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Project
RESTORE De-Risk

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Executive Summary Report

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1 Scope and General Aspects

This document concisely summarises the findings of the de-risk activity RESTORE.

2 Terms and Definitions, Abbreviated Terms and Symbols

CFRP	Carbon Fibre Reinforced Polymer
CS	CubeSat
CSYS	Coordinate System
CONFIG	Configuration
EO	Earth Observation
FEM	Finite Element Model
IF	Interface
LEO	Low Earth Orbit
MAIT	Manufacturing, Assembly, Integration and Test
MOS	Margin of Safety
MS	MicroSat
OOP	Out of Plane
PUG	Payload User’s Guide
QSL	Quasi-Static Load
RA	Rideshare Adapter
S/C	Spacecraft
SPS	Space Structures GmbH

3 Introduction

The trend to small satellite launches will further increase in the next years due to the growing demand for EO applications and internet services (keyword: constellations), which themselves will cause an increasing demand for in-orbit servicing (see Figure 3-1). Together with the trend of replacing those satellites within a much shorter time frame than before to ensure state-of-art satellite technology in orbit (now viable due to cheaper S/C manufacturing, de-orbiting devices, etc.) there will be a growing demand for respective launches. The bandwidth of S/C sizes ranges here from 1U cubesats to microsats of up to 600 kg.

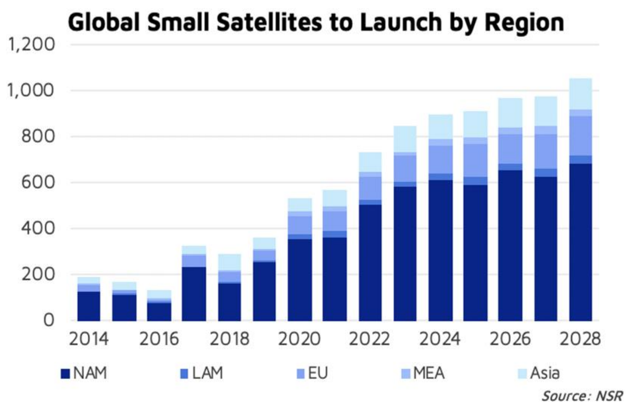

Figure 3-1: Development Trend for Small Satellite Launches

This trend is also reflected by the activities of around 100 privately owned companies worldwide working on micro-launchers with planned maiden flights ranging from 2022-2026. The envisaged benefit of such launchers is the precise and flexible orbit injection for each payload. But in order to be commercially successful also micro-launchers with typical payload ranges for LEO from 100kg to >1to facing the challenge on how to optimally use the existing launch capacity of their rocket.

Hence it is the aim of the RESTORE activity to develop a rideshare structure family, specifically designed for micro-launchers and small satellites.

RESTORE shall have the following features:

1. **Modular** (adaptable to specific missions within the performance of the micro-launcher without significant additional development costs)
2. **Short lead times** (goal: initial 4 months from kick-off to delivery, a gradual increase of stock parts storage for recurring elements, reducing the lead time below 3 months)
3. **Cost efficiency** (goal: <5% of total launch cost, ~137.5k€ and ~275k€ respectively, selling price for the baseline (for 500kg payload) and max (for 1 ton payload) configurations)

4 Main Results

4.1 Design Activities

The main objective of the design task was to develop a rideshare structure compatible with the majority of the small launchers (payload from 100kg up to 1300kg to LEO) capable of carrying cubesat deployers, nanosatellites, microsatellites and minisatellites of up to 600kg.

During the design activities the following steps were executed:

- Survey of micro-launchers being developed
- Survey of potential payloads for the rideshare structure, including separation systems and cubesat deployers
- Sizing Trade-offs
- Definition of the product architecture to fulfil the objective

As a result of these activities and considering cost-effectiveness, modularity and flexibility with respect to last minute changes in the launch manifest, a full aluminium structure consisting of only 5 machined standard parts with a hexagonal shape of the central part was selected (see Figure 4-1).

