

## Optimised flight preparation process for the first Vega Ride-Share mission

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### ABSTRACT

The first European ride-share mission will be carried out by the Vega launch system in mid 2019. The VEGA PoC (Proof of Concept) flight using the SSMS (Small Satellite Mission Service) hardware was conceived in the context of ESA LLL Initiative. This paper describes the Light Sats aggregate selection process and the preparation of the first European ride-share mission with Vega launcher, update on the hardware preparation status and provide insight on the methods and tools used for its implementation. Based on Vega flights accumulated experience, the development of multi-Payload mission concept started from analysis of the activities currently foreseen to fly a single payload mission adapted to the needs multi payload ride-share missions. Evaluation of impacts in terms of technical feasibility, missioning schedule and related programmatic and cost elements were considered for the missioning of the Light Sats launch service. Major elements of the process described in this paper envelope mission analysis, launch preparation including AIT approach and launch service aspects with customers, before and after launch service agreement signature. The described process is intended to constitute a first step using the Vega launch system, useful towards the ultimate goal to support the definition of a finally optimized process applicable to all European launchers.

## 1. INTRODUCTION

Purpose of this document is to report on the preparation status of the first European ride-share mission to be carried out by the Vega launch system in 2019.

Several multi Payload flights have already been implemented with the Vega system (e.g.: VV02: Proba-V, VNredsat, Cubesat; VV07: Skysat (4 off), Perusat;....) demonstrating the system flexibility to successfully support complex missions.

The ESA LLL (Light satellite, Low cost, Launch opportunities) Initiative SSMS (Small Satellite Mission Service) PoC (Proof of Concept) flight goal is to demonstrate reached capability to aggregate, prepare, launch and deliver into orbit a set of Light Sats; enabling timely, standardized and guaranteed access to space to Light Sats Institutional and commercial Users community by means of a dedicated and optimized European launch service .

To reach this goal, design-to-cost approach has been applied to both development of launcher hardware and launch preparation processes; in the following section the major elements are described together with up-to - date preparation status.

## 2. ESA Announcement of Opportunity

### 2.1.1. AO Description

For preparation of Vega PoC flight, first step was to prepare a Announcement of Opportunity to collect Users community feedback on the initiative and probe the Light Sat market status to corroborate the forecasted raise of launch demand on such Spacecraft classes.

As a reference for Users community, the following Light Sat classes were defined, in collaboration with Arianespace:

- Class 4 (including 1U, 3U, 6U): 1Kg – 25Kg
  - Class 3 (including 12U+): 25.1Kg – 60Kg
  - Class 2: 60.1Kg – 200Kg
  - Class 1: 200.1Kg – 400Kg
- 
- Class 4 (including 1U, 3U, 6U): 280x320 mm base, 420 mm height
  - Class 3 (including 12U+): 600x600x600 mm
  - Class 2: from 600x660 mm base, 700 mm height to 800x800 mm base, 1200 mm height
  - mm height

- Class 1: 1700 mm base diameter, 1800 mm height, or inscribed squared base

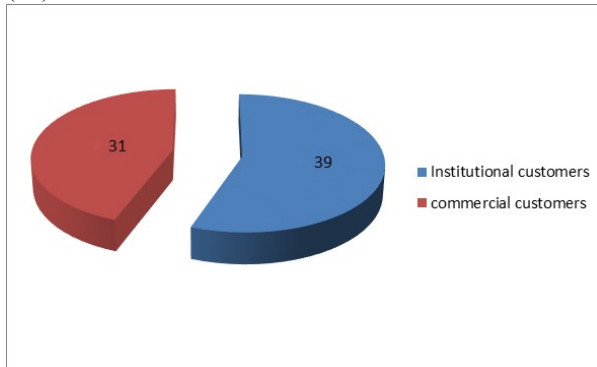
The Announcement of Opportunity was jointly issued by ESA and European Commission, in collaboration with Arianespace. Outcome is addressed in 2.1.2.

### 2.1.2. AO Outcome

70 responses of Notice of Interest (NoI) corresponding to 101 individual projects and to 165 spacecraft overall have been received from the light satellite worldwide community.

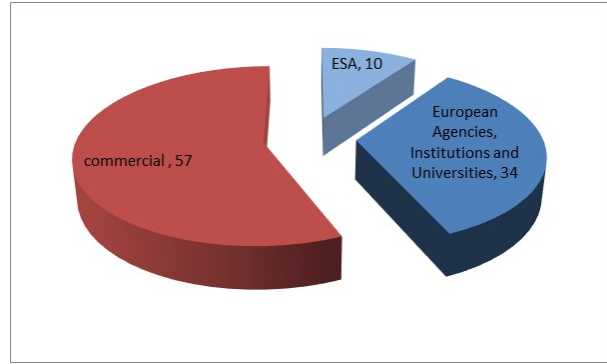
Such a remarkable outcome clearly confirms the great interest of the light satellite market segment in such a kind of service especially needed by the European Institutional and commercial CubeSats community, often in difficulty to find adequate response to its launch service needs.

NoI have been received both from the public sector (39, out of which 10 ESA) than from the commercial one (31).



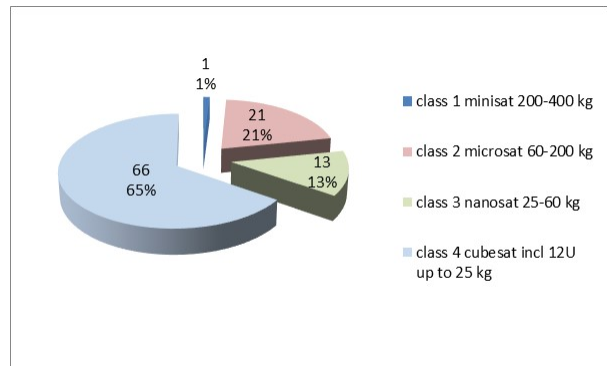
**Figure 1: Vega AO Customers**

Such 70 NoI corresponds to 101 projects, out of which 44 from the European Institutional (EI) market (34 from European Agencies, Universities and Institutions and 10 ESA) and 57 from the commercial market.



**Figure 2: Vega AO Projects by market area**

Above mentioned 101 projects have been divided by class as reported in the following picture.

