DOI: 10.13009/EUCASS2023-925
Aerospace Europe Conference 2023 – 10TH EUCASS – 9TH CEAS

GNC Improvements between Vega and Vega-C

Angelo TOMASSINI†, Irene CRUCIANI*, Christian POMPONI**
Federico SCIUTO and Marco GIANNINI**
**AVIO SpA*
Via Latina, snc 00034 Colleferro (RM) Italy
angelo.tomassini@avio.com – irene.cruciani@avio.com – christian.pomponi@avio.com
federico.sciuto@avio.com – marco.giannini@avio.com
† Corresponding Author

Abstract
The improvements introduced in Vega-C on GNC had the purpose of reduce the missionization costs and simultaneously increase the flexibility of the launcher to cope with always increasing complexity of multi-payload missions. The reduction of missionization costs has been obtained reducing the specific tuning activities for each mission and speeding up some tools to decrease the loop time. Some modifications have been introduced in TVC algorithms in order to limit as much as possible the recurring activities. On the other hand, the increase of flexibility has been obtained introducing a new architecture of the orbital phase, with the so called "timeline flexibility", that allows composing the mission with simple building blocks.

1. Introduction

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 numerous improvements have been introduced not only on the capability but also on the versatility of the missions that can be conducted. This paper will present the missionization logic and the tools developed to facilitate the mission design process.

1.1 Glossary

The following definitions are valid in the frame of this work.

$$
\begin{gathered}
K_1 = \mu_C = (x_{CG} - x_{PvP}) * \frac{T}{J_N} \\
A_6 = \mu_A = (x_{CP} - x_{CG}) * \frac{C_{N\alpha} * S_{REF} * pdyn}{J_N}
\end{gathered} \tag{1}
$$

where

x_{CG} = Center of Gravity abscissa
x_{PvP} = Pivot Point abscissa
x_{CP} = Center of Pressure abscissa
T = Thrust
S_{REF} = Reference Surface
C_N = Aerodynamic force in body axes
$C_{N\alpha} = \frac{\partial C_N}{\partial \alpha}$
$pdyn$ = Dynamic Pressure
J_N = Transversal Moment of Inertia

DOI: 10.13009/EUCASS2023-925

1.2 Vega Heritage

The maiden flight for the Vega (Vettore Europeo di Generazione Avanzata) launcher took place on February 2012, delivering nine satellites on an orbit 1450km above the Earth’s surface. Since then, tens of satellites have been launched following the commanded trajectory with the Guidance Navigation and Control subsystem always working in proper way and demonstrating its robustness in off-nominal conditions. Two failures, not attributable to any software subsystem, interrupted the winning streak in 2019, nevertheless all the investigations and tests performed after these missions, demonstrated that the GNC system worked as expected.
The concept of mission data is aimed at giving flexibility to the so called FPSA (Flight Program Software Alternative) to accomplish various missions by setting different relevant parameters:

- altitudes,
- eccentricities,
- inclinations,
- durations of Long Coasting Phases (LCP),
- orientations during LCP
- orientations at PL release….

Nevertheless, the Vega GNC algorithms run on the On-Board Computer (OBC) through the FPSA, based over 8 mission types (see Fig.1) and associated to a specific sequence of AVUM boosts and PL releases.

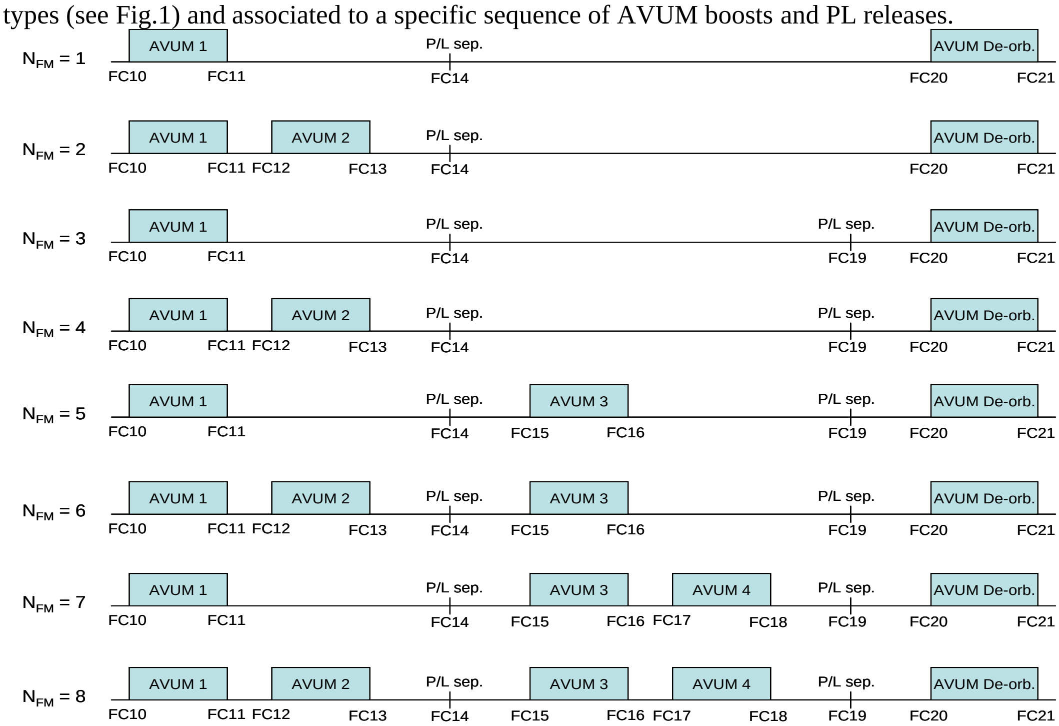


Figure 1: Vega Mission Type.

The structure of the solid propulsion phases is the same for all the types and is not reported in the figure above. This architecture, rigid but reliable, has been used in all the Vega flights according to the requirements of the specific mission and adapting, when needed, the mission data by means of the missionization process. 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.

1.3 New Approach for Vega-C

The new launcher Vega-C has been designed to have enhanced performances with respect to its predecessors, increasing the maximum PL mass and above all, improving the flexibility of the possible achievable orbits. Thanks to FPSA modifications, the versatility of the missions has been increased in terms of:

- Number of orbits (additional AVUM boosts)

DOI: 10.13009/EUCASS2023-925

- Number of PL released
- Orbital Manoeuvres (CCAM, slew)
- Additional LCP with dedicated pointing between AVUM boosts and PL release.

