CHP – OBC Case Study

Customizable High Performance On-Board Computer

Background:

As CubeSat technologies advance, features become diverse, platforms get robust and reliable, and constellations of satellites grant high resolution and near real time imagery, potential clients are waiting for nano-size spacecrafts that fulfill their demands from Earth Observation to IoT purposes. Most of the missions of any nature aspire to solutions that collect huge amount of data, process them and serve the customers with valuable and applicable information. For a long time, one of the major hindering factors was the size of these data which was hard to handle even with broad bandwidth. This was the point, where attention started to focus on Artificial Intelligence and both nanosatellite industry actors and clients started to handle the assumption that no efficient mission is possible without autonomous on-board decisions as a fact.

The list of use cases is getting longer. The most researched theme is EO that encompasses a lot of sub-cases. Agriculture, forestry and smart farming need information to predict the yield. Cloud detection is necessary to avoid useless data. Disaster monitoring includes functions that may assist to damage mitigation processes. Ocean observation enables not only fleet tracking but also algae growth processes with different sensors. The more precise the image the more data to be processed and the bigger the need for a tool that helps to select the valuable data.

IoT is another notable segment of satellite opportunity. Communication between the members of a constellations is not solved yet, however, it would mean a new milestone both in the coordinated information gathering activity of satellite fleets and in integration opportunity of space IoT. Autonomy or the self-governed in-space operation and decision-making ability of CubeSats is a basic requirement for both.

Expanded opportunities of autonomous onboard decisions need to be applied when the spacecraft may leave the Low Earth Orbit and operates almost entirely independently, based on learned patterns. Docking operation or asteroid mining are good examples.

Product:

C3S' Customizable High-Performance On-Board Computer (CHP-OBC) is a general-purpose computation platform for nano- and microsatellites. It provides high computation capacity, versatile and flexible interface capabilities, and robust and reliable power supply for payload subsystems. Its main features are as follows:

- High computational & storage capacity
- Full-featured Linux environment for application development
- Highly customizable interface set
- Wireless link for development-time debug purposes

By integrating a Cortex-A9-based computing platform, it provides a comfortable Linux-based runtime environment supporting mission-specific application software development. Moreover, it facilitates programmable hardware technology (FPGA) for interface extension purposes that provides the solution's flexibility and future-proofness without requiring accurate knowledge about the payload to be integrated throughout the coming missions.

The versatile architecture of the CHP-OBC makes it suitable for different application areas, such as avionics control, traditional or AI/ML-based on-board autonomous spacecraft operation, pre-processing for link budget optimization, etc. It can be used as…

- Payload controller being part of C3S' CubeSat platform or other spacecraft platforms:
  - interface extension logic adaptation to mission-specific payload subsystems' needs is done by C3S.
  - Use its central processor as a computation platform for software IOD purposes. Run-time environment provided by C3S.
  - Use its on-board FPGA as a programmable logic platform for VHDL IP core IOD purposes. Customer IP core integration is done by C3S.

- **Customizable on-board computer:**
  - Only-HW way: SoM with Linux is provided by C3S. "Empty" FPGA is provided, it can be programmed by the customer using standard JTAG interface and programmer solutions provided by the FPGA vendor (Microchip).
  - Full-featured way: SoM with Linux + standard / customer-defined interface extension logic for the FPGA (together with HAL API) is provided by C3S.

Case study:

In the framework of an IOD mission, C3S LLC. develops, manufactures, and launches a 3U CubeSat (Virtual Intelligence Realization for Earth Observation, VIREO), as well as operates it for at least 6 months. The main objective of the mission is to demonstrate how the capabilities of cutting-edge technologies, e.g. CNN (Convolutional Neural Network)-based AI (Artificial Intelligence) solutions can be facilitated on-board nanosatellites. The spacecraft's architecture is based on a flight proven 3U platform of C3S.

The payload (High-reliability Embedded Device for Visual Imaging Goals, HEDVIG) of the satellite is developed as a collaborative project between C3S and aiMotive, a leading provider of camera-first, AI-powered, level 5 autonomous driving technology. It consists of two high-performance single-board computers with two pairs of RGB-only and RGB/IR camera modules.

The submodule developed by aiMotive (AI-On-Board eXperiment, AIOB-X) is based on a special SoC (System-on-Chip) device (NextChip Apache5) including a reconfigurable CNN hardware accelerator IP core, rendering the system extremely efficient in AI-based visual data processing applications, such as pattern and object (e.g. cloud) recognition, localization, classification, and segmentation.

The other submodule within the payload is C3S' aforementioned CHP-OBC acting as an interface unit between the platform and the AIOB-X submodule in this specific mission. Besides being a payload interface unit, the CHP-OBC also demonstrates the third-party's software IOD concept of C3S.

We installed an innovative New Space company's software component on-board the CHP-OBC and right after that we will demonstrate the concept with another partner. By hosting these software modules, we test their operation on our platform, in space environment, and intend to demonstrate that platform-independent AI-powered algorithms can also efficiently facilitate Earth Observation data analysis.