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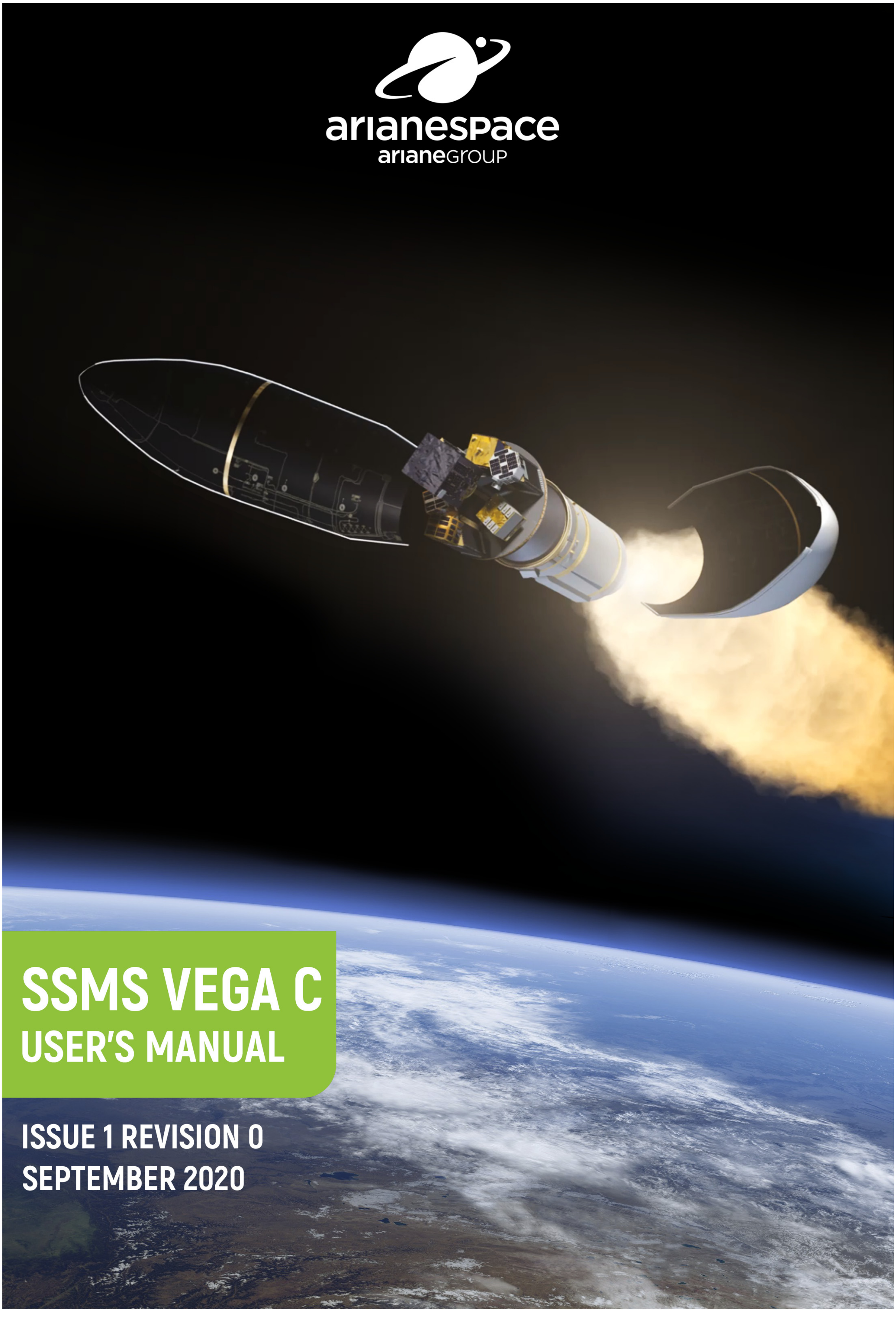

SSMS VEGA C
USER'S MANUAL

ISSUE 1 REVISION 0
SEPTEMBER 2020

Small Spacecraft Mission Service
VEGA-C

User's Manual
Issue 1 – Revision 0

Sept. 2020

Issued and approved by Arianespace

Roland Lagier

Chief Technical Officer

Preface

The present User's Manual is an add-on to the Vega-C User's Manual and provides an overview of the Small Spacecraft Mission Service on Vega-C launch system operated by Arianespace at the Guiana Space Centre.