The modification performed are based on several drivers:

- Introduction of timeline flexibility after the first AVUM boost: the 8 mission types have been demonstrated as not sufficient to cover the specific mission needs.
- Minimization of TVC control tuning activity at each flight, to reduce performance variability and engineering effort.
- Demonstration of the compatibility with previous FPSA (non-regression). It has been demonstrated that thanks to the FPSA modification, all the missions feasible with the previous FPSA version remain feasible with the new one.

2. Timeline flexibility

One of the most challenging elements completely re-designed with respect to the previous approach, is the Orbital Flexibility of the GNC missionization process, developed in parallel with the design of the required algorithms.
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. The granularity of these Mission Blocks has been selected to be elementary enough to ease their combination and complex enough to exploit prebuilt features.
As explained above, 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. They are shown in the table below.

Table 1: Vega-C Mission Block.

Block Name	Description	Max Number
AV2	single block that can be activated in a fixed position, only after the first coasting phase after AVUM1 (kept as CLG is active)	1
RB (RACS Boost)*	Slew+RACS boost	20
PR (PL Release)	Slew+Pointing+PL release	20
CP (Coasting Phase)	Slew+Coasting Phase	20
ME (Main Engine)	Slew+Main Engine Boost+ RACS boost	10
PASSIVATION	single block, always present as last mission block	1

*Containing Collision and Contamination Avoidance Manouvre (CCAM)

This structure allows the guidance designer to model the mission as close as possible to its objectives, expressed in terms of optimal trajectory, performances and accuracy of the PL orbit.
It is important to stress that all the manoeuvres executable with the Vega system are also possible in the Vega-C scenario, but the contrary is not always true.
The eight predefined missions can be rebuilt thanks to the following sequences (the PL separation are marked in red while the VESPA adapter separation considered as a PL separation is marked in orange; the CCAM boost are marked as RB in green).

type	*Sequences after AVUM1*
1	PR ; RB; CP; ME; PASSIV
2	CP; AVUM2; PR; RB; CP; ME; PASSIV
3	PR; RB; PR; PR; RB; ME; PASSIV
4	CP; AVUM2; PR; RB; PR; PR; RB; ME; PASSIV
5	PR; RB; ME; PR; PR; RB; ME; PASSIV
6	CP; AVUM2; PR; RB; ME; PR; PR; RB; ME; PASSIV
7	PR; RB; ME; PR; CP; ME; PR; RB; ME; PASSIV
8	CP; AVUM2; PR; RB; ME; PR; CP; ME; PR; RB; ME; PASSIV

DOI: 10.13009/EUCASS2023-925

With the new timeline, Vega-C is able to handle theoretically up to twelve main engine boosts (AVUM1 + AVUM2 + up to 10 ME) compared to the five for Vega, including the deorbiting, even though the maximum number of boosts is strongly dependent from the complexity of the mission and the manoeuvres shall obey to stringent requirements to guarantee the integrity of the AVUM engine.

Another element of the increased flexibility is the possibility of consecutive blocks of the same type allowing to separate the mission in different sections.
As an example, the phase following the payload release to avoid collision and contamination between the payload and the launcher body (CCAM), can be performed, with the Vega mission type structure, exclusively with a single boost of the RACS that usually shall be intense enough to quickly increase their distance. This raises the risk that the RACS thrusters' plumes can contaminate the payload just released. On the other hand, the new Vega-C mission block structure allows to split the CCAM in multiple boosts (usually no more than two/three at a time) with smaller intensity, less prone to the contamination problem and with different orientation so that the departure results more efficient.
A couple of examples of a CCAM with the Vega-C system are shown in the figure below where is visible how the manoeuvre is split in different sub-boosts allowing the correct orientation for each phase.

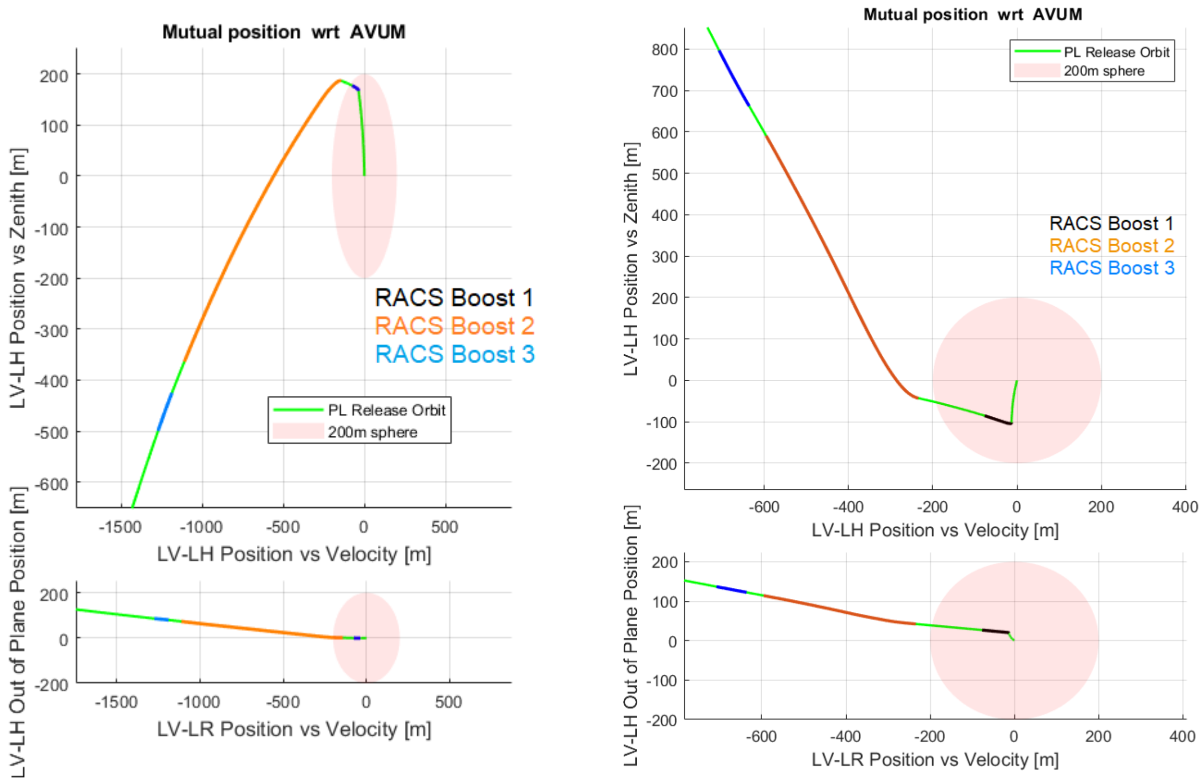


Figure 2: Vega-C CCAM manoeuvres post PL release in Local Vertical – Local Horizontal Reference Frame.

