Intelligent Solutions for Astronomical Space Instrumentation

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The University of Vienna provides Instrument Flight Software for ESA missions including Ground Software modules for operation, testing and document generation. Flight Software and tools are developed for the current space mission CHEOPS and future space missions SMILE, ARIEL, ATHENA and PLATO.

Introduction

Scientific space missions for astrophysical purposes include complex instruments containing interacting computers dedicated to specific tasks. Aside from system control and communication, acquisition, guiding, sophisticated data handling and compression are key components to maximize the scientific data quality. The University of Vienna develops low- and high-level applications for the logical units on board and their operation. Each mission is different and therefore software frameworks, common standards, modular approaches and verification and qualification processes are used to develop the applications in short time with maximum product assurance.

Flight Software

The Instrument Flight Software is running on board the spacecraft and is developed following the ESA ECSS standard, which describes space management, product and quality assurance, space engineering and testing in detail.

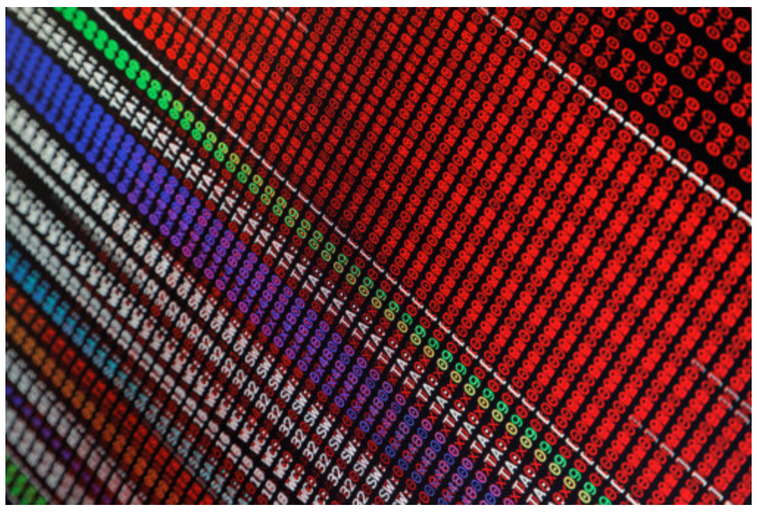

Figure 1: Telecommunication screen.

The Instrument Application Software (IASW) is developed at the University of Vienna as an open-source software, including all drivers and modules.

The low-level software provides access to the hardware using newly developed drivers and operating system functionality with minimal resource usage and system overheads.

On top of the low-level software resides the application software based on the CORDET service framework [1]. This library is developed and provided under an open-source license by PnP Software [2]. It offers a software infrastructure (e.g. state machines in Figure 2) for ECSS-based applications, a consistent solution for communication and control services, event handling and fault detection, isolation and recovery.

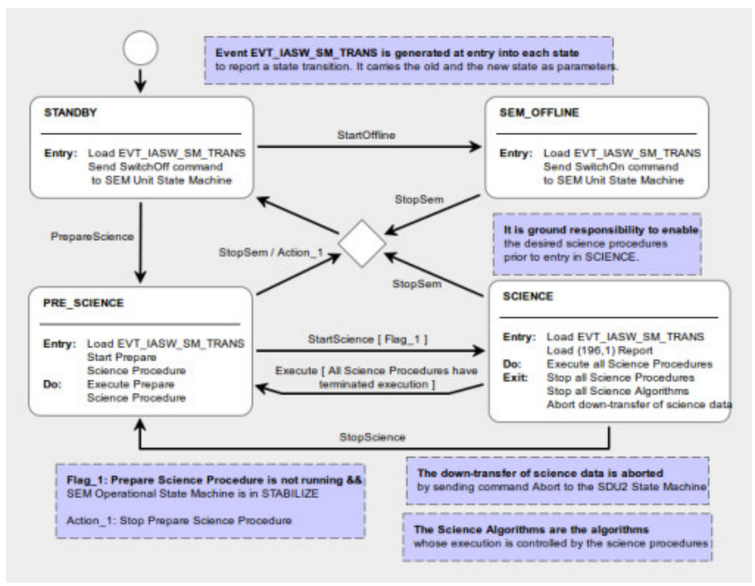

Figure 2: The CHEOPS IASW state machine.

For example, one of the main tasks of a Flight Software is to process the CCD images and compress them in real-time. This is achieved by a highly flexible data processing chain shown in Figure 5 which is used for the CHEOPS satellite mission.

On-board computers in ESA missions are mainly based on the LEON processor, a SPARC8-based family of system on chips. We have developed a lightweight but powerful operating system for LEON-based CPUs, ”LeanOS” is the consequence of almost two decades of lessons learned when dealing with flight components.

Ground System Modules

The contribution of the University of Vienna also includes Ground Software and EGSE software, e.g. modules for data decompression, the Central Checkout System (CCS) shown in Figure 3 as well as simulators. The CCS can connect to any port and/or hardware interface as shown in Figure 4 and allows test configurations ranging from a full hardware setup to the simulation of all sub-units in software. The CCS incorporates vast quick-look analysis capabilities and since it is entirely written in Python, it is extremely user-extensible. The CCS can actually be used for in-orbit commissioning.