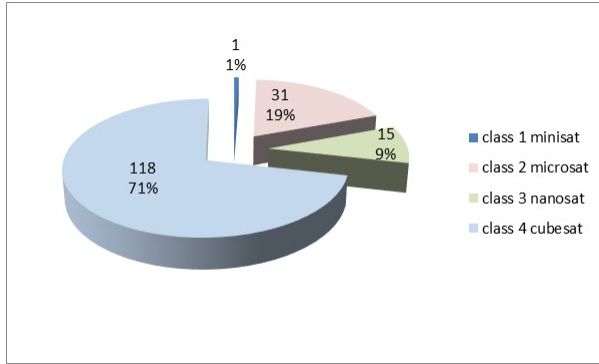


**Figure 3: Vega AO SmallSat Projects class distribution**

101 projects	EI customers	Commercial	Total
class 1	0	1	1
class 2	6 (1 ESA)	15	21
class 3	7 (3 ESA)	6	13
class 4	31 (6 ESA)	35	66
Total	44	57	101

**Table 1: Vega AO SmallSat Projects**

Above mentioned 101 Projects generated 165 spacecraft divided by class.



**Figure 4: Vega AO SmallSats class distribution**

165 spacecraft	EI customers	Commercial	Total
class 1	0	1	1
class 2	6	25	31
class 3	7	8	15
class 4	47	71	118
Total	60	105	165

**Table 2: Vega AO SmallSats**

Out of above mentioned 165 spacecraft 125 were compatible from technical and programmatic standpoint with the Vega SSMS PoC flight, so divided by class and by institutional or commercial nature.

125 spacecraft	EI customers	Commercial	Total
class 2	4	17	21
class 3	1	1	2
class 4	30	72	102
Total	35	90	125

**Table 3: Vega AO SmallSats compatible with PoC flight**

Orbital parameters selected for the Vega PoC flight has been SSO at 500 km altitude, LTAN 10:30.

Total spacecraft mass of NoI received has been above 2.5 T , resulting in total reference load capability at the mentioned orbit of 2 to 3 Vega flights.

All responses have been screened to identify alternative aggregates (set of satellites of different mass and dimensions class with compatible mission requirements in terms of launch date and orbital parameters) to be pre-selected for further evaluation process continuation.

### 3. SSMS HARDWARE DEVELOPMENT STATUS (AVIO)

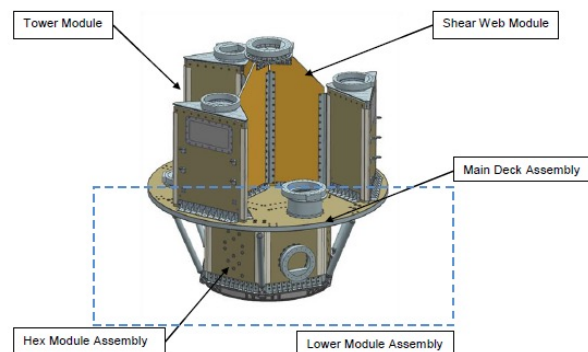
The SSMS hardware is consisting of a dispenser structure accommodating the P/Ls to be deployed, the related separation systems and avionics. The dispenser has been designed to be modular, allowing to interface small satellites in several configurations based on the same structural elements.

Basically the structure is made of sandwich panels with aluminum honeycomb core and CFRP skins. In addition to these composites parts, it is made up of an aluminum machined I/F ring towards the VEGA launcher 1194 PL adapter and aluminum machined brackets.

With reference to the most complex configuration (i.e. “Flexy”), the mechanical structure can be divided in 4 main mechanical subsystems or modules (fig.5) which are used depending upon the configuration chosen to embark the satellites:

1. Lower Module Assembly which comprises:
  - Lower I/F ring
  - Hexagonal Module Assembly
  - Main Deck Assembly
  - External Rod Assembly
2. Tower Module Assembly:
3. Shear Webs Module Assembly
4. Separation System Spacers

Dispenser configuration for the SSMS Proof of Concept (PoC), that will be the first flight on VEGA, is the Flexi-3 that is shown in fig.5.



**Figure 5: Flexi-3 Configuration (PoC)**

The dispenser is equipped with integrated harness and with Lightbands for Payloads separation.

Pre-development test campaign has been performed for critical manufacturing processes related to CFRP panels to validate suppliers. Test at specimens level have been performed both considering laminates and sandwich with inserts taking into account the environmental conditions that the SSMS Dispenser shall withstand, specimens have been tested considering room temperature, vacuum environment and cycling test within the temperature range that will be experienced during orbital life.

Development test campaign is ongoing and foresees tests focused on specimens having representative characteristics (skin thickness, lay-up, honeycomb thickness and inserts dimensions) of the final design of the dispenser in order to extrapolate allowable values to be considered in the mathematical models used for mechanical analysis.

In addition to the test campaign that will be performed at S/S level (Harness and Functional S/S) the SSMS PoC Dispenser (PFM1) will undergo to a complete qualification campaign at System level which includes:

- Mechanical tests: static load test, modal survey test, sinusoidal vibration test, acoustic test, fit check.
- Electrical tests: bonding, grounding, pin to pin verification, isolation, double retention test

#### PoC Dispenser Development roadmap:

- PoC CDR-1 (focusing on panels design) has been completed;
- PoC CDR-2 (covering the entire dispenser design) will be completed by November 2018;
- PoC flight hardware (PFM1) manufacturing will start in July 2018 and will be completed by January 2019;
- PFM1 qualification test campaign will be performed in Q1 2019;
- PoC flight hardware (PFM1) will be available (after post-test-campaign refurbishment) for the Satellites integration campaign by the end of March 2019;
- PoC QR will be completed by mid-2019.

#### **4. AGGREGATE DEFINITION PROCESS**

The definition of the aggregate is a complex interconnected process, from both technical and programmatic stand points.

The following sections will describe the challenges of this process, and introduce the first lessons learnt from the VEGA PoC preparation.