This document contains the essential data which are necessary:

- To assess compatibility of Mini, Micro, Nano S/C and Cubesats Deployers mission with Vega-C launch system,
- To initiate the preparation of all technical and operational documentation related to a launch of any Small S/C either on rideshare mission or as piggyback with main passenger.

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Configuration Control Sheet

Issue / Rev.	Date	Change description	Prepared by	Approved by
Proof of Concept Issue on Vega	Feb, 2017	First issue, dedicated to SSMS Proof of Concept Flight on Vega	C. DUPUIS AE A. SCACCIA ESA	P. LOIRE AE F. CARAMELLI ESA
Issue 1 Revision 0	July, 2020	Vega-C issue	C. DUPUIS	L. BOUAZIZ

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Acronyms, abbreviations and definitions

A			
	AE	**A**rian**e**space	
	AVUM+	**A**ttitude & **V**ernier **U**pper **M**odule (Vega-C last stage)	
B			
	BOB	**B**reak **O**ut **B**ox	
	BT POC	Combined operations readiness review	**B**ilan **T**echnique **P**lan d'**O**pérations **C**ombinées
C			
	CAD	**C**omputer **A**ided **D**esign	
	CBOD-LT	**L**ow **T**ension **C**lamp **B**and **O**pening **D**evice	
	CCAM	**C**ontamination & **C**ollision **A**voidance **M**aneuvers	
	CDR	**C**ritical **D**esign **R**eview	
	CLA	**C**oupled **L**oads **A**nalysis	
	CM	Mission Director	**C**hef de **M**ission
	CNES	French National Space Agency	**C**entre **N**ational d'**E**tudes **S**patiales
	CoG	**C**enter **o**f **G**ravity	
	COTE	**C**heck-**O**ut **T**erminal **E**quipment	
	CP	Program director	**C**hef de **P**rogramme
	CRAL	Post Flight Debriefing	**C**ompte-**R**endu **A**près **L**ancement
	CSG	Guiana Space Centre	**C**entre **S**patial **G**uyanais
	CTU	**C**entral **T**elemetry **U**nit	
	CVCM	**C**ollected **V**olatile **C**ondensable **M**aterial	
	CVI	Real time flight evaluation	**Co**ntrôle **V**isuel **I**mmédiat
D			
	DAMF	Final mission analysis document	**D**ocument d'**A**nalyse de **M**ission **Fi**nale
	DAMP	Preliminary mission analysis document	**D**ocument d'**A**nalyse de **M**ission **P**réliminaire
	DCI	Interface control document	**D**ocument de **C**ontrôle d' **I**nterface
	DUA	Application to use Arianespace launch vehicles	**D**emande d'**U**tilisation **A**rianespace
E			
	EGSE	**E**lectrical **G**round **S**upport **E**quipment	
	EIRP	**E**quivalent **I**sotropic **R**adiated **P**ower	
	EMC	**E**lectro**m**agnetic **C**ompatibility	
	EPCU	Payload preparation complex	**E**nsemble de **P**réparation des **C**harges **U**tiles
	ESA	**E**uropean **S**pace **A**gency	
F			
	FAR	**F**light **A**cceptance **R**eview	
	FEM	**F**inite **E**lement **M**odel	
	FM	**F**light **M**odel	
	FQR	**F**inal **Q**ualification **R**eview	

