 1).
  - The Interface Simulator Unit (ISU), which interfaces directly with the instrument Data Handling: it includes both the power L/F simulator, to power the instruments, and the front-end electronics, for the monitoring of the analog inputs and analog outputs, for the interface between the ISU and the spacecraft.
  - The Central Check-Out Equipment (CCE) is the Master Test Processor used to operate the instrument, i.e. to send the TCs and to receive, display and archive the IFI.
  - The EBHT (Electrical Break-Through Hardware Testing), the OBHT (Onboard Hardware Testing), the ISU-based CA and all other auxiliary items, which is now ready to be used by ESA. Here we report the status of the EGSE, the activity, the problems faced during the setup and the adaptations needed to use it.

- **The new EGSE architecture**
  - The upgrade of the EPIC EGSE with SXE has faced two main problems:
    - ISUIA: it is a Mission Operations Control System developed by ESA to manage the routine operations of the flying missions from the Mission Operation Centre (MOC), which manages the instrument operations, and from the Science Control System (SCSS) of the Science Operation Centre (SOC) for the monitoring and archiving of the scientific data. In this scheme the direct interface with the instrument is still provided by the original ISU equipment, which, due to both technical and financial reasons, could not be replaced or modified.

- **Project development**
  - The ISUIA development went through different phases:
    1. ISUIA: it is a Mission Operations Control System developed by ESA to manage the routine operations of the flying missions from the Mission Operation Centre (MOC), which manages the instrument operations, and from the Science Control System (SCSS) of the Science Operation Centre (SOC) for the monitoring and archiving of the scientific data. In this scheme the direct interface with the instrument is still provided by the original ISU equipment, which, due to both technical and financial reasons, could not be replaced or modified.
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    The next step was the integration of the new SXE-based ISUIA with the real instrument (Figure 2 bottom). This was performed at the Leicester University, where the MOS FS camera is hosted from the XMM launch. With this configuration we performed three different test campaign.
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