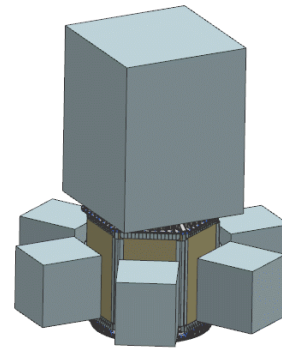
#### **4.1. What is an SSMS aggregate**

The aggregate is the upper configuration of the launcher including:

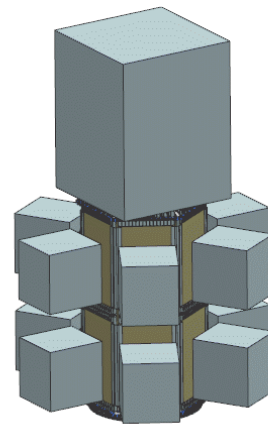
- 1) The S/Cs selected for the mission**
- 2) The chosen SSMS configuration**

The SSMS is a modular concept, allowing to interface small satellites in several configurations based on the same structural elements:

- *Piggy back configuration*  
Based on one our two hexagonal modules



**Figure 6: HEX1 Configuration**



**Figure 7: HEX2 Configuration**

- *Ride Share configurations*  
Based on one hexagonal module and a platform, equipped with or without spacers, a central column, and/or tower module.

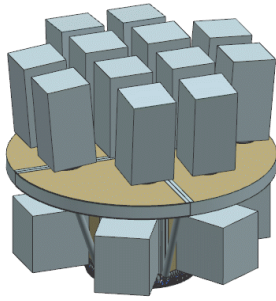


Figure 8: PLAT-1 Configuration

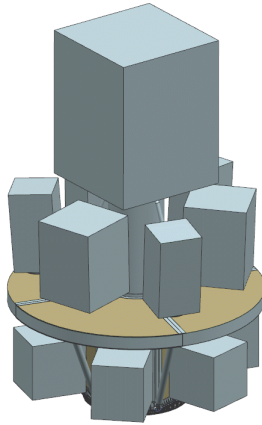


Figure 9: PLAT-2 Configuration

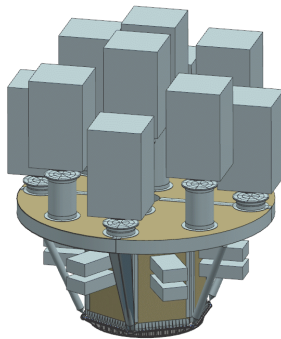


Figure 10: PLAT-3 Configuration

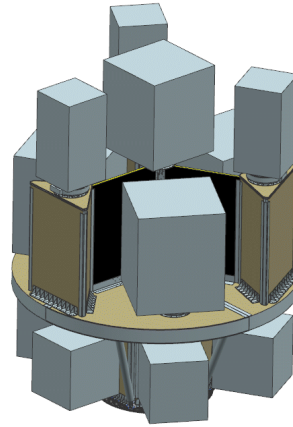


Figure 11: FLEXI-3 Configuration

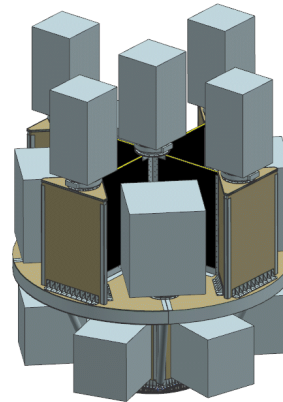


Figure 12: FLEXI-4 Configuration

#### 4.2. An iterative, interdependent process

Defining a final aggregate implies to consider the constraints coming from the satellites themselves, but also those inherent to the SSMS and the VEGA launcher (see figure 13).

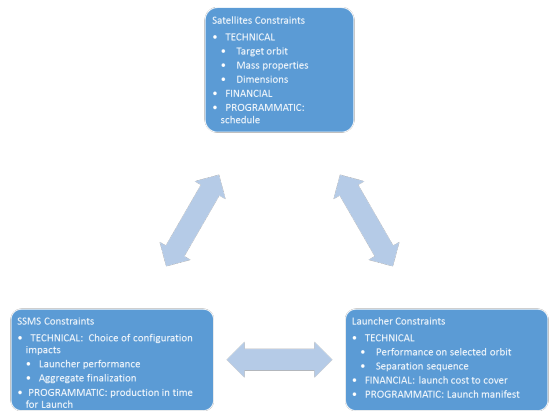


Figure 13: Aggregate definition constraints

The main technical steps during the aggregate definition process are:

- **Choice of the target orbit(s)**

Potential customers are grouped according to their desired target orbit. VEGA allows reaching up to three different orbits on a single mission. According to selected Users demand, the most appropriate orbits configuration is selected for the mission.

- **Check of the launcher performance**

Based on VEGA performance map, the maximum overall aggregate mass associated to the selected orbit(s) is defined as a target.

- **Definition of the aggregate layout**

The overall dimensions and shape of the satellites drive their feasible positioning on the SSMS structure. The SSMS configuration chosen is the one which maximizes the overall S/C mass.

The S/Cs have to fit together on the selected SSMS configuration, with sufficient clearance between themselves and the structure in order to allow a safe separation. Detailed CAD analysis are performed in the context of Aggregate pre-feasibility analyses to assess this clearance.

From a programmatic point of view, the aggregate has to be “time-coherent”, that is:

- all satellites shall be ready to be launched on the same date foreseen by the VEGA manifest
- the aggregate definition has to be frozen in time to procure the SSMS structure and the relevant LLIs (i.e.: raw matl’s).

### 4.3. Application to PoC flight

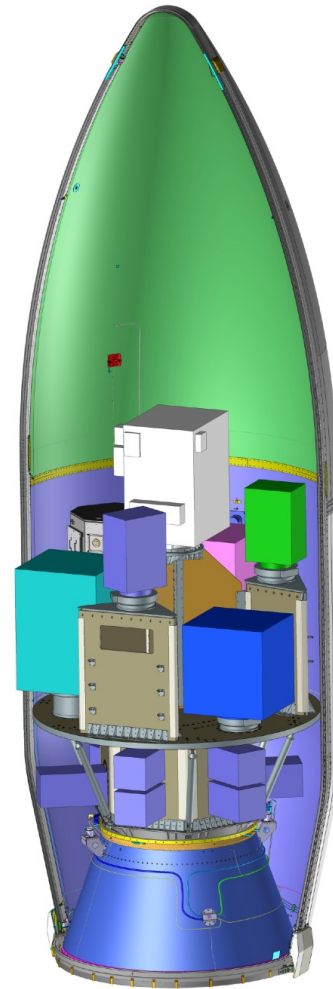
The overall process described above was followed during the preparation of the PoC flight and confirmed the anticipated challenges.