G			
	GRS	**G**eneral **R**ange **S**upport	
	GSE	**G**round **S**upport **E**quipment	
H			
	HPF	**H**azardous **P**rocessing **F**acility	
I			
	IATA	**I**nternational **A**ir **T**ransport **A**ssociation	
	Isp	Specific impulse	
	ITAR	**I**nternational **T**raffic in **A**rms **R**egulations	
K			
	KRU	**K**ou**r**o**u**	
L			
	LAM	Measuring instrument laboratory	**La**boratoire **M**esures
	LBC	Check out equipment room	**L**aboratoire **B**anc de **C**ontrôle
	LEO	**L**ow **E**arth **O**rbit	
	LEOP	**L**aunch and **E**arly **O**rbit **P**hase	
	LMP-103S	"green" **L**iquid **M**ono**P**ropellant	
	LSA	**L**aunch **S**ervice **A**greement	
	LTAN	**L**ocal **T**ime of **A**scending **N**ode	
	LTDN	**L**ocal **T**ime of **D**escending **N**ode	
	LV	**L**aunch **V**ehicle	
	LW	**L**aunch **W**indow	
M			
	MCI	Mass, balances and inertias	**M**asse, **C**entre de gravité, **I**nerties
	MFU	**M**ulti-**F**unctional **U**nit	
	MGSE	**M**echanical **G**round **S**upport **E**quipment	
	MLB	**M**otorized **L**ight **B**and	
	MLI	**M**ulti **L**ayer **I**nsulation	
	MMH	**M**ono**m**ethyl **H**ydrazine	
	MUV	Vega-C User's Manual	**M**anuel **U**tilisateur **V**ega-C
N			
	N/A	**N**ot **A**pplicable	
O			
	OASPL	**O**verall **A**coustic **S**ound **P**ressure **L**evel	
	OCOE	**O**verall **C**heck **O**ut **E**quipment	
P			
	PAC	**P**ayload **A**ssembly **C**omposite	
	PAF	**P**ayload **A**ttachment **F**itting	
	PAS	**P**ayload **A**dapter **S**ystem	
	PDR	**P**reliminary **D**esign **R**eview	
	PFM	**P**roto-**F**light **M**odel	
	PoC	**P**roof of **C**oncept	
	POC	Combined operations plan	**P**lan d'**O**pérations **C**ombinées
	POI	Interleaved Spacecraft Operations Plan	**P**lan d'**O**pérations **I**mbriquées
	POS	Spacecraft operations plan	**P**lan d'**O**pérations **S**atellite
	PPF	**P**ayload **P**reparation **F**acility	
	ppm	**p**arts **p**er **m**illion	
	PSC	**P**lanetary **S**ystems **C**orporation	
	PSD	**P**ower **S**pectral **D**ensity	

Q			
	QA	**Q**uality **A**ssurance	
	QR	**Q**ualification **R**eview	
	QSL	**Q**uasi-**S**tatic **L**oad	
R			
	RAAN	**R**ight **A**scension of the **A**scending **N**ode	
	RAL	Launch readiness review	**R**evue d'**A**ptitude au **L**ancement
	RAMF	Final mission analysis review	**R**evue d'**A**nalyse de **M**ission **F**inale
	RAMP	Preliminary mission analysis review	**R**evue d'**A**nalyse de **M**ission **P**réliminaire
	RAV	Launch vehicle flight readiness review	**R**evue d'**A**ptitude au **V**ol du lanceur
	RF	**R**adio **F**requency	
	RfW	**R**equest **f**or **W**aiver	
	RMS	**R**oot **M**ean **S**quare	
	rpm	**r**evolutions **p**er **m**inute	
	RPS	Spacecraft preparation manager	**R**esponsable **P**réparation **S**atellite
	RS	Safety manager	**R**esponsable **S**auvegarde
	RSG	Ground safety officer	**R**esponsable **S**auvegarde Sol
	RSV	Flight safety officer	**R**esponsable **S**auvegarde **V**ol
S			
	S/C	**S**pace**c**raft	
	SLV	Vega-C Launch Site	**S**ite de **L**ancement **V**ega-C
	SOW	**S**tatement **O**f **W**ork	
	SPORT	**S**atellite **P**roject **O**perational **R**equirements **T**ables	
	SRS	**S**hock **R**esponse **S**pectrum	
	SSMS	**S**mall **S**pacecraft **M**ission **S**ervice	
	SSO	**S**un **S**ynchronous **O**rbit	
	STM	**S**tructural **T**est **M**odel	
T			
	TBC	**T**o **B**e **C**onfirmed	
	TBD	**T**o **B**e **D**efined	
	TC	**T**ele**c**ommand	
	TM	**T**ele**m**etry	
U			
	UC	**U**pper **C**omposite	
	UCIF	**Upper Composite Integration Facility**	
	UT	**U**niversal **T**ime	
V			
	VAMPIRE	**Ve**ga **A**dapter for **M**ultiple **P**ayload **I**njection and **RE**lease	
	VEGA	European small launcher	**V**ettore **E**uropeo **di** **G**enerazione **A**vanzata
	VESPA	**VE**ga **S**econdary **P**ayload **A**dapter	

