Aerospace Europe Conference 2023
Joint 10th EUCASS – 9th CEAS Conference

Abstract #XXX *(to be filled by the organizers)*
Preferred Topics: STUDENT / STRMAT
Corresponding author: GEFFRAULT Ronan
e-mail of corresponding author: ronan.geffrault@ctingenierie.com
Type: Oral
Status of corresponding author: Regular

Structural design of PERSEUS bi-liquid demonstrator: ASTREOS-1

Authors

Ronan GEFFRAULT [1], David Tchou-kien [2]*

** Corresponding author*
[1] CT Ingenierie, Immeuble Arago 1, 41 bvd Vauban, 78280 Guyancourt, France, ronan.geffrault@ctingenierie.com
[2] CNES, 2 Pl. Maurice Quentin, 75001 Paris, France, david.tchoukien@cnes.fr

Abstract

At the crossing between academic institutions and the space industry, the PERSEUS program of the French space agency (CNES) offers future engineers the opportunity to design, manufacture, test and launch some experimental sounding rocket demonstrators. In the current context where the space sector is going through major changes in the economic, strategic and scientific dimensions, this program aims to promote the research and development of new technologies and develop student's vocation for this "new space".
After several successful launches of solid-fueled rocket, PERSEUS is now developing ASTREOS, a bi-fluid propelled rocket. This demonstrator will be the first step towards the DREAM ON challenge: a reusable bi-fluid LOX/CH4 propelled rocket up to 5km apogee.

Due to its bi-liquid propulsion system, designed with the help of our partner ArianeGroup, ASTREOS will differ from its solid propelled predecessors, both in size and take-off weight, and the launcher will be connected to a new modular fluid ground equipment. This propulsion system is quite complex and heavy, therefore its integration involves the development of a way more massive rocket structure, with major issues in terms of mechanical layout, mass and space savings.

ASTREOS is in fact a succession of several intermediate launchers, which will capitalize as much as possible on the developments and the experience acquired with the previous SERA flight demonstrators family. The PERSEUS team is indeed following an iterative and incremental workflow. According to this approach, ASTREOS demonstrators will gradually integrate new propulsion and navigation technologies for the next DREAM ON launchers. In line with an eco-conception process, ASTREOS's structure will also integrate bio based composite parts and a recovery system to foster its reuse. Even if the last ASTREOS demonstrator is targeting supersonic speed, the objective of the first one, ASTREOS-1, is to carry out the first flight test of the propulsion system, validating all the equipment and associated procedures, without a performance objective.

This paper will focus on ASTREOS-1's structure, developed by the PERSEUS team and the students through mechanical conception, simulation and finally, prototyping. Prototype parts fabrication steps will involve innovative and advanced manufacturing processes, like polymer 3D printing, composite filament winding or metallic additive manufacturing. So far, this first demonstrator has been designed as a single-stage rocket with four fins, a length of 6.3 meters, an intern diameter of 250 millimeters, and an estimated weight between 120 and 160 kg. These parameters have to be taken as orders of magnitude, since they will probably change as ASTREOS-1 is being defined and designed. This sounding rocket will be propelled by the MINERVA bi-fluid LOX/ethanol pressure-fed engine. The rocket culmination height will vary between 1300 and 2700m, the maximum speed between 170 and 230 m/s, depending on the weight of the structure, which can be split in 6 main products called "sections":

- The engine section
- The LOX section
- The Ethanol section
- The Nitrogen section
- The avionics section
- The recovery section

All these products will be mechanically linked in series along the rocket and will interact through electric and fluid lines. Therefore mechanical interfaces between sections must let pass those inter-section electric cables or propulsion pipes, be easily assembled/disassembled and resist to mechanical stresses during the flight. The structure will also integrate fluid ground/board interfaces allowing the filling and, if necessary, the emptying of the rocket's various tanks, as well as cooling and passivation operations.