SPACECASE: DEVELOPMENT OF A COMMERCIAL TEST PLATEFORM FOR REENTRY EXPERIMENTS.

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ABSTRACT

The SpaceCase project aims to propose a flexible and affordable in-flight test platform, as a reentry Capsule that shall allow leading experiments and technology validation of space components developed by Space stakeholders during a flight. A considerable panel of environmental solicitations can be proposed, as this SpaceCase capsule would be able to be integrated in heavy launchers as well as on sounding rockets, depending on the customer's experiment required environment. The design of the customer's experiment itself could be supported by the SpaceCase project team. The SpaceCase capsule can be considered as a development tool that can be used by any kind of space actor and able to make Thermal Protection System and Aerodynamic experiments as well as Product/Equipment development and qualification.

1. INTRODUCTION

The space business is more and more a competitive market. This context forces space industry to innovate, develop and validate their solutions much faster than before. If project's timeframes are an obvious target for complex space systems, all these systems rely on a large number of sub-systems and components for which the time-to-market development is then a critical issue.

The SpaceCase project aims to propose a flexible and affordable in-flight test platform, as a reentry capsule, that shall allow leading experiments and technology validation of space components developed by Space stakeholders during a flight. A considerable panel of environmental solicitations can be proposed, as this SpaceCase capsule would be able to be integrated in heavy launchers as well as on sounding rockets, depending on the customer's experiment required environment and associated data needed to be recovered. The design of the customer's experiment itself could be supported by the SpaceCase project team.

Current opportunities to realize a space flight are few, expensive, and imply a very long lasting preparation. The SpaceCase project is the opportunity to propose a new test mean that would fill this gap and be part of space actor's roadmaps when dealing with space products and technologies development, and be considered as a major partner for in-flight experimentations.

Figure 1 : Artist view of a SpaceCase vehicle during Earth re-entry - Credit ArianeGroup

2. DEMONSTRATORS

ArianeGroup development of the first SpaceCase demonstrator was initiated in 2021, with the support of the Nouvelle-Aquitaine Region and the innovation center Way4Space. The SC-X01, for SpaceCase eXperiment number one, was designed to demonstrate the capability to consider this kind of space system as a passenger during a nominal launch. This demonstrator includes basic functions such as the ability to generate and retrieve through telemetry experimental data collected during the flight, the capability of the capsule-like platform to

integrate new Thermal Protection System (TPS) material and architecture, and the compatibility with launcher interfaces and constraints, as well as regulation constraints (i.e. safeguard). SC-X01 development will be finalized 2nd semester 2022 and ready for the flight test.

Figure 2 : SpaceCase demonstrators

A second demonstrator (named SC-X02) is proposed via European partnership to develop additional functionalities linked to the commercial demand to physically recover the embedded payload. Then, the SC-X02 capsule will be the support for the development of parachute systems, among other capacities. It also aims at aligning proper objectives with environmental objectives, integrating materials whose manufacturing processes are constrained by specific "green" requirements. It is planned to validate the descent system with a drop test from a helicopter.

These two demonstrators would allow validating the critical technologies needed for potential customers (agencies, private companies, laboratories and universities) to raise their own product Technology Readiness Level (TRL). In particular, the step to make from TRL6 to TRL7 implies an experiment in a realistic environment, which would be affordable thanks to the SpaceCase project.

3. FOCUS ON SC-X01 DEMONSTRATOR

The SC-X01 demonstrator is a 600 mm diameter and 300 mm height re-entry capsule weighing 40 kg and is one of the experimental payload selected by ESA on the 11th of February 2022 [1] to fly on Ariane6 inaugural flight. It will be separated from the launcher using an EOS BB8 ejection system from the French company MecanoID [2] located in Toulouse. To reduce development schedule, the selected shape is an Hayabusa like shape that allows to use and fly the frontshield made of Naxeco® that was developed in cooperation with ESA during the PreHead [5] project aiming at demonstrating our capability to manufacture a carbon/resin structural frontshield in one single piece (see [3], [4], [5]). Such a heatshield is compliant with the stringent constraints of a Mars Sample return mission.
The backshield is made with the lightweight carbon resin Asterm® thermal protection glued onto an internal 3D printed structure. Asterm® was also specially developed by ArianeGroup in cooperation with ESA for sample return vehicles and can sustain heat-fluxes up to 15MW/m². The antennas are the same as the ones flying on Ariane launchers and are protected by radio-transparent Norcoat® 4000 thermal protection.
Even if SC-X01 re-entry velocity will be at about 7 km/s, such an architecture was selected, as it is representative of a hypervelocity sample return capsule entering the atmosphere at 12 km/s. SC-X01 is thus a first step to prepare development of a hypervelocity re-entry vehicle in Europe such as the proposed demonstration mission HEARTED [6] proposed by ESA and supported by ArianeGroup.