INTRODUCTION Chapter 1

1.1 Purpose of the Small S/C Mission Service User's Manual

Arianespace has been launching Small Spacecraft since the early days of Ariane in 1980. Arianespace initiated a standardized approach with the introduction of the ASAP carrying system (Ariane Structure for Auxiliary Payloads). This allowed many teams worldwide to gain easy and cost effective access to space for their small projects.

In order to address the needs of a growing number of Small Sat projects, Arianespace is now offering a tailored, standardized launch service for Small S/C, with regular rideshare missions on Vega-C, in addition to some piggyback opportunities.

A first "Proof of Concept" rideshare mission on Vega successfully took place on 02 September 2020 with a total of 53 Small S/C.

Vega-C launch system has improved capabilities compared to Vega: higher performance (60% more), larger fairing, improved versatility (3 different orbits can be targeted) and a wider spectrum of payload accommodations for any S/C. This will allow embarking even more Small S/C at the same time and will make the life always easier to any entities that want to take advantage of affordable access to space.

The present Small Spacecraft Mission Service User's Manual provides information for launching Small S/C from 1kg up to 400 kg using the Vega-C launch system operated from the Guiana Space Centre by Arianespace.

The content encompasses:

- the Small Spacecraft classification;
- the description of the available carrying systems on Vega-C;
- the description of the interfaces between Small Spacecraft and Launch Vehicle;
- the requirements for Small Spacecraft design and compatibility verification and the launch environment;
- the mission management & launch campaign organization.

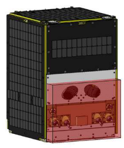
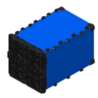
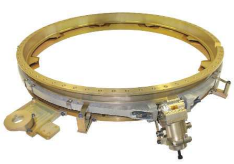
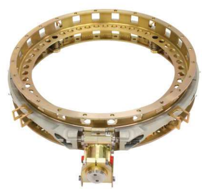
Together with the Vega-C User's Manual, the Spacecraft Processing Facility at CSG User's Manual and the Payload Safety Handbook, it gives readers the information to assess the compatibility with the proposed standardized configurations.

1.2. Small Spacecraft classification

Arianespace has established the following classification for Small Spacecraft in order to provide a standard launch service tailored to each class of Small S/C:

- **Mini S/C**: small satellite with a mass from 200 up to 400 Kg,
- **Micro S/C**: small satellite with a mass from 60 to 200 Kg,
- **Nano S/C**: small satellite with a mass from 30 to 60 Kg,
- **Cubesat Deployers**

The table below summarizes the Small S/C main characteristics:

	Mini S/C	Micro S/C	Nano S/C	Cubesat Deployers
				
Mass range	**400 – 200 kg**	**200 – 60 kg**	**60 – 30 kg**	**35 – 10 kg**
Max. dimensions *	**H1800 Ø1500**	**H1200 L800 W800**	**H1000 L600 W600** (or H800 L500 W 600)	**H600 L300 W300**
Interface with the LV	**MLB 24''**  or **PAS 610 S** 	**MLB 15 or 13''**  or **PAS 381 S** 	**MLB 11,732'' or 8''** 	**Bolted IF**

* NOTE1: H represents the dimension of the S/C in the direction of separation.

Each class of Small S/C has been associated with some positions available on the Arianespace multiple launch systems (SSMS carrying system, VESPA+R, VAMPIRE: refer to chapter 1.4 below for a detailed description).

