ESA Contract No. 4000130541/20/NL/BJ/va

Assessments to Prepare and De-Risk Technology Developments

"Generic Flexible Nanosat Platform for IOD and IOV Services"

ESR Executive Summary Report

Summary of the De-Risk Study performed by Ororatech

Contents

1 Introduction

This document shall give a short and precise overview over the work performed by OroraTech for the GENA-Sat de-risk study for ESA.

1.1 OroraTech

OroraTech or Orbital Oracle Technologies GmbH is a Munich based start-up. The main focus of OroraTech is the detection of wildfires from space using data from available satellites and to extend this with its own constellation of CubeSats. With the expertise in CubeSat technology available to OroraTech it was decided to participate in this ESA project and to investigate additional commercial activities.

1.2 Project Overview and Goal of this Study

The GENA-Sat project focuses on helping to create an In-Orbit-Demonstration (IOD) and In-Orbit-Verification (IOV) service in Europe. Such a service allows industry from Europe and abroad to test new technologies and space components in space. This is commonly the last step in the development of new technology or commercial component. Providing a cheap yet capable service is therefore critical.

To reduce the cost of this service OroraTech has developed two new technologies: The first technology is a new type of bus architecture. The bus architecture determines how the components of a satellite are connected to each other in terms of power and data distribution. The goal of new architecture is to be more flexible in the satellite design and to increase the available volume on a CubeSat that can be used for payload. An important component of the new architecture is the SmartPanel. It will replace the side panels of a CubeSat to provide the bus functionality. The degree to which SmartPanels are used to take over tasks from the other subsystems of the satellite is investigated in this study.

The other major technology OroraTech has developed is a so-called payload processing unit (PPU). This component allows to perform demanding calculations like artificial intelligence or real-time image processing on a CubeSat. Both are applications which could become relevant in the near future of CubeSats.

The goal of this study is to develop these technologies and to design a service which can offer new opportunities to the industry at a competitive cost. For this, a de-risk activity was performed to demonstrate the feasibility of the new technologies that OroraTech wants to use. This includes the manufacturing and consequent tests of hardware prototypes of both the PPU and the SmartPanel. The long-term goal is to establish a commercially viable service.

2 Findings

2.1 Market Research

The goal of the market research was to determine what requirements the customers were having for an IOD/IOV service and to get a preliminary price estimate of what the customers are willing to pay. For this reason, a questionnaire was sent out to 500 potential customers and a total of 43 responses were received. The responses helped to establish the user requirements and showed that on average the customers were willing to pay 87,000 €/kg for an IOD/IOV mission.

2.2 Service Description

The proposed service should as flexible and easily accessible as possible to further increase the number of customers. OroraTech's satellite designs allows a flexible reconfiguration of the satellite without extensive redesign. Therefore, any payload could be integrated into the system. Also the goal was to increase the capabilities of a CubeSat platform at a competitive cost. For more detail about these capabilities refer to section 2.3.

To increase the accessibility of the service excellent customer support is necessary. This includes clearly documented hardware interfaces for the payload. Each customer will have access to an interface mock-up, structural as well as for data and power to be able to adapt and test his payload to the IOD/IOV satellite platform. Also an easily accessible user interface in term of a web interface that will guide the customer through every step of the mission, from booking and early design to testing, launch and finally operations will also be provided.

2.3 Satellite Architecture

This section shall describe the satellite architecture.

2.3.1 Overview

The satellite architecture is a 12U CubeSat. Two main configurations of the satellite were planned, based on the same architecture, but with different capabilities. The two configurations mark the two extremes, one at the top end of the capabilities which will be referred to as the default, and a configuration with reduced capability referred to as the minimal configuration. The main purpose of the minimal configuration is to offer an even lower price than the default configuration, but at the cost of reduced capability. The main difference between the default and the minimal configuration is that the default configuration has a high grad attitude control system featuring a star tracker and reaction wheels, as well as a drag-sail which helps to increase the available orbit altitudes without contributing to the space debris problem.
The major selling points of the whole architecture are however available in both configurations. Those benefits are:

- Flexible reconfiguration of the satellite and simple integration of every payload
- Availability of a high-performance GPU for on-board processing of payload data
- 24/7 up- and downlink access to the satellite via Globalstar for real time data and commanding

In addition to this the platform features a high-grade satellite bus with precise attitude control, high downlink capability over X-Band and high amounts of available power. A summary of the most important specifications is given in TABLE XX. The price of a commercial mission with 1 year of operations is set to be 94,000 €/kg for the default configuration and 76,000 €/kg for the minimal configuration. This perfectly fits the price expectations of the customers.