The avionics package was designed internally and some parts (e.g. motherboard) manufactured in the Aquitaine Region. SC-X01 will be turned ON just after release from Ariane6. Monitoring thermal protection will be done by Thermal Plugs embedded in the Naxeco® and Asterm® as well as recessions sensors. Trajectory will be monitored by an Inertial Measurement Unit (IMU) and a GPS system. Data will be hopefully recovered by telemetry using the Iridium system starting before Entry Interface Point, at 120 km altitude, and during the entry up to the splash down in the South Pacific Ocean. Communication black-out will be managed by on-board memories.

The scale one 3D printed mockup on top of the EOS separation system as shown in the following picture is used for communications reasons but also will help validating tools for assembly of the proto-flight vehicle itself and integration on the Launcher. Naxeco® frontshield is the black part, Asterm® thermal protection is represented in yellow and the patch antennas are in white.

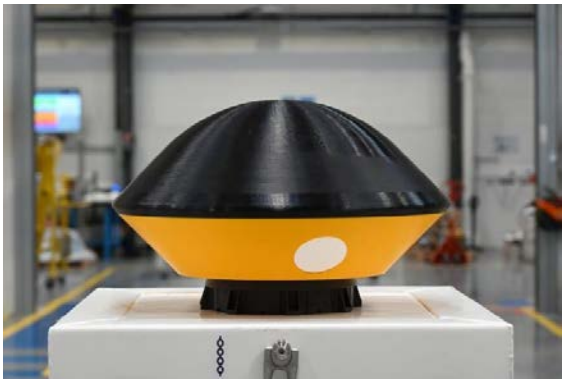

Figure 3 : SC-X01 – Scale 1 3D printed mock-up - Credit ArianeGroup

4. A STANDARDIZED VEHICLE

The proposed SpaceCase capsule is a standardized re-entry vehicle, and designed to:

- sustain a re-entry environment with thermal heatshield and full Thermal Protection System,
- manage all the flight phases and collect data with its avionics system,
- be recovered with a descent system (e.g., parachutes),
- sustain the mechanical environment and integrate experimental payloads secured by a primary and secondary structure as necessary.

Its size is voluntarily limited to about 500 mm diameter and 500 mm height to ease its integration as piggyback or auxiliary payload on heavy launchers (such as Ariane 6), medium launchers (such as VEGA) and sounding rockets, as well as to ease flight opportunities and master costs. The key elements of this vehicle are the telemetry system using satellites to be independent from ground stations and thus propose as many flight opportunities as possible and a parachute system to increase the descent duration and thus data transmission time but also safe recovery of the experiments.

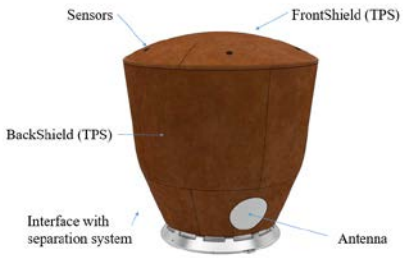

Figure 4 : Capsule external view

Figure 5 : Capsule internal view

The SpaceCase capsule can be considered as a development tool that can be used by any kind of space actor and able to make:

- TPS experiments
- Aerodynamic experiments
- Product/Equipment development and qualification

A future upgrade of the SpaceCase is planned to also integrate experiments that would need to “stay” in space, in addition of performing a reentry under specific conditions. Microgravity, radiation, vacuum are specific physical parameters that are of high interest when it comes to orbital missions, organisms development in space, etc. To be able to stay a few weeks/month in space offering a variety of space-like environments is a long-term goal taken into account in SpaceCase project work logic.

5. NEW SPACE SERVICE

Space Case will constitute a novel new space service. The project will develop and validate an innovative, industrially manufacturable Space Capsule that will allow to lead experiments in re-entry environment and offer opportunity for spatialization of technologies. This new service, illustrated below, will: i) give access to endo-atmospheric and/or exo-atmospheric mission phase representative environment; ii) allow experiment on thermal shield system, mechanics & aerodynamic flight parameters, and passenger; iii) allow experimental data recovery; iv) allow the adaptation on several launcher interfaces and v) allow several experiments/year , thereby ensuring delay and cost optimization for the customers.