1.3. Type of missions

Arianespace proposes two types of missions for Small S/C:

- rideshare missions dedicated to Small S/C,
- piggyback missions with main passenger.

1.3.1. Rideshare mission

The rideshare missions on Vega-C take place regularly, at least one per year. The launch period is confirmed once Arianespace has secured a sufficient number of Customers. The main characteristics of the mission is defined by Arianespace taking into account the preferences expressed by every customer.

1.3.2. Piggyback mission

The piggyback missions on Vega-C take place when extra performance and volume are available on an already manifested mission with Main Passenger(s). The launch period and the main characteristics of the mission are defined by the Main Passenger(s).

1.4. Carrying systems for Small S/C on Vega-C

1.4.1. Introduction

In order to provide more launch opportunities for Small S/C, Arianespace, with the support of ESA, has developed several carrying systems to carry and deploy Small S/C, either for rideshare mission or in piggyback.

- SSMS modular carrying system, mainly for a cluster of Small S/C of any size and mass,
- VESPA+R (VEga-C Secondary Payload Adapter, reinforced version of existing VESPA+ on Vega), for one large passenger and additional Small S/C of any size and mass,
- VAMPIRE 937 MPL, for one large passenger and up to 6 Nanosatellites,

The SSMS carrying system is very modular and a high number of configurations can be proposed ; some of them (with the base Hexagonal module) can be also used for piggyback type missions.

The SSMS and VESPA+R systems can also be combined to offer even more positions for Mini S/C.

The table below summarizes the carrying systems capabilities:

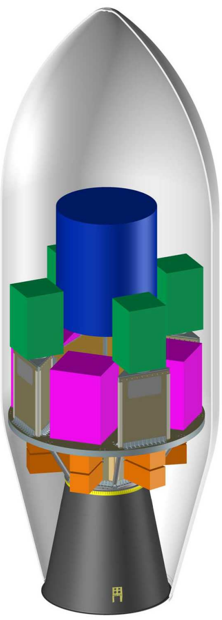
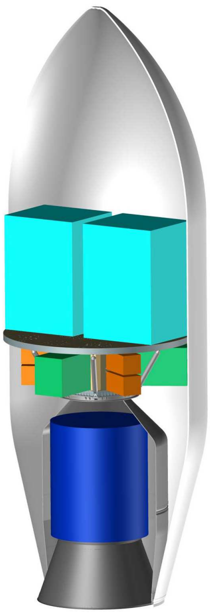
TYPE	RIDESHARE		PIGGYBACK		
CARRYING SYST.	**SSMS** **Plat-1** **Plat-2** **Plat-3** **Flexi-3** **Flexi-4**	**SSMS** **&** **VESPA+R** **combined**	**SSMS** **Hex-1** **Hex-2**	**VESPA+R**	**VAMPIRE 937** **MPL**
TYPICAL PAYLOD ASSEMBLY COMPOSITE CONFIGURATION	Cluster of Small S/C 	Cluster of Small S/C with one large Mini S/C 	One main passenger with Nano S/C or Cubesats Deployers 	One main passenger with Mini, Micro or Nano S/C 	One main passenger with Nano S/C 

Table 1.4.1a - Vega-C carrying systems capabilities

1.4.2. SSMS carrying system

The Small Satellite Mission Service (SSMS) carrying system is a modular system designed to address the small satellites market by providing dedicated rideshare Small S/C missions on Vega-C.

The SSMS carrying structure is manufactured by SAB Aerospace and is mainly composed of:

- sandwich panels with aluminum honeycomb core and with carbon fiber composite skins,
- aluminum machined I/F rings,
- aluminum connecting frames between the different panels and harness support parts (brackets and others).

The different modules (hexagon, main deck, columns, towers, shear webs, spacers) allow to accommodate a large number of Small S/C of various sizes and masses.