This kind of manoeuvres with the Vega system would have required a single boost and more time to move the launcher in an area safe from possible collisions and contamination of RACS and even from the following AVUM boost.

In analogue way also the classical coasting phase performed with the barbeque manoeuvre in Vega (rotation around the longitudinal axis pointing perpendicularly to the Sun direction to avoid overheating of some parts of the launcher and of the payload) can be split in Vega-C including at the end a short coasting phase preparing the next manoeuvre in a smooth way. These techniques of enhanced flexibility, that would be unrealizable with the Vega FPSA, have been used in the first real Vega-C flights, also to demonstrate the new capabilities of the new launcher.

- In the maiden flight (labelled VC01) carrying the LARES satellite the Long Coasting phase LCP1 between the first two AVUM boosts has been divided into two parts, the first one with a barbeque manoeuvre and the second sub-phase pointing the nozzle towards the Sun direction. Figure 3 shows the launcher longitudinal axis with respect to the Sun direction for the orbital phase and the split LCP1 phase.

DOI: 10.13009/EUCASS2023-925

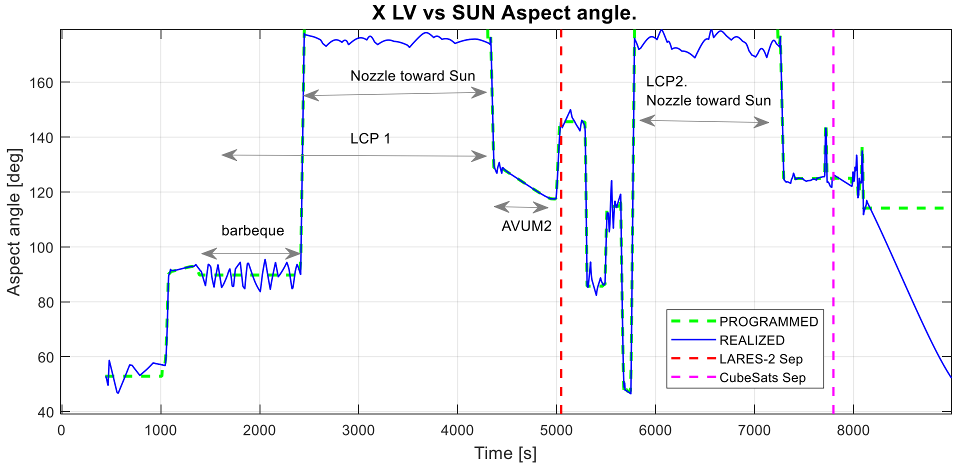


Figure 3: VC01 longitudinal axis vs Sun direction.

- Also the commanded timeline of the second Vega-C flight (VC02), had it not been unexpectedly interrupted during the 2nd stage, should have included a manoeuvre impossible with the Vega software. The mission required to deliver two set of payloads in two different, but similar, orbits so the required AVUM manoeuvre to transfer from the first to the next orbit was very short (less than 3s). Nevertheless, the total amount of AVUM propellant required by the whole mission was quite demanding so the transfer orbit boost has been replaced with a RACS boost included in the CCAM post release. In the following figure is visible how the CCAM has been split in 2 parts: the green branch is used both to increase the distance between the launcher and the released payload and to transfer to the next orbit.

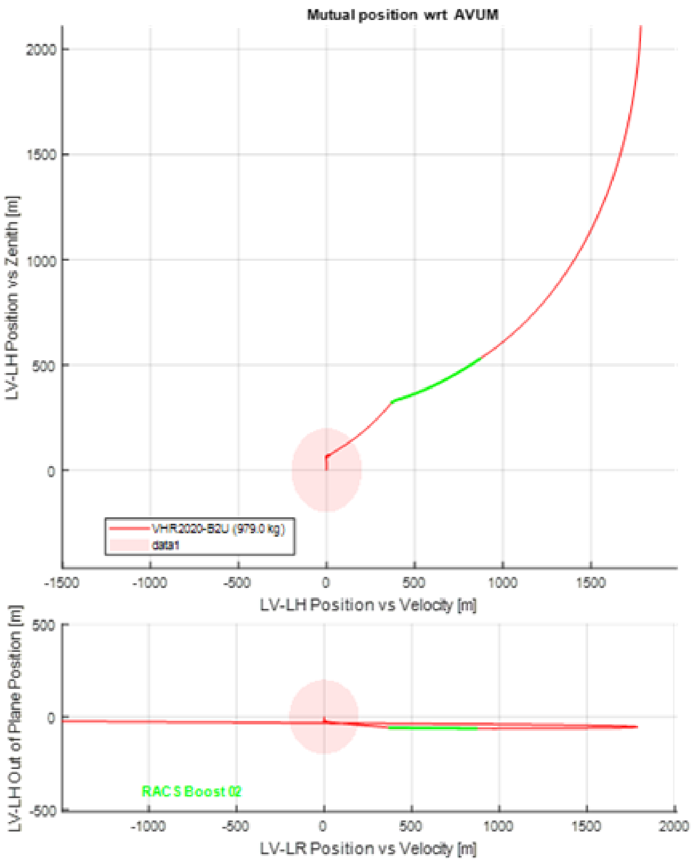


Figure 4: VC02 CCAM1.

Each Mission Block is composed by a slew, having the same structure for all the sub-phases, 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 or angular range.

DOI: 10.13009/EUCASS2023-925

The figure below shows the structure common for all the mission blocks with the slew having the scope to reach a predefined attitude before the following action implementation (different from phase to phase).