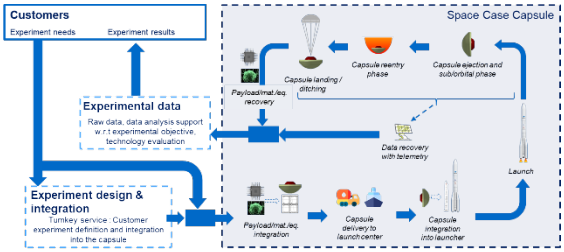

Figure 6 : SpaceCase service

Space Case service will be plug & play to ensure easy access to a broad community. The customer will provide the exploiting company with a CubeSat sized experiment with an electronic system compatible with the capsule (as it will be described into to the publicly available user’s manual). The experiment is integrated into the Space Case capsule test platform, which is itself integrated in a launch vehicle chosen to guarantee the needed environment for the customer experiment. The flight takes place; the capsule is released and performs his own flight back to Earth. Depending on the customer need, experimental data can be retrieved through telemetry during the capsule flight, and/or after capsule landing (on ground or in the sea) through capsule physical recovery. All those phases will be under Space Case exploiting company responsibility.
Additional services will also be offered, including design of the experiment integration within the

capsule or experimental data analysis before being delivered to the customer.
The specific nature of the experimental data, which are what the customer pays for, are identified and agreed at first. They can be:

- The experiment hardware itself, after submission to operational environment. In case of experimental hardware recovery, the damage level of the hardware, because of the landing specificities, can also be adjusted. The physical recovery of an experiment is often of greater added value, scientifically and technologically speaking, and is consequently of great interest for space actors. It is particularly true when it comes to material development, as well as biology and chemistry experiment analysis. Then, descent and landing systems are considered, from a Space Case project point of view, as a critical technology. One of the most known and efficient systems to allow experimental data retrieval (either data telemetry or hardware physical recovery) is the parachute and associated systems.
- Experimental data generated by the instrumentation (for instance, a maximal temperature that has been measured inside the experiment)

6. DEVELOPMENT LOGIC

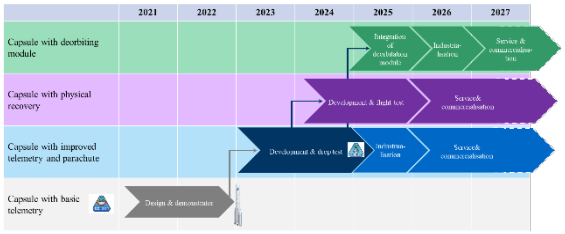

Figure 7 : Development roadmap

The development of Space Case service has been initiated in 2021 to achieve a technical and economical proof of concept (project SC-X01 – grey line). This successful project that will end in 2022 by a flight test, now enables the development of a new capsule, integrating all the required functions to fully meet customers' needs. After the end of Space Case SC-X02 project, the capsule will be industrialised to achieve market launch and first commercial flights by 2026. In parallel, developments will be continued to enable physical recovery of the capsule (purple line) and associated experiments (floatation system, geo-tracking system, recovery logistic organisation). As of 2025, a de-orbiting module (green line) will be investigated to open new market segments to the service: longer stay in space, mastering of Entry interface Point (EIP) and related environment and landing sites. This upgraded version of Space Case service is planned to be commercialised by 2027.

10. CONCLUSION AND PERSPECTIVES

Space Case will facilitate and foster space access by disrupting maturation of technologies for return capability. Space Case capsule will offer a space volume dedicated to experiments corresponding to 3 to 4 CubeSat's units and pave the way for the development of innovative technologies and solutions by embedding them into space, enabling to test in real condition like in orbit Demonstration / Validation experiments(IOS/IOV)). Space Case is entirely based on European knowledge and technologies and will be strongly exploited by European industries. This project will thus contribute to the European objective of doubling the accessible new space transportation service market to European industry by 2030. This outcome will mainly benefit to space industry, in particular new space actors involved in satellite activity, companies and labs looking for atmospheric re-entry expertise related to large re-entry and/or reusable vehicles (for instance) and testing capability for novel equipment/sensors/material.

10. REFERENCES

[1] ESA selects payloads for Ariane 6 first flight 11/02/2022 https://www.esa.int/Enabling_Support/Space_Transportation/Ariane/ESA_selects_payloads_for_Ariane_6_first_flight
[2] https://www.mecano-id.fr/wp-content/uploads/2022/05/25-04-22-Press-Release-EOS-on-Ariane-6.pdf
[3] D. Boury, E. Gautronneau & al. (2007) 58th IAC, C4.2
[4] R. B. Menz1, J. H. Koo, M. Berdoyes, Characterization of 3-D Woven Carbon/Phenolic using In-Situ Ablation Sensing, Video Imaging, and Numerical Simulation, AIAA Scitech, 01/2018, DOI:10.2514/6.2018-0098
[5] Innovative heat shield for earth return capsule, IPPW21, June 2021, R-M Besnier, G. Pinaud, T. Pichon, JM. Dupillier.
[6] Feasibility study of a Hyper-velocity Earth Re-entry technology Demonstrator (HEARTED) ESA AO/1-9600/19/NL/BJ/abz