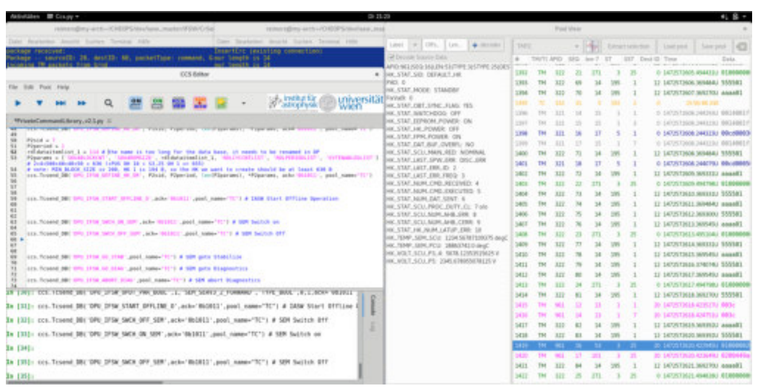

Figure 3: The Central Checkout System with commanding and telemetry monitoring capabilities.

In order to be able to encode the commands and decode the received telemetry reports, an Instrument Database (IDB) has to be available at the Mission Operations Centre (MOC). It contains the interface information from the Interface Control Documents in machine-readable form (a set of files in SCOS-2000 format).

Since the IASW is by far the biggest contributor to the IDB and we are also requiring it to generate our flight software DataPool as well as in the CCS to run our tests, it is most efficient that we provide the IDB ourselves. This is one lesson learned from previous missions to speed up the development cycle.

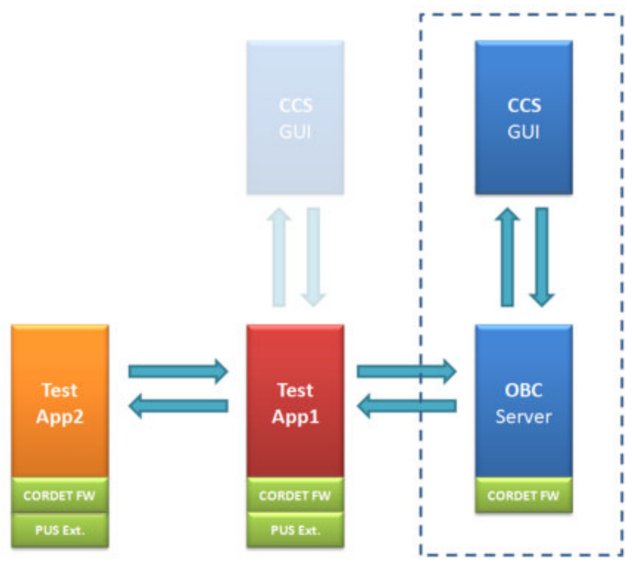

Figure 4: Test and Verification setup using simulators.

Testing and Document Generation

The Flight Software implementation and testing is carried out according to ECSS standards. The University of Vienna also contributes to various test campaigns including acceptance and qualification testing.

One new module under development is the Test Specification Tool, which shall greatly facilitate the workflow from test specification to execution and reporting.

A portfolio of simulators has been developed, which allow to emulate functional units involved in the on-board data stream and connect them either to others or to actual hardware interfaces using I/F Routers. Basically, we can simulate a complete payload instrument and we are making great use of these capabilities during flight software development.

The list of documents to be delivered during the development is given by the ECSS and the software code is also implemented by integrated Doxygen documentation.

References

[1] Cechticky, V., Ottensamer, R., and Pasetti, A., “Flight software development for the cheops instrument with the cordet framework,” *DASIA Proceedings* (2015).

[2] Pasetti, A. and Cechticky, V., “The framweork profile - c1 implementation,” PnP Software (2013).

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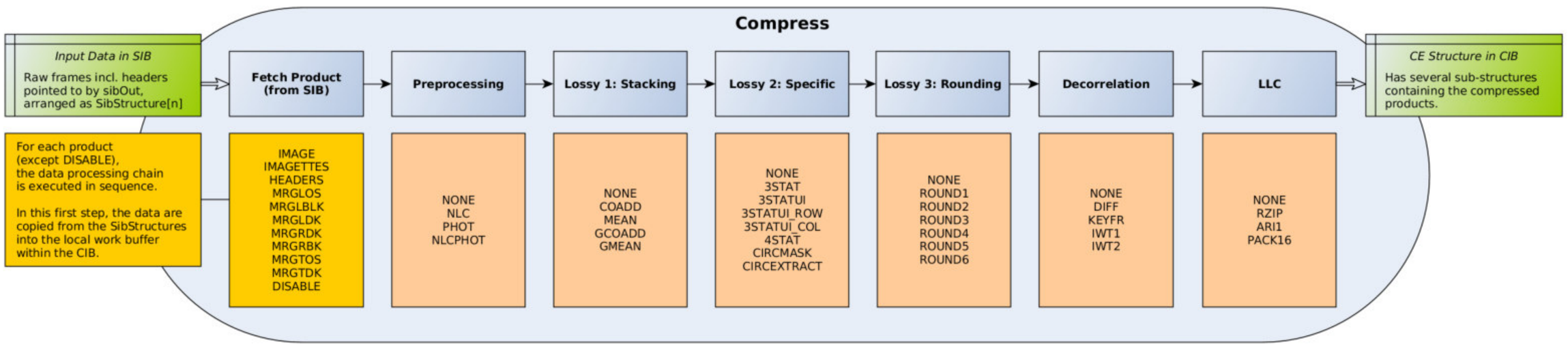

Figure 5: Overview of the science data processing chain for CHEOPS.