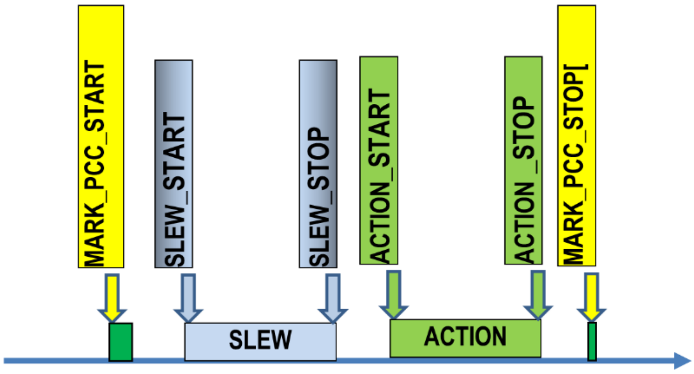


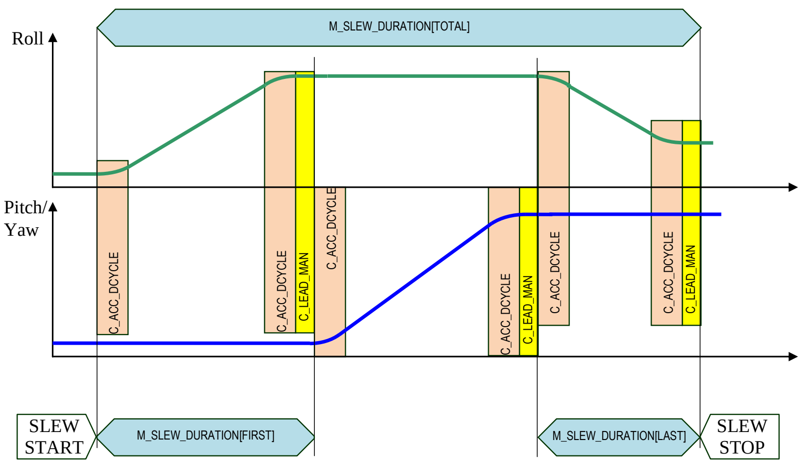
Figure 5: Sub-phase Timeline.

Slew

The slew manoeuvre can be performed with several types, to cope with the requirements of the different phases of the mission. The manoeuvre can be achieved with 1, 2 or 3 successive rotations defined in the following bullet list and schematically represented in the figures below.

- DUMMY NO manoeuvre performed
- PITCH SHORT manoeuvre by two rotations: roll around XLV axis, then in pitch around ZLV axis toward shorter angle direction
- YAW SHORT manoeuvre by two rotations: roll around XLV axis, then in yaw around YLV axis toward shorter angle direction
- EULER SHORT single plane rotations around intermediate axis to put XLV axis toward required attitude by shortest angle direction
- PITCH LONG as PITCH_SHORT but the second rotation takes a reverse direction toward longer angle
- YAW LONG as YAW_SHORT but the second rotation takes a reverse direction toward longer angle
- EULER LONG as EULER_SHORT but the rotation takes a reverse direction toward longer angle
- EULER 3D single rotations to reach required attitude by 3 Euler angles

A specific flag can be selected to add one more rotation in roll if the roll angle is requested, otherwise the last rotation isn't implemented.



DOI: 10.13009/EUCASS2023-925

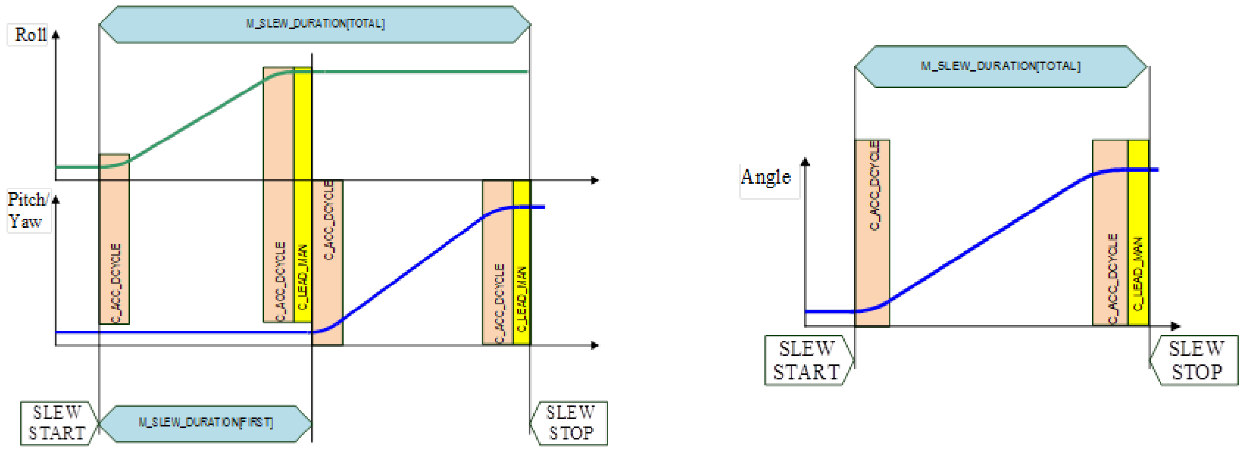


Figure 6: Slew Timeline with 1, 2 or 3 rotations.

During the design of the mission the GNC specialist will decide which of these options is the right one for each phase, depending on the requirements of the mission block and on the environmental conditions.

3. TVC improvements

Thrust Vector Control architecture for Vega-C is based on the same logic used for Vega, with a different tuning logic, 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.

3.1 First Stage improvements

The progress made on VEGA-C 1st stage TVC control algorithm aims at reaching advanced performance, repeatability, cut of missionization effort, lead time and augmented system robustness to uncertainty and dispersion.
To better appreciate the architectural evolution, let's do a brief recap of VEGA heritage. As depicted in Fig. 7, the TVC control of VEGA 1st stage consists of several elements. Being the launcher axisymmetric, only the yaw planar motion is shown (the pitch is obtained by duality). It should be noted that this hypothesis is no more valid in case of roll rate for which a specific analysis is to be performed [1]. Specifically, there are four channels to act on:

- Attitude and attitude rate error $(\psi_e, \dot{\psi}_e)$. It means that the reference command shall be tracked by reducing the actual attitude deviation.
- Drift and drift rate error $(z_e, \dot{z}_e)$. In this case the intent is to regulate the lateral motion to a null target value.

Each control line has:

- A signal shaping transfer function (denoted by TFi), which could be a low-pass filter, band-stop and/or lead-lag.
- Either a proportional or derivative gain ($K_{\psi P}$, $K_{\psi D}$, K_z , $K_{\dot{z}}$).

All channels are summed up and subject to another filtering (TF5) needed to phase or gain stabilize LV bending moments. The output is the commanded TVC angle. As highlighted by the dependency between brackets, all the control parameters are scheduled versus Non-Gravitational Velocity (NGV for short).