In particular, the SSMS configuration evolved during the process, from a FLEXI-4 to a FLEXI-3, due to changes in SCs aggregate during mission preparation activities.

Evolution of the S/C aggregate also implies potential change of the interfaces and the separation system required. A standardized concept is adopted on SSMS such that on PoC flight, this issue was addressed by selecting only one type of separation system (PSC’s Lightband), which comes in several

different diameters is selected. From the aggregator perspective, it has the drawback of being a Long Lead Item. Potential adjustments of aggregate SCs leading to separation system diameter requirements from Users were addressed and an appropriate spare policy was put in place.

The final aggregate is represented in **Figure 14**.



### 4.4. Conclusion

The complexity of the aggregate definition implies an optimized mission analysis process able to:

- allow starting the Final Mission Analysis at the latest, in order to have additional time to converge on a frozen configuration, without impacting the launch date

- manage the late evolution of the aggregate, which cannot be discarded a priori even if the previous objective is reached

## 5. MISSION ANALYSIS PROCESS

### 5.1. Pre-feasibility analyses

Once the aggregate is defined following the process described in previous section, analyses of a higher level of details are performed in order to consolidate the final aggregate and the definition of the mission.

The activities foreseen for the PoC flight pre-feasibility loop are summarized in Table 1.

Activity	Scope
<b>Mass properties computation</b>	Input for the following analyses: trajectory, separation Assessment of the CoG offset of the overall aggregate gives an indication about its controllability
<b>Trajectory analysis</b>	Optimization of the trajectory to quantify the performance reserve (if any) and nominal timeline of the mission. Scattered analyses for a limited number of critical parameters: 3 <sup>rd</sup> stage re-entry footprint, thermal flux...
<b>Separation analyses</b>	Definition of the separation sequence of the aggregate: delays between each command, springs' energy and position... Input to other subsystems involved in the mission: Flight Software and Avionics for delays, springs' characteristics for the separation system. Preliminary verification of no-collision between the separated S/C.

**Table 4: PoC pre-feasibility analyses**

### 5.2. Final mission analyses

Typically, on standard VEGA missions, the final mission analyses (FMA) are initiated about 8 months before the flight. They are the final and most extensive analyses performed to verify that the Launcher satisfies all the requirements expressed by the satellites and that the mission is inside its qualified perimeter. The main activities are listed hereafter:

- Trajectory design and validation through Monte-Carlo analyses and Hardware-in-the-loop campaign
- Separation analysis for each S/C
- Contamination analysis for each S/C
- Coupled Load Analysis for each S/C

- Thermal analysis for each S/C
- Electro-Magnetic Compatibility for each S/C

Consequently, addressing the Ride Share missions, which implies to have a high number of satellites on board, critically increases the workload associated with the FMA with consequent need for optimization of the process.

Furthermore, as discussed earlier, the characteristics of the Ride Share mission (late definition and potential later evolution of the aggregate) make it critical to optimize the process to make it more efficient and flexible. One of the important goals of the VEGA SSMS PoC flight in that respect is to revise the process and implement a streamlined approach.

The potential improvements shall focus on:

- **Simplification:** by using the return-of-experience from eleven VEGA flights, remove all the analyses that are not strictly necessary, for example some CLA load cases could be revisited
- **Standardization:** define standard manoeuvres - for example, collision and contamination avoidance manoeuvres after the separations, or the ascent profile of the first stage of VEGA - independently from the S/C characteristics ; define a standard sequence for the Cubesat separations
- **Increased genericity** of the studies: through an ad-hoc margin policy, try to cover the changes of mass properties connected to S/C aggregate evolution.

## 6. AIT PROCESS

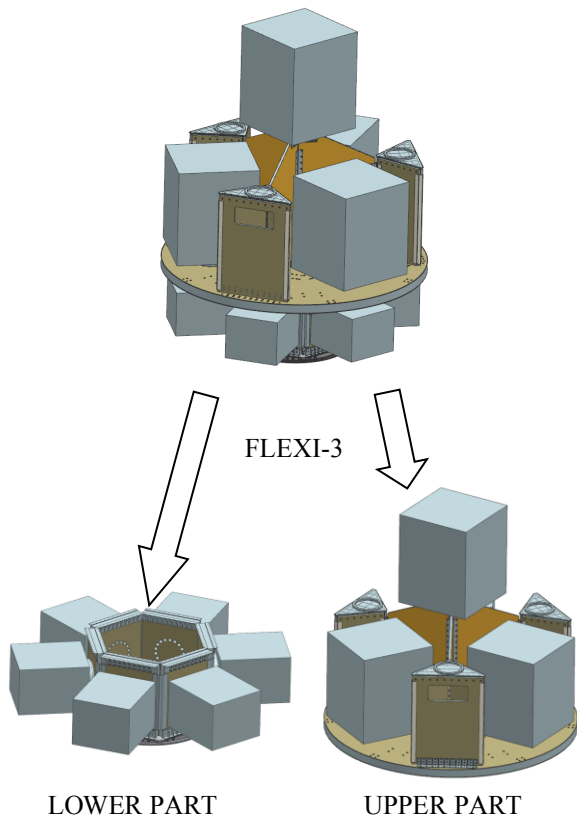
### 6.1. Integration flow concept

In order to standardize the launch preparation operations and reduce the mission costs, the activities related to the integration of the spacecrafts with the dispenser structure in Europe shall be maximized.

For the same reasons, to shorten the integration time and to have the possibility to work in parallel with the integration of the S/Cs also in different locations, it has been decided to design the dispenser in such a way that the upper and lower part can be integrated and transported separately with dedicated transport containers.

