CSES-LIMADOU data processing at ASI-SSDC

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CSES-01 and HEPD-01

The main scientific objectives of CSES-01 mission are:

- monitoring the near-Earth electromagnetic environment
- measuring iono-magnetospheric perturbations possibly due to seismo-electromagnetic phenomena
- monitoring man-made electromagnetic effects at Low Earth Orbit altitudes
- studying spectra of charged particles precipitating from the Van Allen radiation belts
- observing changes in solar activity

The High-Energy Particle Detector (HEPD-01), developed by the Italian Collaboration, detects electrons, protons and light nuclei. The main objective is to measure the increase of the electron and proton fluxes due to short-time perturbations of the radiation belts caused by solar, terrestrial and anthropic phenomena. The energy range explored is 3 - 100 MeV for electrons and 30 - 200 MeV for protons.

CSES-01 Data Retrieval

The CSES-LIMADOU mission's ground segment consists of two elements: the Chinese Ground Segment at ICD-CEA and the Italian Ground Segment at SSDC (ASI, Italy). Major elements of the China Ground Segment are:

- Data Receiving System,
- Data Processing System
- Data Application System.

As soon HEPD-01 data are downlinked from the satellite are transferred to the Limadou Ground Segment at the Space Science Data Center (SSDC) located in the ASI HQ.
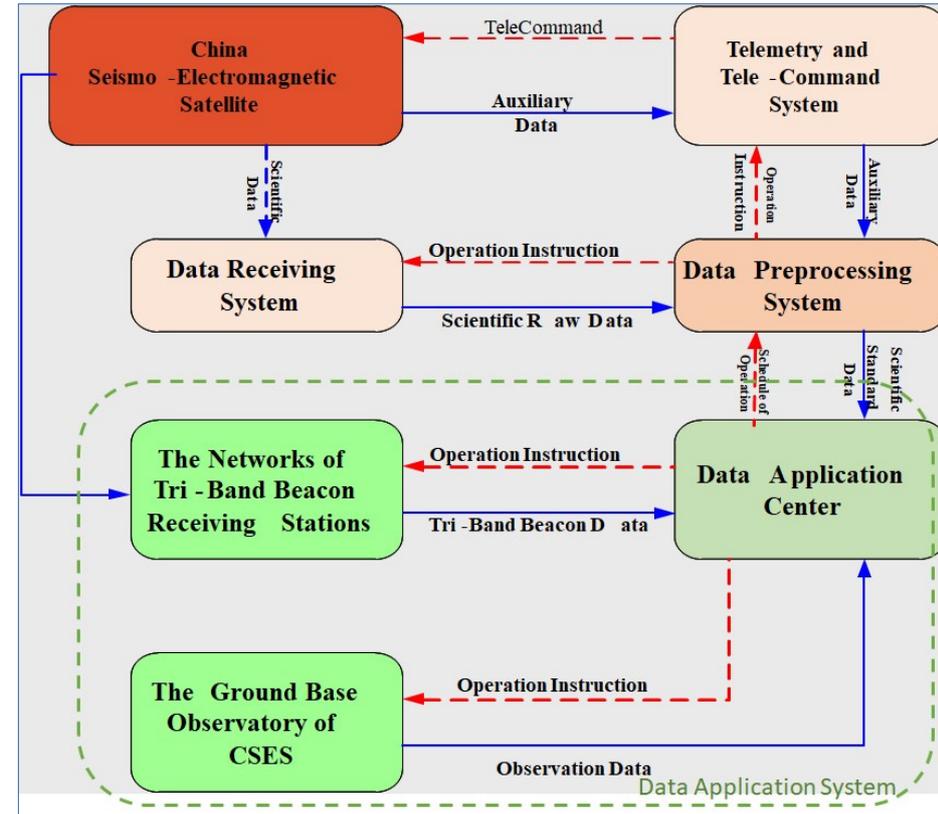
HEPD-01 Data Levels

The reconstruction occurs in three phases, which determine three different data formats, namely 0, 1 and 2, with increasing degree of abstraction.

    1. raw data as downlinked from the CSES. They include ADC counts of silicon strip detector, trigger scintillators, calorimeter layers, lateral veto, together with other very low-level information.

    2. level 1 data contain all data after calibration and equalization. All scintillator responses are calibrated and equalized.

