Executive Summary Report

GENA-SAT

Generic flexible NanoSat platform suitable for IOD/IOV service

Prepared by	**O. Ruf** **J. Scharnagl**

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EXECUTIVE SUMMARY

Unique Features

The customer oriented and cost effective in-orbit demonstration and verification service based on a generic NanoSat platform developed within the GENA-SAT activity

- was developed by team members experienced in CubeSats since 2005, in satellite business since 1961. The study team for innovative satellite design consists of the creative start-up S^4 and the experienced research institute ZfT, as well as the reputed test Company IABG
- uses award-winning modular satellite design approach (winner Airbus challenge 2017)
- enables suitable IOD/IOV for any payload with CubeSats in range between 1U and 16U due to flexible standard design
- provides the best performance platform tailored to payload demands
- enables rapid and reliable IOD/IOV based on modular platform and software building blocks with flight heritage and redundancy concepts
- offers a full service from the IOD/IOV mission goal analysis to the final evaluation of in-orbit experiment data for maximum customer convenience
- offers to IOD/IOV customers experience in mission background for a broad spectrum of applications
    - in VLEO and LEO missions
    - for Earth observation, telecommunication, internet of things
    - multi-satellite formations and self-organizing sensor networks in space
    - sensors and equipment for multi-point observations
    - intersatellite communication links and methods (integrated AOCS and communication solutions)
    - extensive test equipment access in team

Background and Objectives of the Activity

Quick in orbit test capacities to increase TRL in a fast manner offer significant potential. Reliable, small, cost-efficient CubeSats promise to offer an appropriate solution approach. This way a fast test capability for classical and COTS [Commercial Off The Shelf] components can be provided. In particular for COTS, advantage in better performance and availability, can be complementarily tested for suitable space environment protection by appropriate shielding (for example also by software). Prior in-orbit demonstration and verification (IOD/IOV) helps to identify and prove the capability of non-space parts for these space applications.

Thus, cost effective opportunities for the IOD/IOV of qualified and non-space qualified products/components should be made more easily accessible for customers. This activity is

aiming at the development of a customer oriented and cost effective IOD/IOV full service based on a generic NanoSat platform.

The main objectives of this activity are the development of a generic flexible NanoSat platform suitable for IOD/IOV service and the preparation of a business plan for a sustainable IOD/IOV service concept based on the platform development. It should enable the setup of a customer oriented and cost effective full-service provider by establishing a self-standing and commercially successful IOD/IOV service.

Achievements

Mission Concept & Strategy

The mission realization concept of an IOD/IOV activity for small payloads following the CubeSat form factor has been established. The key elements of the mission concept, e.g. the mission goal, strategy and different mission phases have been described. The mission realization concept summary acts as a generic step-by-step procedure for future IOD/IOV missions based on the GENA-SAT concept. The proposed phases, work packages and flow charts will be revised for each specific activity and act as a guideline which cover the main principles of such activities.

The consortium will set up a business unit acting as a customer-oriented “full-service-provider” which is offering all necessary steps to realize an IOD/IOV mission. The offered services include the design of the mission and platform as well as the payload interface, AIT, launch, operations, and payload experiment preparation and execution. This enables the customer to focus on the payload instead of the IOD/IOV mission. It enables the customer contacting the consortium at any TRL or stage of payload development.

The strategy is to offer various options for the platform and mission concept. Instead of providing a fixed one-size-fits-all platform, modular building blocks enable the best suitable platform and mission concept for the specific payload. Therefore, the technology of the customers’ payload can be on component-, equipment-, or subsystem level.

Platform Design Drivers

In order to get an overview of possible IOD/IOV payloads and the requirements they impose on a satellite platform, more than 150 payloads were considered in a technical payload survey. The insights obtained here were then used in a next step to identify and aggregate typical payload requirements. From these payload requirements, the following main design drivers for the optimum platform module selection have been selected: Payload dimensions, Payload Mass, Peak and Mean Power, Downlink Data Rate, Pointing Accuracy, Orbit Control Capability, and Need for Redundancy. Although all identified requirements will drive the platform design, these main design drivers have a major impact on the platform. They will be used to select the appropriate modules from the portfolio in order to achieve an optimum platform design.

