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The Instrument Control Unit of ARIEL

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Abstract

ARIEL (Atmospheric Remote-sensing Infrared Exoplanet Large-survey) is a medium-class mission selected by ESA to be launched in 2028 [1], aiming 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 Instrument Control Unit (ICU) [3] is a subsystem of the ARIEL Payload (P/L) and it is the warm electronics unit, residing into the Service Module (SVM), in charge of managing the ARIEL Infrared Spectrometer (AIRS) and processing the delivered scientific data before sending it to the Spacecraft On Board Data Handling system (OBDH).

Here we describe the baseline ICU architecture and its key parts in the overall functionality of the satellite.

1. Introduction

The ARIEL P/L is based on a 1-m class telescope ahead of a suite of instruments: three spectrometric channels covering the band from 1.1 to 7.80 µm without spectral gaps and three photometric channels working in the range 0.5 to 1.1 µm. It is composed of many subsystems on both its cold and warm sides.

The warm Units, maintained at ambient temperature (~270-300 K), host analog and digital electronics whose aim is to drive and control the overall data acquisition chain (scientific data and instrument housekeeping - HK), monitor the telescope and the P/L subsystems temperatures, command and provide the SVM with the scientific telemetries and the Instrument health status.

2. Instrument Control Unit

The ICU is conceived as an assembly composed of multiple boxes hosting four subsystems: the Power Supply Unit (PSU), the Command and Data Processing Unit (CDPU), the Telescope Control Unit (TCU) and the Detector Control Unit (DCU). The present ICU architecture is based on a partial cold-redundant and cross-strapped configuration, in particular both TCUs and DCUs are cross strapped and can work along with both the nominal and redundant PSU and CDPU assemblies.

PSU and CDPU (including the processor running the Application SW), along with the ICU Assembly, Integration and Test/Verification (AIT/AIV) activities are in charge of Italy (INAF and its Prime Contractor), while the DCU design and manufacturing, and the TCU are respectively in charge of France (CEA) and Spain (IEEE).

2.1 Power Supply Unit

The PSU board adopts, as baseline, a typical design hosting DC/DC converters with a number of secondary sections needed to support the adopted cross-strapped and partially redundant configuration. In addition to the production of the secondary voltages needed by all units on board ICU, PSU is in charge of collecting currents, voltages on secondary outputs and temperatures HK.

The PSU is mainly composed of three sections: power conditioning section, power distribution section (hosting Output Power-Controllers, implementing switching capabilities and

overcurrent/overvoltage protections) and HK acquisition section.

2.2 Telescope Control Unit

The TCU subsystem is mainly in charge of active thermal stabilization of the primary mirror (M1) and thermal monitoring of several P/L subsystems. To constrain the P/L thermo-mechanically induced optical aberrations, the temperature of M1 will be monitored and finely tuned by means of an active thermal control system based on thermistors and heaters that will be switched on/off to maintain the temperature within ±1K, thanks to a proportional-integral-derivative (PID) controller.

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.

2.3 Detector Control Unit

The DCU is actually the digital warm electronics of the AIRS instrument and interfaces internally the AIRS FPA (Focal Plane Assembly) composed of the CFEE (Cold Front End Electronics) and the IR detectors.

The DCU digital outputs are linked to the CDPU in order to transfer the Science data towards the spacecraft, once compressed and packetized in CCSDS format. The main functions of the DCU subsystem are to control the data acquisition at detector level through the CFEE, to process the data from the detector prior the formatting of the science data packet (SDP) done by ICU, and to ensure the proper interface with the CDPU for telecommand reception, HK, and SDP transmission.

2.4 Command and Data Processing Unit

The CDPU is designed as a single board hosting a Central Processing Unit (CPU) and several memories (PROM, RAM, NVM) to host the boot SW, the Application SW and running it once loaded into RAM. In addition to the data acquisition and compression (with a lossless algorithm) tasks, this subsystem will acquire and monitor HK, configure and command the spectrometer subunits, manage the on-board time, handle telecommands and control the instrument (AIRS).

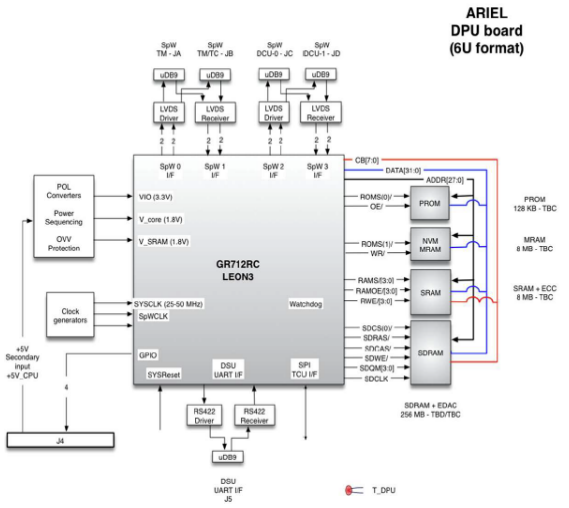

Figure 1: a possible configuration of the CDPU, hosting the GR712RC Leon 3 dual-core processor and different kinds of memories.

3. Summary and Conclusions

This short paper has described the design status of the ARIEL ICU subsystem during the B1 phase of the project. The selected architecture, HW and SW, is still under consolidation as it will undergo two following reviews by ESA during the next year, the P/L System Requirements Review (SRR) and the Mission Adoption Review (MAR), before starting the activities concerning the B2 phase of the project.

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