As sketched in the pictures below, for instance, a FLEXI-3 configuration is divided in a Lower Part (made by the

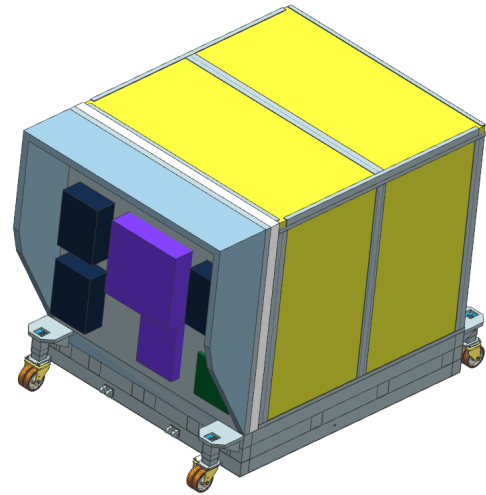
Hexagonal Module and the Lower I/F Ring) and in an Upper Part (made by the Main Deck, the Towers modules and the Shear Web Module)



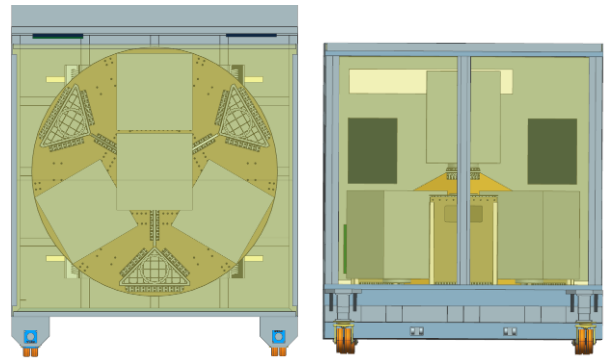
**Figure 15: FLEXI-3 Configuration**

**6.1.1. SSMS Transport Containers**

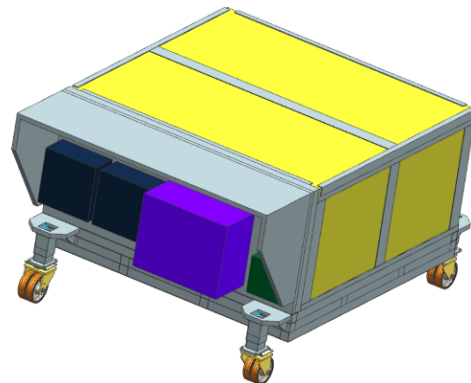
Two dedicated transport containers equipped with Air-conditioning units able to guarantee ISO 8 Environmental conditions have been developed. Dampers systems and conditioning/monitoring systems have been also included in order to attenuate the transmission of the transport loads, monitor and condition internal environment where needed.



Upper Part Container

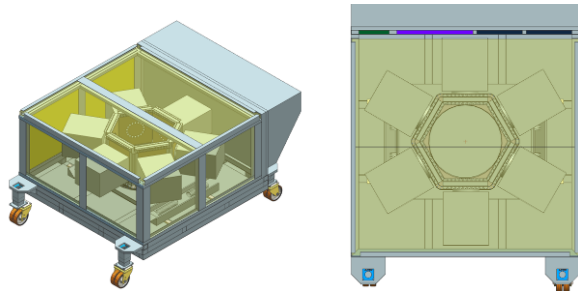


Upper Part Container – Internal view



Lower Part Container





Lower Part Container – Internal view

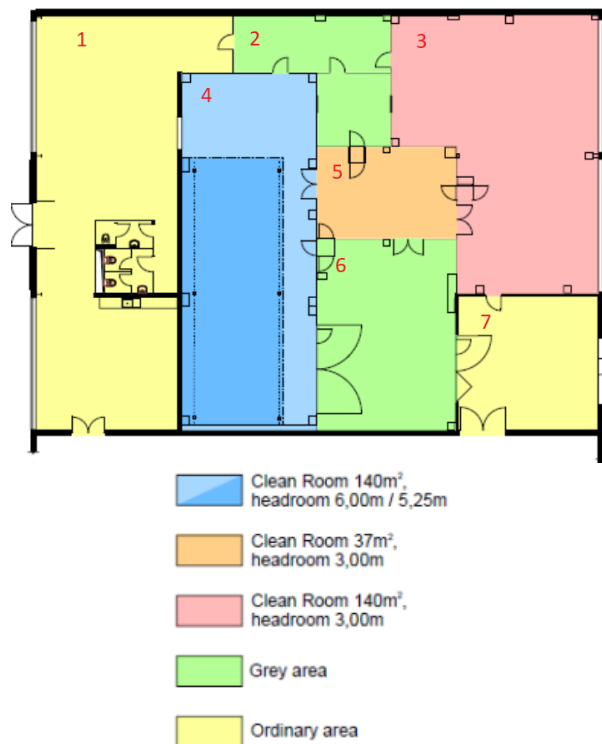
**Figure 16: SSMS transport containers**

These containers have been sized according to final VEGA C SSMS Dispenser dimensions and will be refurbished after the use for the VEGA PoC Flight.

### 6.1.2. SAB Integration Facility

SAB Aerospace facility located in Brno has been selected for integration of the Payloads on the SSMS Dispenser structure.

For the PoC flight only the S/Cs to be mounted on the Lower part of the dispenser will be integrated, however the facility is equipped to perform the integration also for the upper part for the future VEGA C SSMS Dispenser. The facility plan is reported in the picture below.



**Figure 17-1: SSMS Dispenser Integration Facility**

There are about 300 square meters of ISO 8 clean room environment, which will be dedicated to the SSMS activities during S/Cs integrations.

#### 6.1.2.1. SSMS Integration Flow

The integration of the P/Ls with the SSMS structure will be performed in the Area 4 (blue area in the picture above). In this area, equipped with lifting crane, there will be the SSMS structure ready for integration fixed on a dedicated integration stand.



**Figure 17-2: SSMS Dispenser Integration Facility**

The P/Ls Transport container will be received in Area 7 and after a cleaning of the container will be moved in the Grey area (Area 6).

According to the needs of the satellite, the container and the satellite can be moved directly in area 4 to perform integration or in Area 3 to perform functional and electrical checks before integration. Indeed the Area 3 is equipped with standard instrumentation for electrical checks and with workbenches for any need of the customer before integration on the structure.