NanoSat Platform Concept & Strategy

The NanoSat Platform Concept for an IOD/IOV activity for small payloads following the CubeSat form factor has been established. The key elements of the platform concept, e.g. the platform strategy, product breakdown, model philosophy, requirements, design drivers, the

hardware and the software concept as well as the payload integration concept have been described. The platform concept acts as a generic step-by-step procedure to be followed for selecting the optimum platform concept from the existing building blocks for future IOD/IOV missions based on the GENA-SAT concept.

By adopting the UNISEC-Europe system bus as well as the standardization and automation capabilities of previous missions, a swift development process can be achieved, while also attaining a modular satellite that is specifically tailored to an externally provided payload. Selecting modular and flexible building blocks following the payload and mission requirements and combining them creates an optimum platform for each specific payload. With this flexibility, the generic and modular platform concept enables integration of any payload into the platform. The flexible and modular Nano-Satellite Platform can be realized in different CubeSat form factors in the range of 1U to 16U as possible IOD/IOV platforms within the GENA-SAT activity.

Many different building blocks are available for selection of the optimum platforms. Most of these systems have been part in former missions and have been successfully verified and used in orbit. Various subsystems are available in different form factors to realize different platform sizes and can be adapted accordingly.

The developed optimum platform concept includes the structural, thermal and electrical design, and describes different modular subsystems with flight heritage e.g. On-Board data handling system, Electronic power system, communication system, propulsion system, attitude and orbit control system, side panels with solar cells and the payload controller. Furthermore a uniform software concept has been developed, which enables easy and fast integration of the payload into the IOD/IOV service mission network.

Data Management and Software Concept

Designing a custom satellite for a third-party payload usually involves many tailored solutions on the hardware and software level. Advancing the data management concept to a more generic solution improves the overall exchangeability of the payload while keeping the software concept largely unchanged. Therefore, the main goal of the data management development was to create a software concept enabling the integration of various payloads. The generic data management concept, its protocol and its interfaces are scaled to the foreseeable payload aspects. The strategy is to grant the customer access to the mission network consisting of logical platform and payload nodes as soon as possible by providing the generic software in order to reach a rapid and reliable IOD/IOV of the payload.

The platform and payload will be accessible throughout the entire mission in the Compass mission network, thus giving the payload developer the possibility to frequently test the payload interaction with the remote platform subsystems. The remote interfacing is technically enabled by Development Kits and Operations Software.

Qualification & Verification

An AIV plan has been established to verify efficiently a generic IOD/IOV platform with its payload for the pre-flight phase of the mission. This AIV plan acts as a generic step-by-step procedure and will be followed to provide a complete AIT and verification program for the preflight phase for each mission. A dedicated tailoring of the test requirements will be

performed and will be justified with the mission needs, and evaluated with a risk analysis and strictly controlled to avoid oversights. Transparency and traceability of the defined requirements and the verification approach is key to create a successful baseline for an IOD/IOV mission. With the created AIV-Plan, it is possible to also guide potential customers and propose solutions that match their individual risk approach for an IOD/IOV mission, while fulfilling the mandatory requirements set by the launch service provider or further stakeholders.

In-Orbit Experiments

The mission execution and methods have been developed in order to describe the in-orbit activities to be performed to demonstrate and validate the performance of the customers payload in-orbit. Similar to the other concepts, this generic in-orbit AIV plan acts as a step-by-step procedure which will be followed to provide a complete AIT and verification program for the in-orbit demonstration and validation phase. This plan will be used for detailed planning of the mission concept of the specific IOD/IOV activity.

Business Plan

The developed business plan indicates that the demand for small and mostly commercial satellites will drastically grow within the next decade. ESA, EU and national governments are supporting related technologies allowing an annual growth rate of up to 12% until 2030. As a result, launcher prices will decrease significantly and cost efficient technologies will need to be developed.