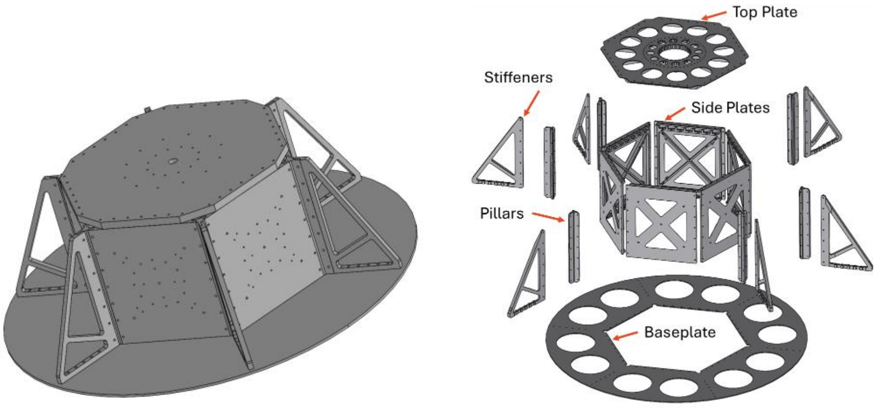

Figure 4-1: 1-Ring Config (left), Overview of parts (already weight reduced) (right)

This approach allows for many different configurations depending on the respective launch manifests (see Figure 4-2).

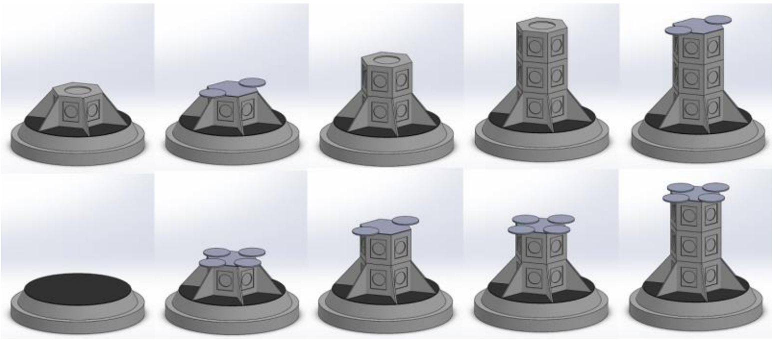

Figure 4-2: Conceptual Sketches of Potential Rideshare Adapter Configurations

4.2 Analysis Results

A detailed analysis study for two configurations (see Figure 4-3) was done, where the following analyses have been performed to assess the overall feasibility of the proposed rideshare adapter structure considering envelope of the microlauncher requirements:

- Modal Analysis
- Quasi-static Load Analysis (QSL)
- Frequency response analysis
- Shock attenuation assessment