DOI: 10.13009/EUCASS2023-925

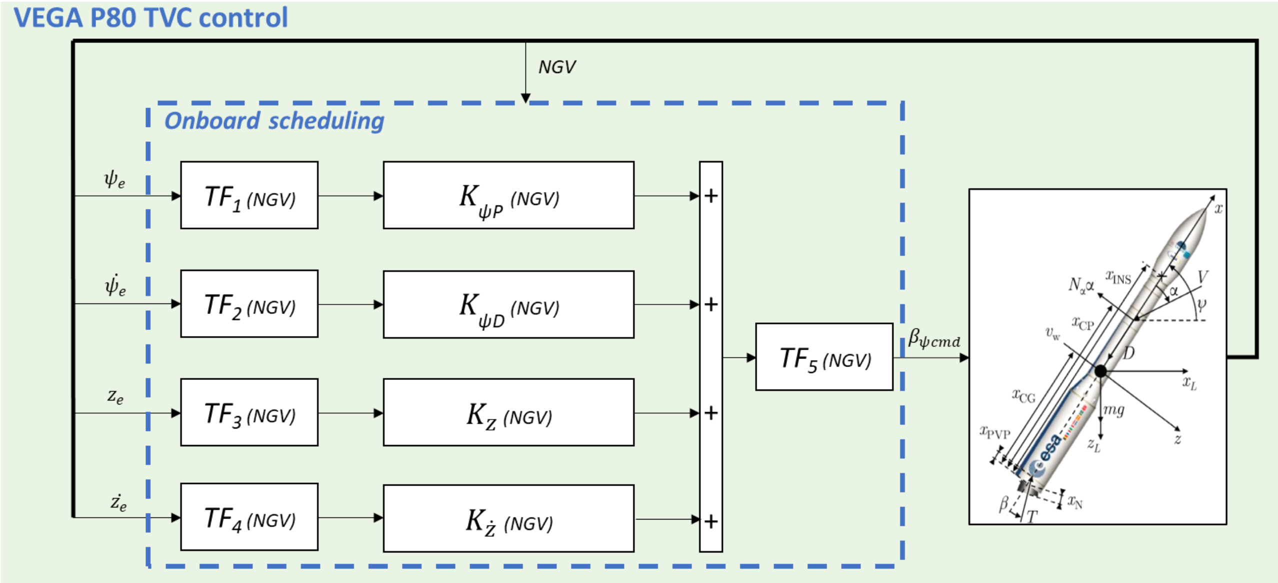


Figure 7: VEGA 1st stage TVC control scheme.

Moving on VEGA-C upgrade, the control system changed in the following parts (refer to the flowchart of Fig. 8):

- Attitude gains $K_{\psi P}$, $K_{\psi D}$ became function of measured Non-Gravitational Acceleration (NGA) and estimated online Relative Velocity (VREL) besides NGV.
- System desired closed loop response coded in terms of bandwidth and damping are stored inside mission data files to allow an onboard real time computation.
- Lateral drift rate $K_{\dot{z}}$ gain varies against roll rate ($\dot{\phi}$) besides NGV.