To achieve a low cost approach, off-the-shelf hardware will be used which needs to be qualified for the rough ride on the launcher and harsh environment in space. Additionally, new companies entering the market will have to demonstrate the reliability and required performance of their products and services. Product development cycles need to be significantly shortened compared to the traditional space engineering approach, if commercial companies want to establish a successful business in their market field. The existing test facilities for space systems on ground are designed for large and often scientific missions. Facilities can host test specimen up to 10 tons or more. It will therefore be extremely expensive to qualify small hardware for future commercial missions in large test facilities. Additionally, the traditional test facilities will provide priority to larger governmental or national missions.

To demonstrate the reliability and performance of new hardware to the end-user, in-orbit validation and demonstration (IOV/IOD) can therefore be a sustainable and cost effective approach for small and commercial satellite systems and constellations. Modular satellite platforms will be utilized to flexibly adapt to various payload sizes. The scenarios presented in this business plan have shown that an IOV/IOD business with end-to-end service including satellite assembly, qualification, launch, in-orbit operation and data transfer to the customer can be profitable and according to the customer needs. Taking into account the services offered by already established competitors on the European market, a customer price point below 500,000 € for mission carrying a 2 unit (2U, equivalent to a volume of 10 x 10 x 20 cm3) payload and an end-to end service needs to be reached. 1U payload slots on 6U or 12U satellites carrying payloads from various customers need to be offered below 100,000 €. Considering the market dynamics and amount of potential customers, this goal seems to be challenging but still realistic. Due to the decrease of prices in the market,

especially regarding launcher cost, the price point will further decrease in the coming years. On the other side, the demand for IOV/IOD missions will significantly increase from currently at least 30 missions per year up to almost 100 mission in the year 2030. This progressive market segment therefore requires a dynamic organization set-up for continuous improvement and optimization of their internal and external processes.

The business plan provides a basis for the establishment of such a business including required team size, assembly and operational infrastructure as well as suppliers for hardware delivery, launch services, in-orbit operation, ground station operation and data transfer to the customer. Indications for annual company cost, recurring satellite cost as well as revenue and profit estimations are provided in detail for various company sizes and platform configurations. Furthermore, a comprehensive recommendation for the growth of business and increase of portfolio from 3U to 6U and 12U platforms is highlighted.

Follow-on Activity

Finally, a detailed development plan for a potential follow-on activity was created. The purpose of the proposed activity is to demonstrate the commercial IOD/IOV service capability of the consortium by validation of the business plan concept and implementation of an IOD/IOV mission. The long-term goal is to establish a business unit which offers commercial IOD/IOV missions as a full-service provider. This activity will follow the results and achievements of the GENA-SAT phase 1 de-risk activity and will enable a pioneering mission for the prospective IOD/IOV service provider business unit. The execution of this mission is therefore acting as an IOD/IOV of the proposed GENA-SAT concept itself.

The proposed activity aims to reach two main objectives:

1. Implementation of a business unit acting as commercial IOD/IOV service provider according to the phase 1 business plan concept. Validation of the business viability in terms of innovation and disruptiveness of the commercial IOD/IOV service
2. Implementation of an IOD/IOV pioneering mission, demonstrating rapid in-orbit verification of a payload

All involved elements realizing an IOD/IOV missions will be offered, thus demonstrating the full-service capability of the implemented IOD/IOV business unit. This includes the mission and payload requirement analysis & design; platform, payload interface and ground segment development; satellite assembly, integration and testing; LEOP, nominal and IOD experiment operations; as well as flight data acquisition and analysis. Furthermore, the business unit will demonstrate its' viability by implementing marketing and sales strategies which shall lead to customer acquisition for follow-on IOD/IOV missions.

According to the developed business plan, a 3U-CubeSat in the identified minimum configuration shall be used for the demonstration. The rapid design, implementation, testing and operation of a 3U-CubeSat in a Low Earth Orbit (LEO) will be enabled by the modular and flexible design of hard- and software components which will be selected according to the payloads' requirements from the building blocks with flight-heritage.