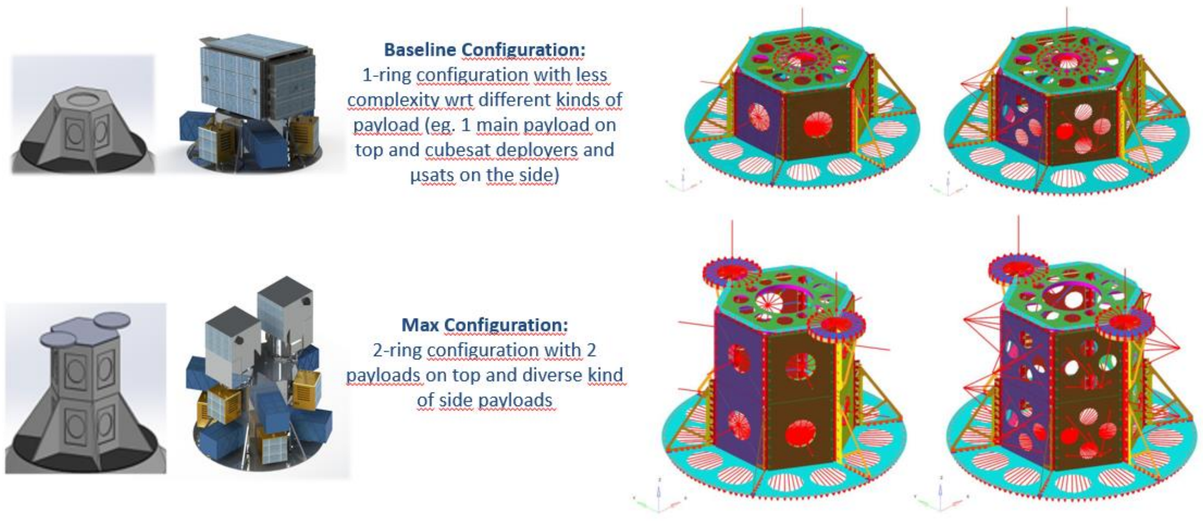

Figure 4-3: Analysis Model Setup (right) of the Two Selected Configs

During these analyses the overall feasibility of the proposed rideshare adapter was demonstrated:

- Positive MOS under QSL are obtained for the envelope of potential launchers
- Worst-case configurations have frequencies compatible with the potential launchers
- Based on the transfer functions, it is demonstrated that payload requirements for the proposed rideshare adapter are mostly compatible with the ones for VEGA SSMS and SpaceX rideshare.

4.3 Testing of Breadboards

For the test campaign integration checks, geometrical verification and fit checks with each other and separation systems/CubeSat Deployer in cooperation with the supplier of such systems were performed.

Two breadboard assemblies were tested. They represent a section of the rideshare adapter structure developed in the current project. In detail, the plate supporting the payload and the two triangular reinforcements are components from the actual rideshare structure, while the other parts such as the baseplate and the rear rods are MGSE components to represent realistic boundary conditions.

One breadboard (Id NOVA) is equipped with a plate designed to support a cubesat deployer (of NOVA family), while the second breadboard can hold a 8 inch ring separation system for microsats (Id CX) (see Figure 4-4)

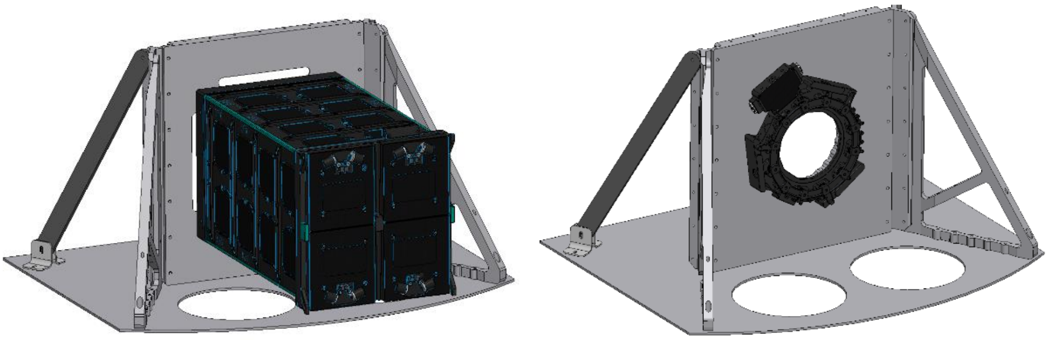

Figure 4-4: Breadboard sets (left: NOVA, right: CX)

The performed test activities could successfully:

- rehearse payload integration and side plate handling in a similar way to the real payload integration on a rideshare structure.
- check geometric constraints and side plate compatibility with separation systems currently on the market.
- assess the side plate minimum stiffness (in terms of maximum displacement under static load)
- perform the separation of the payload, for both Cubesat and Microsat passengers.
- help identify areas of improvement and further investigations.

5 Conclusion

In the frame of the de-risk activity RESTORE a highly modular and cost-effective rideshare structure was successfully developed which complies with most of the upcoming and already existing micro-launchers and their respective payload manifests. Analysis and test results show a general feasibility of the concept which needs further detailed optimization and extensive qualification testing within the scope of a planned follow-on activity with the end-goal of providing a ready PFM structure for an upcoming launch.