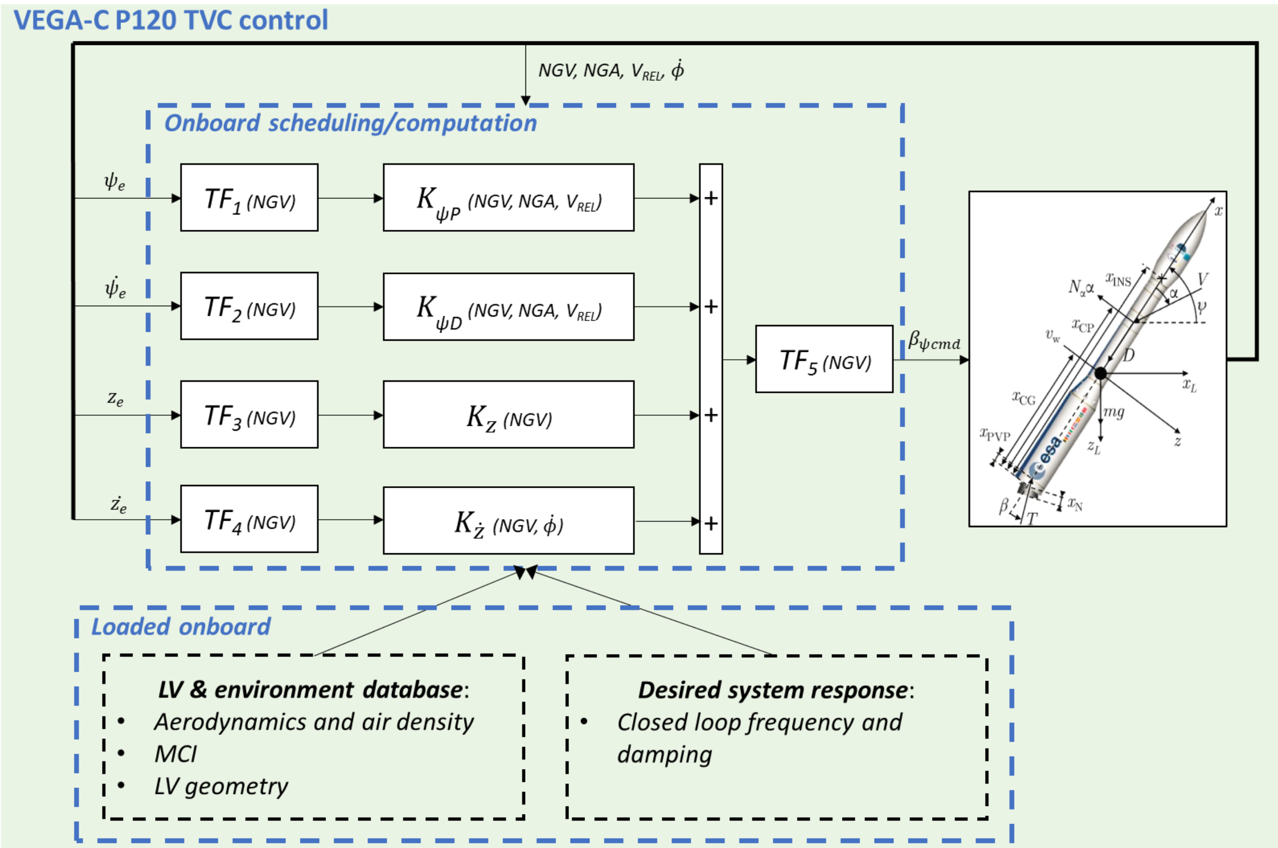


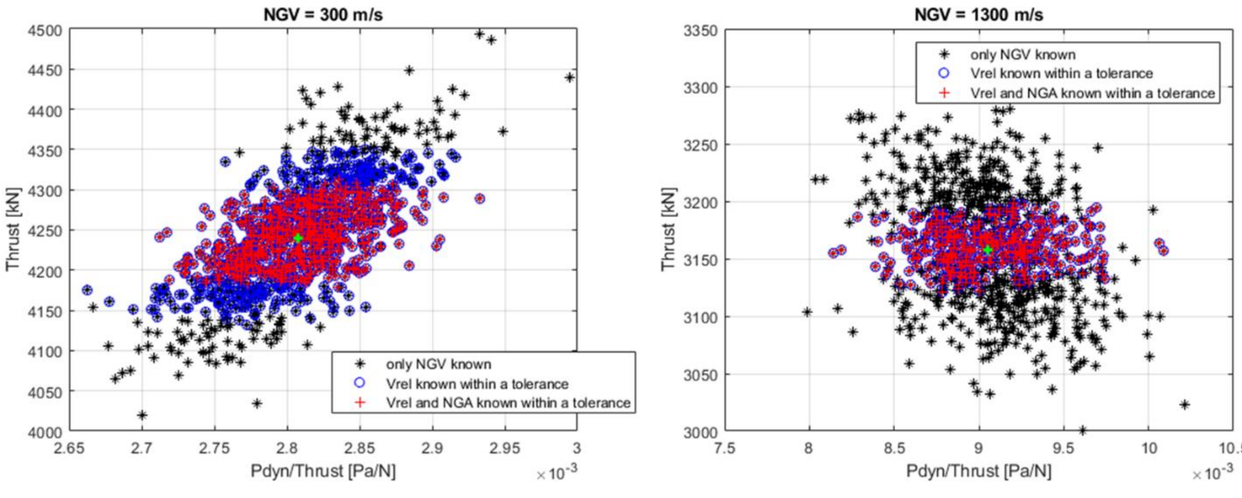
Figure 8: VEGA-C 1st stage TVC control scheme.

DOI: 10.13009/EUCASS2023-925

Generally speaking, the use of multiple real time measures gives a better knowledge of the operating point by reducing the relative uncertainty and simultaneously enlarging the flight envelope [2]. The VREL variable embeds information on dynamic pressure, NGA allows an estimation of the engine thrust and $\dot{\phi}$ is meaningful to perform an adaptation of lateral drift rate gain.
As previously mentioned, some guidelines directed the development. To succeed in cutting missionization effort and lead time some complexity has been clearly transferred from the missionization process to the onboard software. On VEGA the TVC tuning is performed completely offline and doesn't have adaptive features on $\dot{\phi}$, NGA and VREL. Therefore, the designer is induced to best fit the specific mission and "authorized" to change each control component. This activity is not only prone to time consuming re-loops between frequency and time domain analysis, but also may produce mission-to-mission performance variation by affecting the promptness of the system response linked to perturbations and disturbances. For example, a direct consequence caused by this method might be an unwanted detection of Qα requirement exceedance.
Conversely, on VEGA-C we decided to avoid this kind of inefficiency and privilege mission-to-mission performance repeatability. We consider the closed loop bandwidth and damping as an invariant data as well as the shaping filters except TF5 devoted to bending modes stabilization. It remains the only to be synthetized each mission due to the considerable difference on bending modes among the entire class of PL. The shaping filters and the closed loop properties have been fixed by solving a laborious optimization problem to search for a unified solution for PL min and max, which are the extremes of the admissible PLs.
Practically, the list of parameters to be missionized mission by mission reduces to the MCI characteristics and TF5 filter (since aerodynamics, propulsion and geometry don't change). The MCI enters in the A6 (aerodynamic coefficient) and K1 (thrust parameter) computation, that in turn allows to define the values of rigid gains as per the following formulas (recalled also in §3.2):

- $K_s = (A6+\omega^2)/ K1$ **(2)**
- $K_d = 2*\omega*\xi / K1$

In this way, the desired closed loop frequency and damping (missionized) are still assured wrt current flight condition. This is a strong guarantee on reliably predicting the expected results and at the same time lower the risk associated to an unconstrained missionization. As a trade-off with respect to safety authority, the on-line adaptation has been not introduced during the first seconds of the flight in order to allow a comparison with the already flew missions in terms of safety corridors.
To appreciate the advantage of using the NGA and Vrel beyond the NGV (scheduling variable also on VEGA flight SW), some explanatory graphs are shown in Figure 9. The dispersed physical cases drawn are obtained as a result of a MC performed with Morpheus. Each graph freezes the system at a given NGV by displaying the relationship between two fundamental parameters, namely thrust and the ratio pdyn/thrust which are directly connected to LV manoeuvrability and stability. In particular, NGA enters into the thrust and in turn into K1, while Vrel enters into the dynamic pressure and in turn into A6. Its interesting to see how the cloud of physical points shrinks when Vrel and NGA are known within a tolerance (for example 3 m/s and 0.3 m/s). This allows the controller to better adapt on real flight conditions as a consequence of narrowed uncertainty. For example, at NGV = 300 m/s the knowledge of thrust is improved of roughly 5% and on its ratio out of the dynamic pressure of 2%.



DOI: 10.13009/EUCASS2023-925

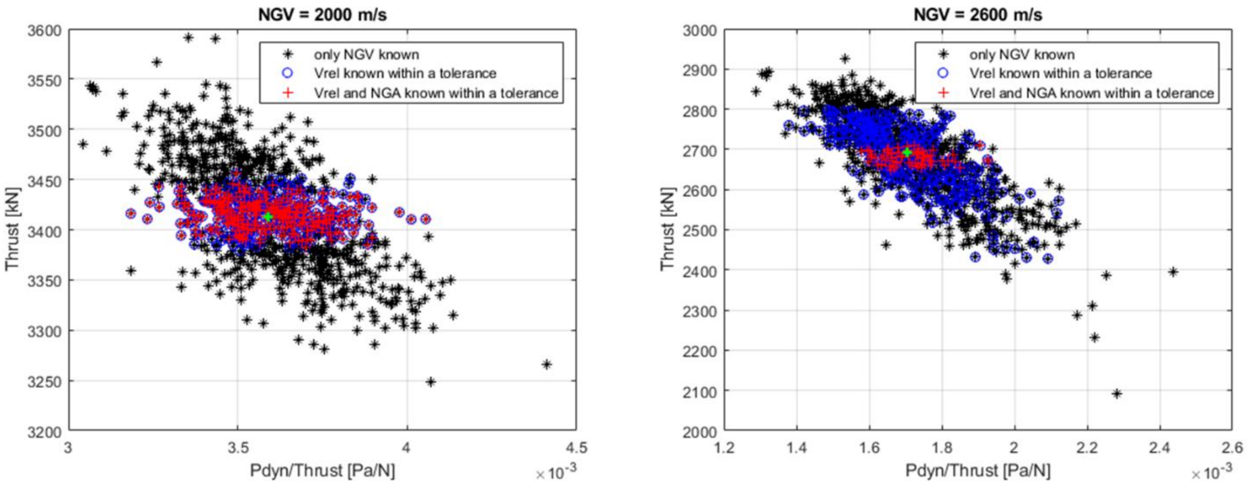


Figure 9: Dispersed physical cases as a result of a MC performed with Morpheus. Each graph freezes the system at a given NGV (300 m/s - upper left, 1300 m/s – upper right, 2000 m/s – bottom left, 2600 m/s bottom right), showing the relation between two fundamental parameters: thrust and the ratio pdyn/thrust.