Table 1: Proposed Satellite Platform

	Default Configuration	Minimal Configuration
Satellite		
Satellite Class	12U CubeSat	12U CubeSat
Payload		
Total Available Payload Volume	9U	10U
Available Interfaces	Low Data Rate: RS422, Spacewire, CAN, USB, I2C, UART, GPIO, SPI, PPS High Data Rate: SPI, PCIe, USB	Low Data Rate: RS422, Spacewire, CAN, USB, I2C, UART, GPIO, SPI, PPS High Data Rate: SPI, PCIe, USB
Available On-Board Computing Power	NVIDIA Jetson based GPU for high data rate real time processing	NVIDIA Jetson based GPU for high data rate real time processing
Power		
Solar Panel Configuration	3 solar panels with triple deployment	3 solar panels with triple deployment
Available Payload Power (per Unit)	peak: 40W @ V-Bat (only one payload unit at a time) average: 4W @ 3.3V, 5V, V-Bat, 12V	peak: 40W @ V-Bat (only one payload unit at a time) average: 4W @ 3.3V, 5V, V-Bat, 12V
Bus Power	average: 20W	average: 20W
Total Energy Storage	130Wh	130Wh
ADCS		
Sensors	Sun Sensors, Magnetometers, Gyroscopes, Star Tracker	Sun Sensors, Magnetometers, Gyroscopes
Actuators	Magnetorquers, Reaction Wheels	Magnetorquers
Planned Accuracy	pointing: 1°	pointing: >1°
COM		
TT&C and Uplink	S-Band	S-Band
Downlink	X-Band	X-Band
Ground Stations	K-Sat Network	K-Sat Network

Other	Globalstar module for intersatellite links and ad-hoc communication with low data rates	Globalstar module for intersatellite links and ad-hoc communication with low data rates
Additional Capabilities		
De-Orbit System	Dragsail for space debris mitigation	No Dragsail included

Figure 1shows an overview the satellite platform. The markers designate the following subsystems:

- 1: Stack of COM transceivers and ADCS boards with star tracker and reaction wheels
- 2: S-Band Antennas
- 3: Magnetorquer Rods
- 4: X-Band Antenna
- 5: PPU
- 6: Battery Stack
- 7: Dragsail

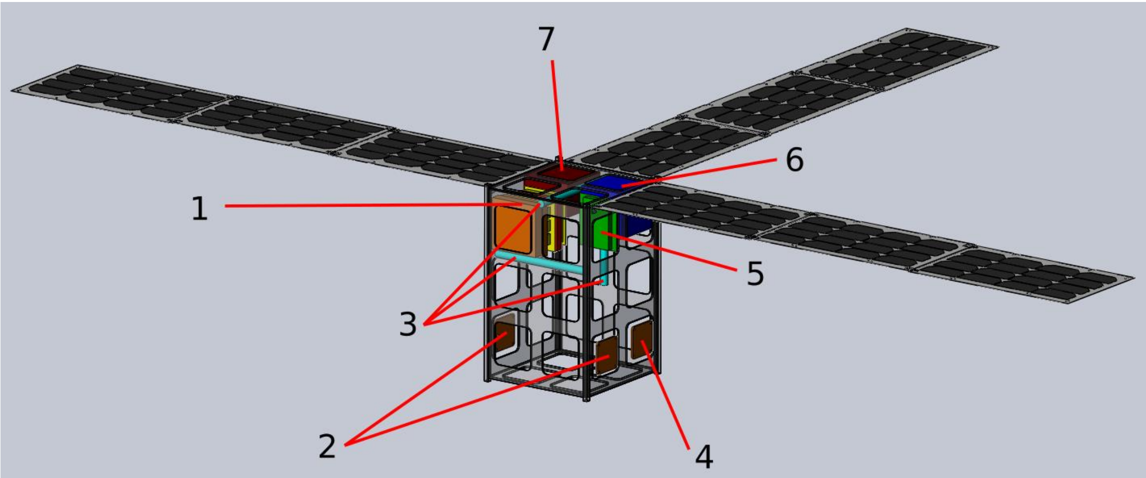

Figure 1: Overview of the planned Satellite Platform

2.3.2 SmartPanel Bus

The simple reconfiguration of the bus is accomplished by the SmartPanel bus. This new bus architecture replaces the side panels in a traditional CubeSat with the SmartPanels. The SmartPanels are responsible for connecting the subsystems and payloads to the bus to distribute data and power. Originally it was planned that the SmartPanels could also incorporate tasks from other subsystems like the batteries from the EPS and magnetorquers from the ADCS or even the COM transceivers. However, following a detailed investigation it was decided to reduce the capabilities of the SmartPanel to limit the development effort. The major benefit of the SmartPanels was to increase the available payload volume. The total increase was however not big enough on a 12U satellite to justify an expensive redesign of all possible subsystems to fit on SmartPanels. A schematic of the final SmartPanel bus design is shown in Figure 2.