### Figure 17-3: SSMS Dispenser Integration Facility

Once the activities in Area 3, if performed, are finalized the P/L can be moved through Area 5 in the integration area. In such a way the P/L will never leave the ISO 8 environment.

#### 6.1.3. SSMS Lower Part Integration

For the PoC flight launch campaign and all future missions, the SSMS Lower part will be integrated in Europe.

Before the handling of the P/Ls, the Hexagonal Module (HM) will be ready for integration and fixed on the dedicated integration stand as illustrated below.

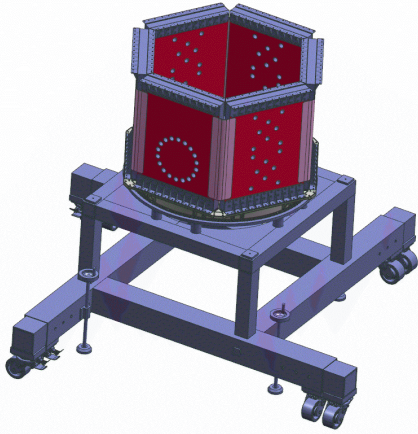


Figure 18: HM on the integration stand

Two different scenarios have been foreseen for the population of the HEX Module (HM) with the spacecrafts. In the first case the panels of the HM will be loaded with cubesats deployers and in the second case a microsat up to 60 kg will be connected to the HM panel.

- Cubesat Deployers Integration

The sequence for the cubesat deployers is:

1. The cubesat deployer according to its dimensions will be handled and lifted by hand or by the crane (from 12U) and moved close to their interface on the HM panel.

2. An operator will be inside the HM and will connect the screws with the I/F holes in the deployer base plate thanks to the thru holes inserts on the HM panel.

In case of need, a dedicated adapter plate shall be developed to connect the deployer to these interface holes.

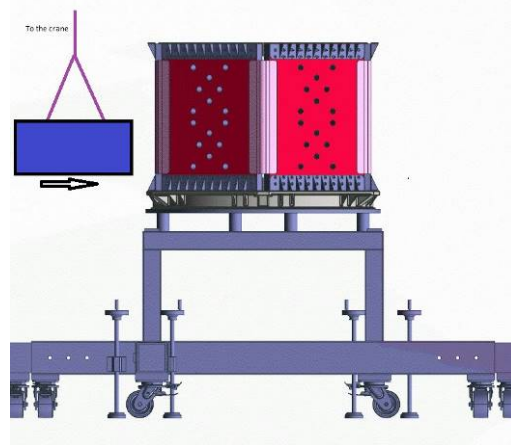


Figure 19: SmallSat integration on HM

Up to 2 deployers 12 U per panel can be fixed, the integration flow foresees to start the integration from the one assigned to the lower position for the use of the crane, but in case of need accessibility to the lower position and dismounting of the deployer is guaranteed up to encapsulation in the fairing. In case of need a dedicated trolley with adjustable height can be used as support during deployer removal.

- SmallSat integration on Upper Part of SSMS dispenser

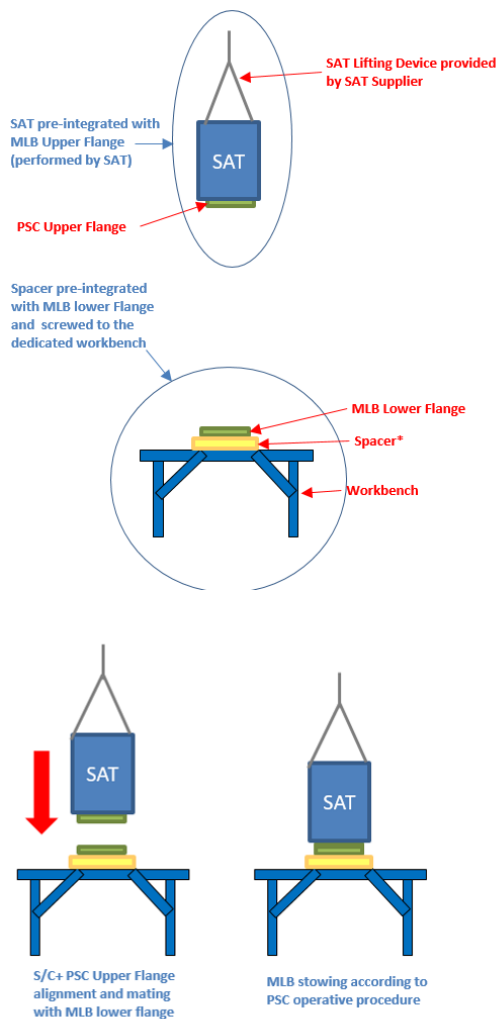
The integration of satellite is more complex because before the integration with the SSMS structure the satellite shall be connected with the separation system. For the PoC flight, the PSC Lightband separation systems have been selected.

With these separation system the sequence will be the following:

1. The upper ring of the separation system will be mechanically connected to the S/C and the S/Cs umbilical connectors will be fixed in the related position on the ring.
2. The satellite spacer (I/F towards SSMS panels) will be secured on a dedicated workbench

3. The lower ring of the PSC system will be fixed to the satellite spacer and the separation connectors LV side and the separation switches (if present) will be locked in their position.
4. The satellite will be lifted and moved for the mating with the lower part of the separation system.
5. Once the part are in contact the stowing and the set for flight for the separation system will be performed.
6. The separation system will be secured with additional mechanical safety clamps before lifting.

These steps are schematically depicted in the figure below.



**Figure 20: SmallSat integration on dispenser Upper Part**

The reported sequence above is similar for both P/Ls to be integrated on the Lower Part and for P/Ls to be integrated on the Upper part of the SSMS dispenser.

For the P/L to be mounted on the HEX panel it is necessary to proceed after step 6 above with the tilting of the satellite.

In order to have a standard interface for the tilting of the S/C it has been developed a tilting trolley which will assure the rotation by connecting a frame to the spacer. With this solution the tilting frame is adjustable to the size of the S/C spacer, defined by the size of the separation system, and is independent from the lifting and hoisting points on the S/C which will change case by case.