Worth mentioning the huge improvement brought by the adaptation of $K_{\dot{z}}$ versus roll rate (by way of illustration, the reader may find a typical profile in Fig. 10). The derivative action on drift rate not only limits the lateral motion but, most importantly, acts indirectly on the angle of attack. For a certain extent, the higher the gain the more effective the AoA reduction. From a physical point of view, this can be explained by greater reactivity of the controller wrt deviation in lateral channel that are likely to be produced by wind gusts.
Nevertheless, increasing $K_{\dot{z}}$ has a conflict with stability margins, which tend to drastically reduce, by making incompatible the MIMO (Multiple Input Multiple Output) margins where the roll rate is set to an important value (it depends on flight time, and reaches almost 30 °/s). Such a rate is a 3-sigma boundary never reached in flights. The devised strategy is to set the gain high at small roll rate (which is also more probable) and decrease it as the roll rate increase. In this way, sufficient stability margins for each roll rate can be assured, while improving the time-domain response.

The closed-loop stability has been analysed in a classical way with LTI system by freezing functioning equilibrium points along the trajectory path. The discretization is dense and not only limited to the assessment of controller scheduling nodes. Being the controller structure intrinsically dependant on time varying parameters a further improvement could be to adopt LPV techniques.

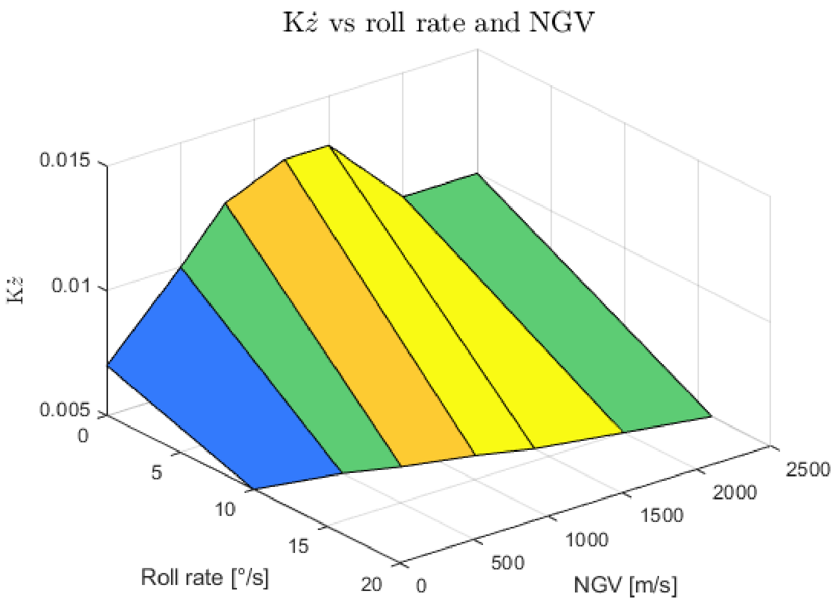


Figure 10: VEGA-C 1st stage TVC lateral drift rate gain $K_{\dot{z}}$ adaptation vs roll rate.

DOI: 10.13009/EUCASS2023-925

3.2 Fourth Stage improvements

Last Vega (and Vega-C) stage is composed by the AVUM (AVUM+ for Vega-C, with higher tanks capacity), the payload adapter and the PL itself.
This stage has an important weight variation between different missions, being PL mass strongly influent on the total mass of the stage, and between different instants along the same mission, taking into account the variation of propellant mass and the potential high number of PL releases.
Mass, inertia and CoG (the so-called MCI) varies a lot during the boost and this implies the need of varying the tuning accordingly.
Thus, keeping the same gains for every PL configuration or for every AVUM boost can lead to time domain responses not optimized (typically damping of the PD tuning either too low or too high).
In order to avoid the design of a specific TVC tuning for each mission and for each boost, Vega-C implements a scaling of the gains considering the MCI estimation.

The aim of the adaptation is to scale the rigid gains wrt:

- the inertia of the stage
- the arm between CoG and TVC pivot point

A “mass composer” function is in charge of computing the MCI at each discrete change of flight configuration (separations of PL, fairing, VESPA). The CoG position is than used to compute the arm wrt missionized TVC pivot point.
This modification is especially useful in the frame of the implementation of the Orbital Flexibility since it avoids missionizing TVC gains for each AVUM boost (which can become numerous).

Based on pole placement theory, all the gains can be expressed as follows, in which (p1,p2) are the poles to be placed and (ω, ξ) are the closed loop characteristics of the fast rigid mode, to obtain the desired response (lateral gains only for open loop guidance scheme):

- $K_s = \omega^2 / K1$ = *f(Inertia / lever arm)* **(3)**
- $K_d = 2*\omega*\xi / K1$ = *f(Inertia / lever arm)*
- $K_z = \omega^2 *(p1*p2) / (K1*acc)$ = *f(Mass * Inertia / lever arm)*
- $K_{z\_dot} = \omega^2 *(p1+p2) / (K1*acc)$ = *f(Mass * Inertia / lever arm)*

4. Mission Design Tools

As explained in the previous paragraph one of the main updates in the TVC design process from Vega to Vega-C has been to increase the robustness of the solution for a wide range of missions, covering the remaining degree of freedom with a few missionizable parameters in charge of cope with the properties of each specific mission. This has been possible due to the intrinsic stability of control on the TVC system but not all the tools updated can take advantage of the same solution. Most of the missionization phases have a high number of parameters to be tuned to adapt the software to the specific mission.
In this case the tools have been made faster to quickly provide a rapid answer to the changes to be tested and some additional functionalities have been added to evaluate separately different aspects of missionization.
This modification impacts the missionization and verification tools.