    3. level 2 data contain higher level information, namely:

        a. estimated energy loss in the tracker;
        b. estimated energy loss in the trigger plane;
        c. estimated energy loss in the scintillator tower;
        d. estimated arrival direction;
        e. particle identification estimators.
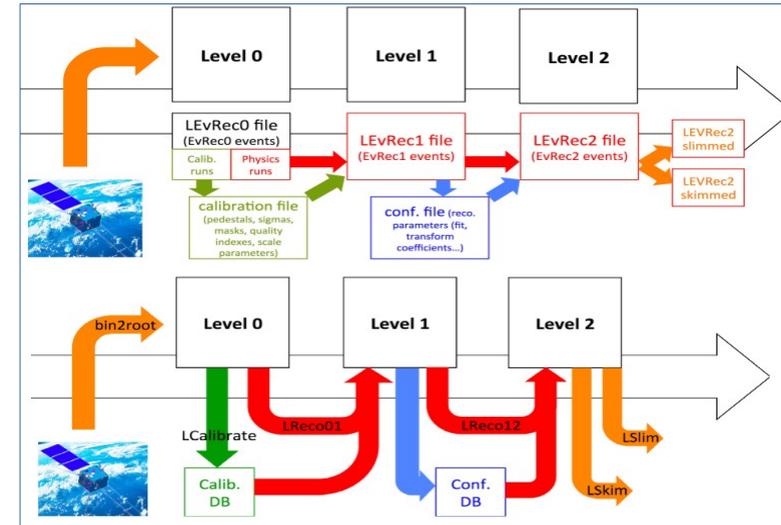
HEPD-01 Processing Pipeline

The processing pipeline has been developed as several layers of software with an interface to a processing database.
The Database, is used to keep track of the different stages of processing and for data bookkeeping.

The layers are divided in:
- Listening Daemon:
    1. Input: Raw files (binary) from CGS.
    2. Output: Raw file storage, Database (bookkeeping, Metadata)
- Automation Pipeline Daemon:
    1. Input: Raw Files
    2. Output: Level 2 files, Quick-look files, Database (Processing data, Metadata, Calibrations)

The Automation Pipeline Daemon will be divided into 3 indipendent sub-processes for each level of processing.
The high modularity of the pipeline allow to achieve asynchronously single steps of the processing.
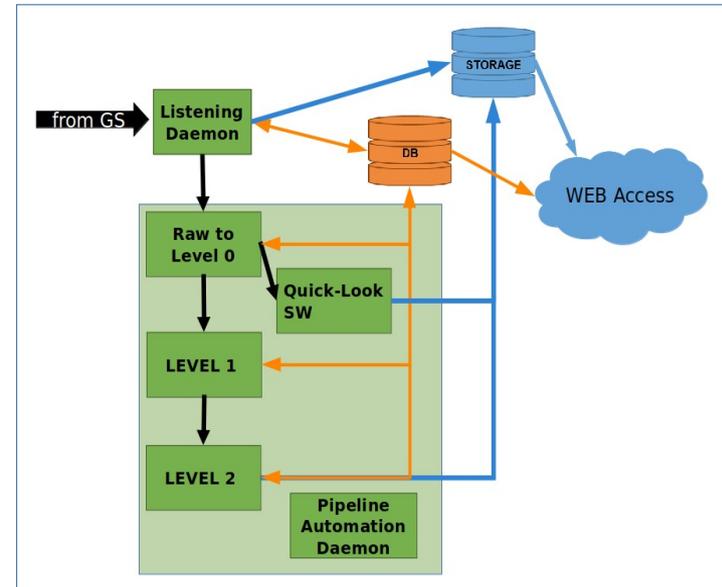
Results

A fully scalable, high availability, processing infrastructure has been designed, installed and configured to process and store CSES-01 satellite data at the Italian Space Agency – Space Science Data Center.

We also developed a fully automated processing pipeline for HEPD-01 data and a bookkeeping database to monitor and control al steps of the data processing.

After more than 3 years of mission:

- 40995 RAW HEPD-01 (~3 TB) files transferred from ICD (as of June 2021)

- 486026 Level2 Data files (acquisition run, ROOT format) produced in ASI

- 40 TB of CSES-01 payload data available @ASI https://limadou.ssdc.asi.it/

The facility will be expanded in the following months to cover the needs for the upcoming CSES-02 mission.