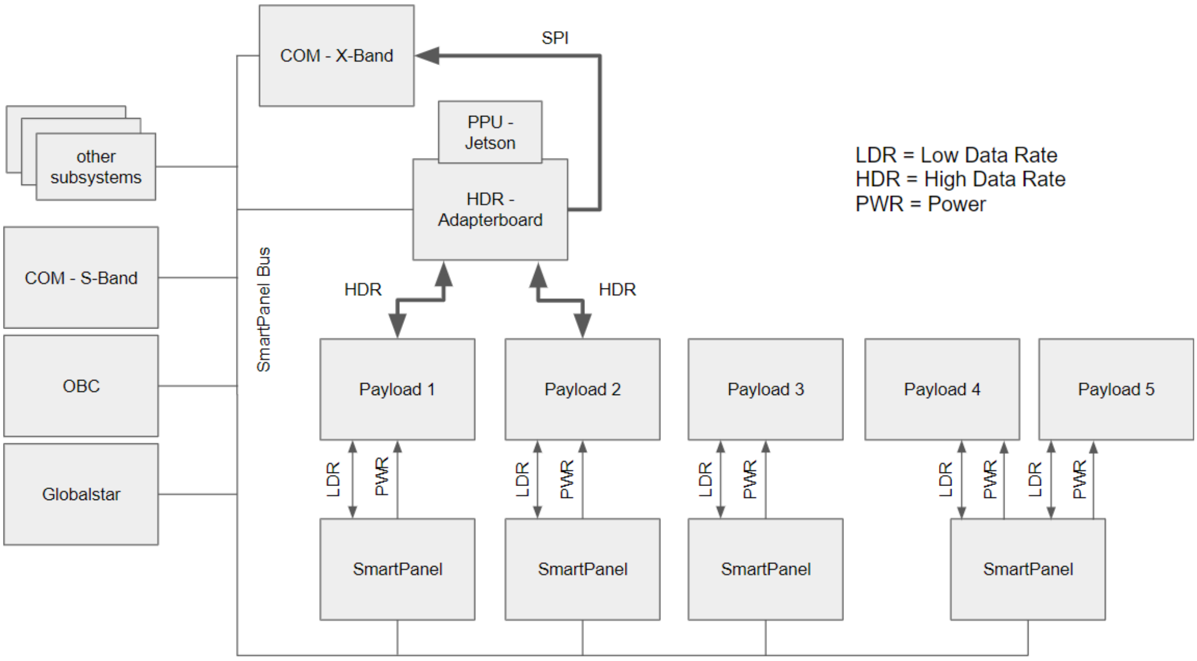

Figure 2: Schematic of final SmartPanel bus

During the course of this activity prototypes of the SmartPanel were built and tested, both in the laboratory and in a thermal-vacuum chamber. The most important functions, like power and data distribution between SmartPanels and external components could be tested successfully.

2.3.3 Payload Processing Unit

The payload processing unit is based on the commercially available NVIDIA Jetson series. Being a consumer electronic device the primary objective during this activity was to prove that the PPU could be used in a space environment. A thermal solution for the PPU was developed consisting of a custom thermal transfer housing and the selection of a suitable thermal interface material (see Figure 3). To evaluate the performance in the thermal-vacuum environment several benchmarks were executed at different temperatures. The PPU was also successfully tested in the laboratory and in a thermal-vacuum chamber.

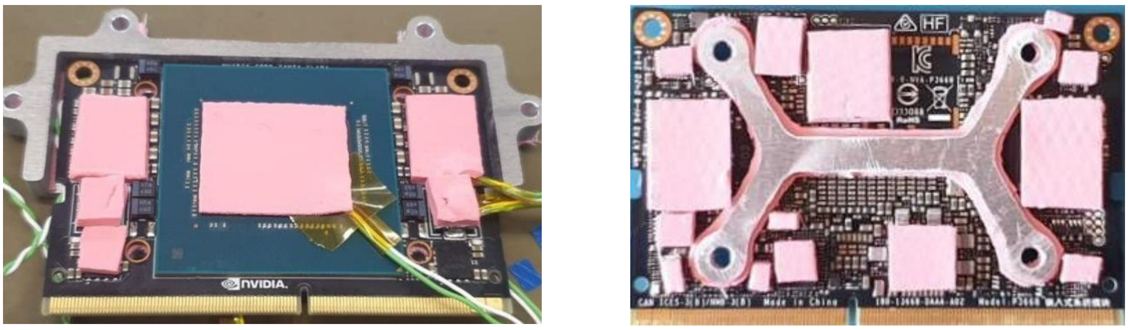

Figure 3: Xavier NX with thermal interface material (Therm a Gap 579) and stiffening x-profile

3 Future Development and Conclusion

Over the course of this activity all major goals and milestones could be achieved. A preliminary design of the satellite platform and the service was conceived as well as first hardware prototypes built and tested. PPU and SmartPanel therefore reached a technology readiness level (TRL) of 5. Additionally, a plan for the future development was drafted. In the next phase of the project it is planned to enter the detailed design of the service and platform and to prepare the first IOD/IOV mission with customers so that at the beginning of the next phase the first mission can be launched. The PPU and SmartPanel will be developed to TRL 8 and the acquisition of the first customers was already started during this activity.

The service provided fulfils all set requirements including reaching the price expectations of the customers while extending the capabilities of current CubeSat IOD/IOV platforms.