Flexible Orbital Phase
This is the main tool to design the orbital phase, allowing to handle all the Mission Data relative to the section after the AVUM1 and their fast modifications. The figure below shows the GUI of the new configuration.

DOI: 10.13009/EUCASS2023-925

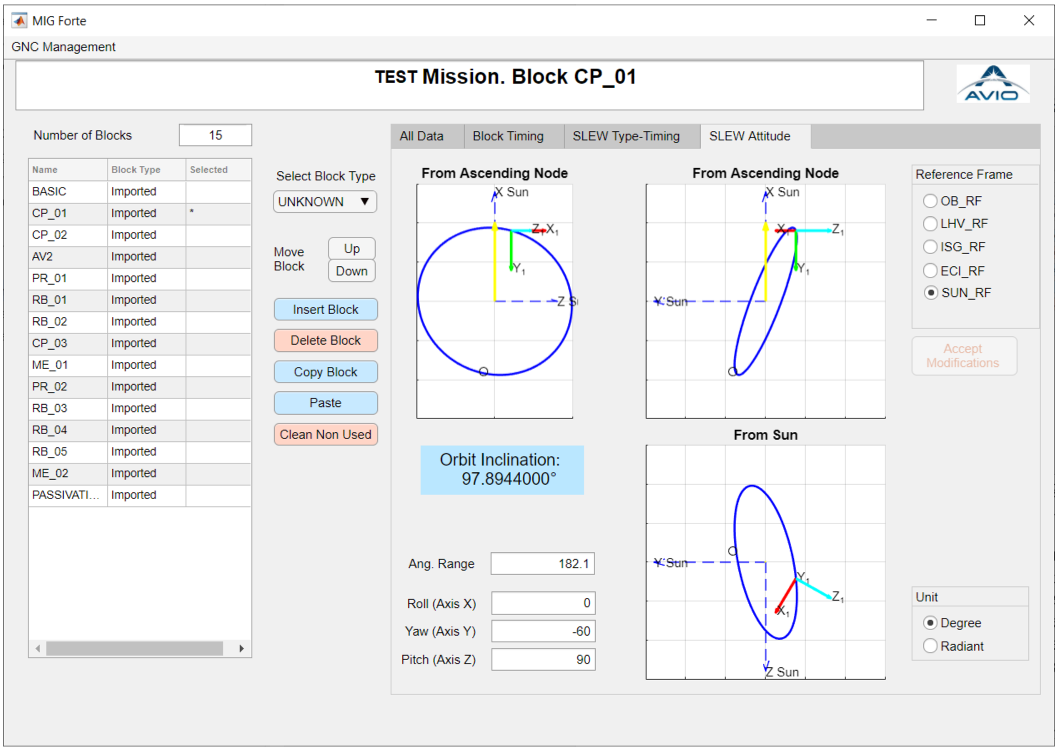


Figure 11: GUI of Flexible Orbital Phase tool.

The new tool is now able to manage the increased number of slew manoeuvre, of PL release and of coasting phase. The tool editor allows to differently customize orbital phases by inserting new elements in chain, delete elements from the chain, move elements up/down in the chain, import an existing element from previous missions and modify element parameters for fine tuning.

3DoF/Morpheus/Vegamath

These are the central tools to simulate the missions, both phase-by-phase than end-to-end, to evaluate the impact of the modifications on the mission data in the missionization process and following verification against the system requirements. The level of complexity in the simulators increases from the 3DoF tool taking into account only the translational motion with an ideal control with no attitude errors or delays, to Morpheus allowing fast simulations with 6DoF models of all the stages in Matlab/Simulink environment to finish with the Vegamath using more accurate 6DoF models in C and ADA language. All those simulators have been updated to manage all the new structure of the mission (up to 20 PL, Mission blocks, separation) and the new interface with SW.

Syracuse

This tool is a help for the GNC expert to obtain the tuning for the FPSA RACS model and to verify it. It allows also to verify the stability margins of the tuning for the different flight phases. The tool is divided into two stand-alone tools the first one is the tuning tool, the second one is the stability tool. The **tuning** tool allows to create the Mission Data file relative to the ACS for different missions starting from the MCI characteristics of the selected mission and from the control gain to use for the different phase of the mission. The **stability** tool allows to verify the stability margin of a selected tuning for a selected phase of flight. The main changes implemented on the tool have been the modification of the format of the Mission Data to take into account the new architecture used in Vega-C and the introduction of the Orbital Flexibility phase.

Valer/Vegastab

These tools evolved to consider the new features implemented in the TVC algorithms, particularly for P120 to compute rigid gains in flight through an easy pole placement law. VEGASTAB is a tool which performs stability analysis of the TVC control algorithms of VEGA-C launcher in the frequency domain. The stability analysis is based on a SISO approach (single input – single output) on the controlled system transfer function broken at the command point i.e. the commanded nozzle deviation. The possible couplings (such as due to roll motion) are analyzed through MIMO approach.

DOI: 10.13009/EUCASS2023-925

5. Conclusions

This paper illustrates the enhancement introduced to several features of the GNC missionization process in the transit from Vega to Vega-C launcher. These changes have been realized to reduce time and cost of each missionization loop normally required to reach a reliable solution in terms of accuracy of the target orbit, safety of the operations and allow GNC specialist to design a wider range of possible missions. Indeed, the previous GNC design procedure (used for Vega flights) was based on eight rigid types of scenarios to witch the mission needed to be adapted. The introduction of a new set of building blocks (called Mission Blocks) in the Vega-C mission design process inverted the perspective and permits to build the mission in a flexible way putting near each other the needed blocks to be as close as possible to the wished requirements. Another improvement in the evolution of the missionization activity has been on the robustness and on the simplification of the tuning logic of the TVC, increasing at the same time performance repeatability, avoiding in this way to adapt the required parameters of the TVC control algorithms of the 1st and 4th stage to each mission and each manoeuvre.
The described modification on the procedures contributed to the upgrade of the tools used in the chain of the missionization that have been made compatible with the new block’s structure and the architecture.

References

[1] C.Roux, I.Cruciani. 2007. Roll Coupling Effects on the Stability Margins for VEGA Launcher. AIAA-2007-6630, AIAA Atmospheric Flight Mechanics Conference and Exhibit, Hilton Head, South Carolina.
[2] C.Roux, I.Cruciani. 2008. Scheduling Schemes and Control Law Robustness in Atmospheric Flight of Vega Launcher. Proceedings of the 7th International ESA Conference on Guidance, Navigation and Control System, Tralee, County Kerry, Ireland.