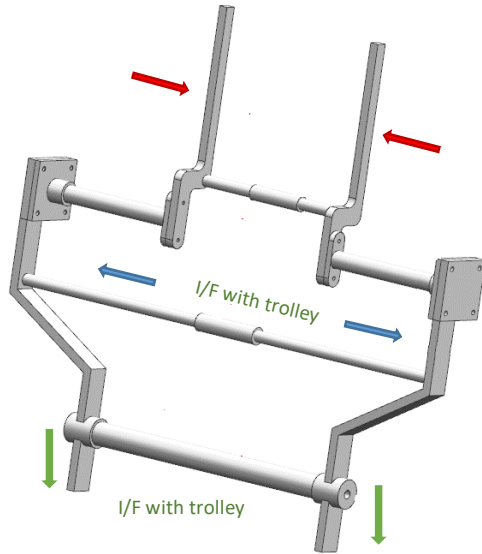
The tilting frame is connected to a movable trolley which also have the possibility to adjust its height.

The steps are the following:

1. With the tilting frame in horizontal position will be performed the connection to the spacer via the dedicated holes.
2. After securing of the frame, the screws which hold the spacer on the workbench will be removed to allow the transfer and rotation of the P/L.
3. With the gear system the S/C will be rotated in a safe way and once the tilted position is reached the frame is secured. (the trolley also have a ballast system to prevent tilt-over of the assy)
4. The trolley will be moved close to the HM panel, the height will be adjusted with the dedicated system and the spacer will be connected as for the Cubesat deployer.
5. Once the spacer connection is finalized the tilting frame will be dismantled and the trolley will be removed.

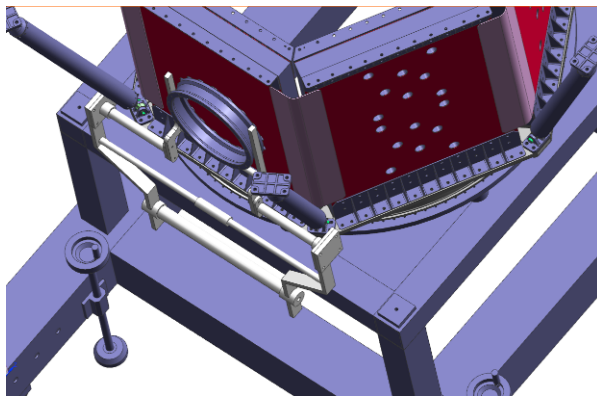
The developed tilting trolley has the great advantage that it can be also used for the dismantling of the P/Ls on the HEX panels up to the last second before encapsulation in the fairing, also after the mating of the Upper and Lower part of the dispenser.

Here below some pictures of the tilting system.



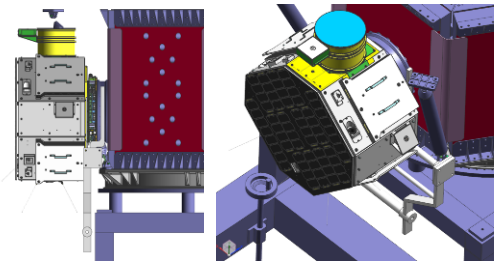
**Figure 21:** Tilting Frame

The upper parts indicated by the red arrows is the interface towards the spacer, the position of the 2 frames can be adjusted. The lower part indicated by the green arrows is the interface towards the trolley which is fixed and connected to the gear system (not shown in the picture). All these parts can be dismantled in a right part and in a left part in order to not interfere with the other S/Cs and with the Dispenser structure during disconnection of the tilting trolley.



**Figure 22-1:** Tilting Frame envelope

The picture above shows the envelope of the tilting frame and it has been conceived to be used also with the rods in position in the case it will be needed for the dismantling of the S/C after mating with Upper Part.



**Figure 22-2:** Tilting Frame clearance

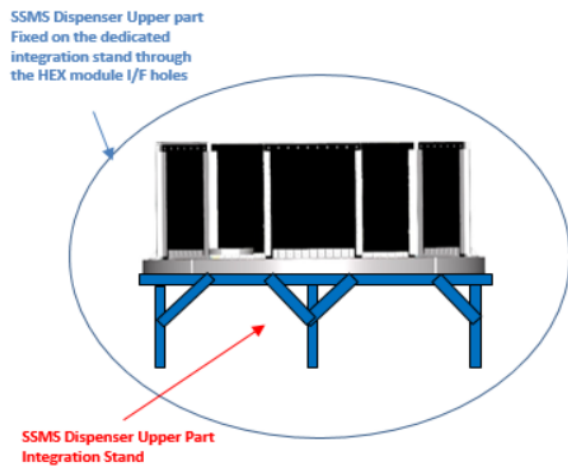
The sequence above is valid for each one of the 7 possible configurations of the SSMS Dispenser. In the case of HEX-2 it will be repeated for each HM and then the 2 modules will be coupled.

#### 6.1.4. SSMS Upper Part Integration

For the PoC flight launch campaign the SSMS Upper part will be integrated in EPCU in Kourou. In the context of multi-satellite missions AIT process standardization and refinement, future missions of SSMS feasibility and constraints of SSMS Upper part integration in Europe is under development. To this aim the transport containers have been already designed to fulfil this integration approach. The integration of the P/Ls to be accommodated on the Upper Part of the SSMS Dispenser will proceed in a similar way of the flow of the Lower Part, but it will require dedicated stands and scaffoldings to operate in a safe way at the height of the different decks.

The integration of the Upper Part in FLEXI-4 configuration has been described below, because this configuration has the more complex aggregate to be loaded.

The Upper part will be secured on the integration stand through the HEX I/F holes located at the center of the Main Deck and additional supports will be fixed to sustain the cantilevered part the deck as schematically represented below.



