A modular design for the ARIEL on-board electronics

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Abstract

The ARIEL (Atmospheric Remote-sensing Infrared Exoplanet Large-survey) Mission has been selected by ESA as the fourth medium-class (M4) scientific satellite of the Cosmic Vision Program, to be launched in 2028 [1].

ARIEL aims at the study of the atmospheres of a selected sample of warm and hot exoplanets mainly by means of primary and secondary transit spectroscopy [2].

The payload is based on a 1-m class telescope ahead of a suite of instruments: three spectrometric channels covering the band from 1.20 to 7.80 µm without spectral gaps and three photometric channels working in the range 0.5 to 1.2 µm.

AIRS, the ARIEL IR Spectrometer [3], is connected to and operated by the Instrument Control Unit (ICU), in charge of the overall Instrument Control, and by the Telescope Control Unit (TCU), whose actual aim is the thermal monitoring of the telescope and the fine thermal regulation of the AIRS detectors Control Thermal System (TCS).

Here we mainly describe the baseline ARIEL on-board electronics architecture, from the AIRS output to the electrical I/F to the Service Vehicle Module (SVM).

1. Introduction

The ARIEL Payload (P/L) is composed of many subsystems on both its cold and warm sides. The ICU, TCU and DCU (Detector Control Unit) are located on the warm part of the SVM, maintained at ambient temperature (~270-300 K).

DCU interfaces the FPA (Focal Plane Assembly) CFEE (Cold Front End Electronics) in order to control the detection process, and to the ICU to transfer the Science Data Packets towards the Spacecraft [4].

2. Warm electronics

The warm Units host analog and digital electronics, whose aim is to drive and control the overall data acquisition chain (scientific data and instrument housekeeping, HK), monitoring the telescope and the payload subsystems temperatures, commanding and provide the SVM with the scientific telemetries and the Instrument health status.

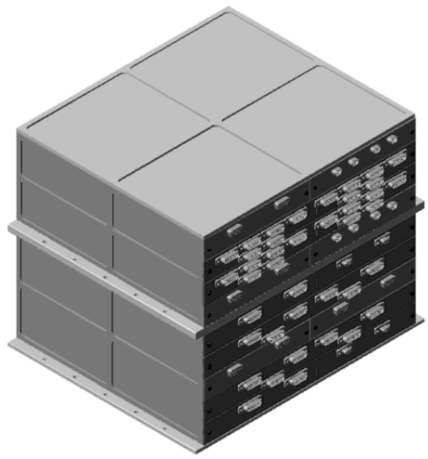

Figure 1: The modular design of the ARIEL-AIRS warm electronics, based on stacked drawers hosting the DCU, TCU and ICU analog and digital electronics.

2.1 Instrument Control Unit

The ICU [5] is interfaced on one side with the instrument and on the other side (Spacecraft, S/C, side) with the Data Management System (DMS) and the Power Conditioning and Distribution Unit (PCDU), both belonging to the hosting platform.

The ICU design is conceived for scientific data pre-processing and to implement the commanding and control of the AIRS Spectrometer. It will run the Application SW (ASW) [6] in charge of instrument management and scientific data processing and it will feed and control the TCU, in order to collect all the needed housekeeping for a proper active control of all the on-board subsystems (SS). In this sense, TCU is considered an ICU slave subsystem.

2.2 Telescope Control Unit

To constrain the P/L thermo-mechanically induced optical aberrations, the temperature of the primary mirror (M1) [7] will be monitored and finely tuned by means of an active thermal control system based on thermistors and heaters. They will be switched on and off to maintain the M1 temperature within ±1K thanks to a proportional–integral–derivative (PID) controller implemented within the Telescope Control Unit, the payload electronics subsystem mainly in charge of active thermal stabilisation of the TCS of two detectors belonging to AIRS, besides M1.

TCU shall also control the on-board IR calibrator by means of an accurate feedback-loop system, the M2 refocusing mechanism and will collect the HK of the controlled subsystems, forwarding them to the ICU.

2.1 Detector Control Unit

DCU interfaces internally to the AIRS FPA CFEE and the detectors to control the detection process and, externally, to the ICU to transfer the Science Data Packet. The main function of the DCU are:

- control data acquisition at detector level through the CFEE;
- process the data from the detector prior the formatting of the Science Data Packet done by ICU;
- ensure the proper interface with the ICU for TC reception, HK and Science Data Packet transmission.

3. Cold electronics

The detectors and their control electronics are located on the cold side of the Payload (P/L) to limit noise and efficiently detect the IR spectroscopic signatures of the selected exoplanetary atmospheres. Detectors shall work down-to 42 K, while the CFEE will be operated at a higher temperature.

The baseline design for the AIRS IR focal plane sensors is based on the adoption of the H1RG-type detectors from Teledyne coupled with the Teledyne SIDECAR ASIC, already developed to drive efficiently the H*RG detectors and tested in relevant space environments. Both detector arrays and ASIC are based on US technology.

In parallel, a particular effort is being planned in the ARIEL Consortium to provide an alternative solution for the AIRS focal plane assembly, based on European technology: the sensors are under study at CEA-Saclay (F) and the readout ASIC is under development at SRON (The Netherlands Institute for Space Research).

4. Summary and Conclusions

This short paper has shown the status of the ARIEL on-board electronics at the beginning of the Phase B1 of the Project. The selected architecture is still under consolidation as it will undergo two following reviews by ESA during the next two years, the P/L Preliminary Design Consolidation Review (PDCR) and the System Requirements Review (SRR).

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