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

Abstract #XXX
Preferred Topics: FDGNCAV
Corresponding author: Tomassini Angelo
e-mail of corresponding author: angelo.tomassini@avio.com
Type: Oral
Status of corresponding author: Regular

Title
GNC Improvements between Vega and Vega-C

Authors
Angelo TOMASSINI [1], Irene CRUCIANI[2], Christian POMPONI[3]*

** Corresponding author*
[1] AVIO SpA, Via Latina, snc 00034 Colleferro (RM) Italy, angelo.tomassini@avio.com
[2] AVIO SpA, Via Latina, snc 00034 Colleferro (RM) Italy, irene.cruciani@avio.com
[3] AVIO SpA, Via Latina, snc 00034 Colleferro (RM) Italy, christian.pomponi@avio.com

Abstract
Vega-C is the new rocket designed and produced by AVIO whose successful maiden flight took place on July 13, 2022 from the CSG spaceport in French Guyana. It has inherited, especially in the initial phase of the ascent, several components from its “little brother” Vega but several improvements have been done not only on the capability but also on the versatility of the missions that can be carried out.
The improvements that have been introduced in Vega-C on GNC had the scope to reduce the missionization costs and, at the same time, increase the flexibility of the launcher to cope with always increasing complexity of the multi-payload missions.
The reduction of the missionization costs has been obtained reducing the specific tuning activities for each mission. In particular some modifications have been introduced in TVC algorithms in order to limit as much as possible the recurring activities.
From the other hand, the increase of flexibility has been obtained introducing a completely new architecture of the orbital phase, with the so called “timeline flexibility”, that allow composing the mission with simple “building blocks”.

TVC Improvements
Thrust Vector Control architecture for Vega-C is based on the same logic used for Vega, with an improved tuning logic for each mission, reducing costs but also increasing performance repeatability. To do this, we have worked on the first stage, the most complex because of aerodynamics and bending modes control, and on the last stage, the AVUM phase, because the MCI is strongly dependent on PL characteristics. This paper will describe these improvements and show the advantages in terms of performances.

Timeline Flexibility
One of the most challenging elements completely re-designed with respect to the previous approach, is the Orbital Flexible of the GNC missionization process, developed in parallel with the design of the required algorithms.
The Vega architecture was based on 8 mission types, each one with a specific list of predefined events. The mission timeline had to fit with one of the mission types, otherwise a modification of the invariant part would have been needed, with the consequent need of delta qualification activities. The new design philosophy presented here is based on a modular approach allowing to build up the required mission in a more flexible way. The keystones of this versatility are the Mission Blocks with which several orbital phases can be customized just like the bricks are used to erect a wall. These Mission Blocks are elementary enough to ease their combination and complex enough to exploit prebuilt features.

The initial part of timeline, from the lift-off up to the first boost cut-off of the fourth liquid stage (AVUM1), is fixed because the sequence is always the same.
For the following parts of the flight, six element types are available to design the Flexible Orbital Phase chain:

- AV2: second AVUM ignition using Closed Loop Guidance
- CP: Coasting Phase
- PR: Payload Release
- RB: RACS Boost
- ME: Main Engine Open Loop boost
- Passivation

Each Mission Block is composed by a slew followed by a specific action and limited by time events (at starting and at the end). The constraints on them are that these events are obtained by fixed delays from other time events or driven by state conditions, such as ΔV and angular range.
This paper will present the missionization logic and the tools developed to facilitate the mission design process.