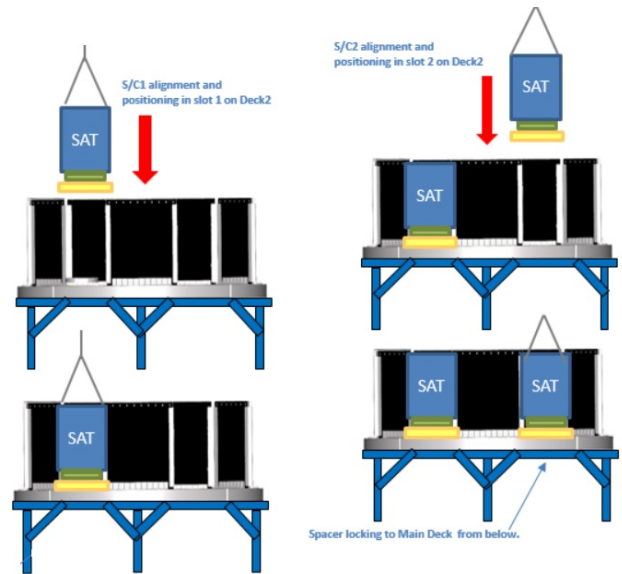
**Figure 23:** Integration stand

The S/C will be connected to the PSC separation systems as for the Lower Part as described in §6.1.3 on a dedicated workbench before mating with the Dispenser.

In order to reduce the risks of interference between the different S/Cs, the loading sequence will be the following:

1. Fixation of the P/L to be mounted on the Main Deck (MD)
2. Fixation of the P/L to be mounted on the SWM Deck (Upper Central Deck)
3. Fixation of the P/L to be mounted on the Tower modules (TM)

The P/L will be lifted, aligned and put in position on the MD. The spacer will be fixed from below the stand thanks to the thru holes available on the MD.

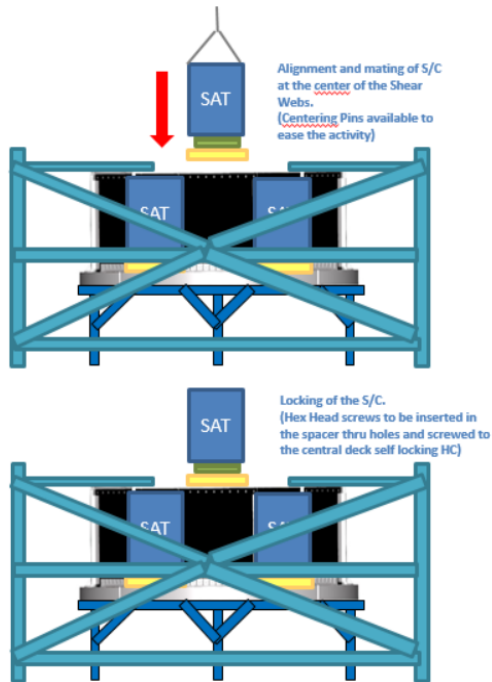


**Figure 24-1:** Upper Part integration sequence

The sequence will be repeated for all the 4 P/Ls to be embarked on the MD

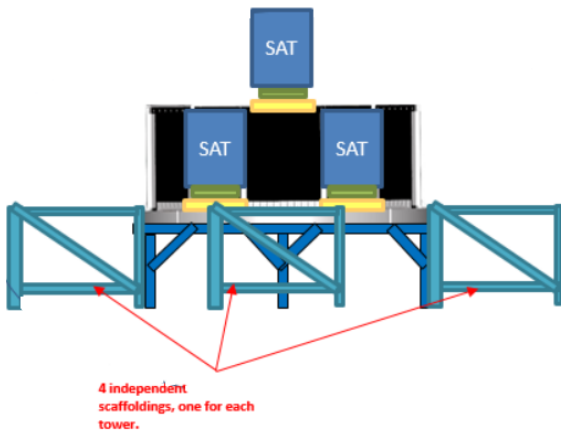
The integration of the central Satellite positioned on the Shear Web Module (SWM) deck is the more complex integration. It will require the use of a dedicated scaffolding to reach the related interfaces towards the Dispenser, both electrical and mechanical.

The spacer of this satellite will be mounted from the top with hexagonal head screws to improve the accessibility, centering pins are present on the deck to ease the alignment and the positioning of the S/C.



**Figure 24-2: Upper Part integration sequence**

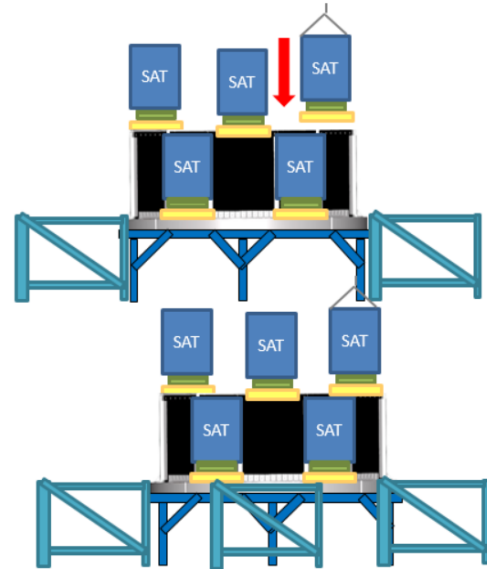
After the integration of the central P/L the scaffolding will be removed and smaller platforms will be placed around the dispenser to reach the TM interfaces.



**Figure 24-3: Upper Part integration sequence**

The P/L will be positioned on the TM deck one by one up to the completion of the aggregate integration.

In order to ease the integration of the P/L on the TM deck, a dedicate access window has been defined on the Tower Module external panel.



**Figure 24-4: Upper Part integration sequence**

#### 6.1.5. SSMS Final Integration

The final integration of the SSMS Dispenser will be completed at the Guiana Space Centre (CSG) in Kourou before mating with Payload Adapter PLA. The Lower Part loaded with its satellites will be fixed and secured on the Integration stand.

The loaded Upper Part will be removed from its TC or from its stand, depending in which location the assembly with the S/Cs has been finalized, and it will be aligned with the lower part.

The connection between the 2 SSMS parts will be performed with the specific brackets available on the HEX module.

Once the brackets have been fixed, the last step is related to the integration of the external bracing rods assy.

Electrical connections of the Harness bundles on the intermediate brackets will be performed and the SSMS will be ready for the integration with the LV P/L adapter.

## 7. ACKNOWLEDGMENTS

The authors acknowledge the contribution provided by all the members of the Industrial team, who have so far made possible the current progress of LLL Initiative and SSMS development.