SET OF SSMS MODULES

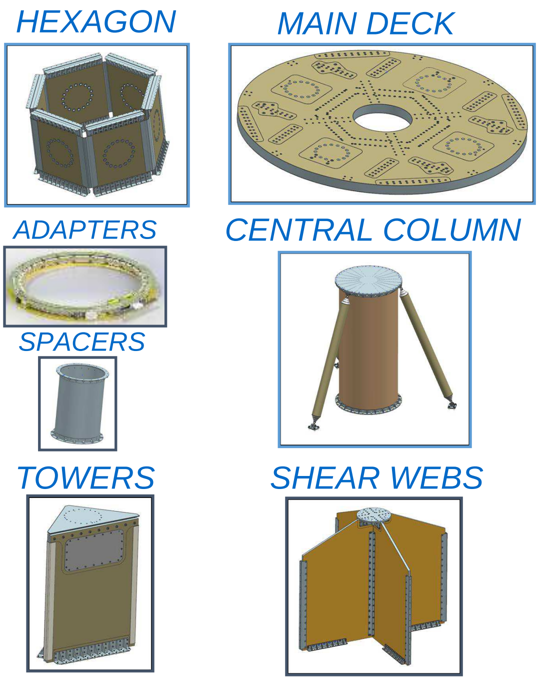


Figure 1.4.2a - SSMS carrying system modules

The Hexagon is the base module present in every configuration.

The main deck comes above the Hexagon base module and struts ensure the proper rigidity of the assembly.

The shear webs, central column and towers module can be installed on the main deck as necessary.

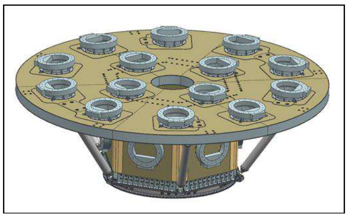
For every Small S/C, the adapter comprises the separation and distancing system and the so-called spacer acts as an interface between the carrying system and the adapter. The spacer can be customized in order to raise the Small S/C or tilt the Small S/C or shift the Small S/C axis w.r.t. the standard position/orientation.

By combining all these elements, a high number of carrying system configurations can be obtained.

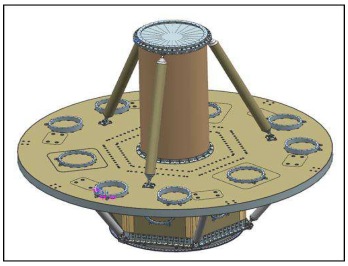
SSMS CARRYING SYSTEM CONFIGURATIONS

RIDESHARE

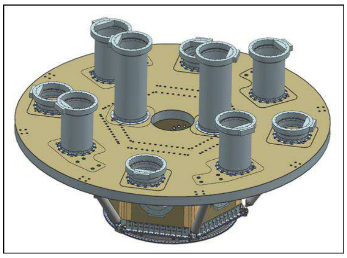
PLAT-1



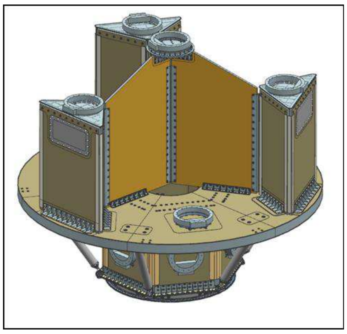
PLAT-2



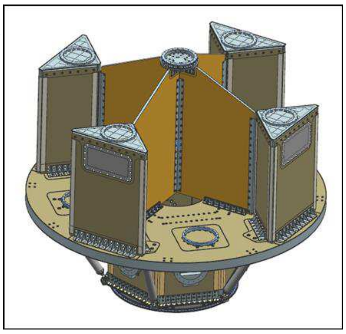
PLAT-3



FLEXI-3

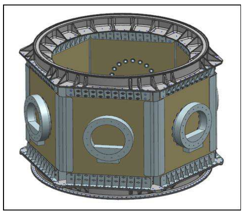


FLEXI-4



PIGGYBACK

HEX-1



HEX-2

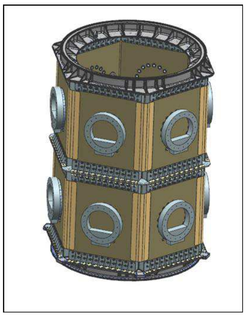


Figure 1.4.2b - Possible SSMS carrying system versions

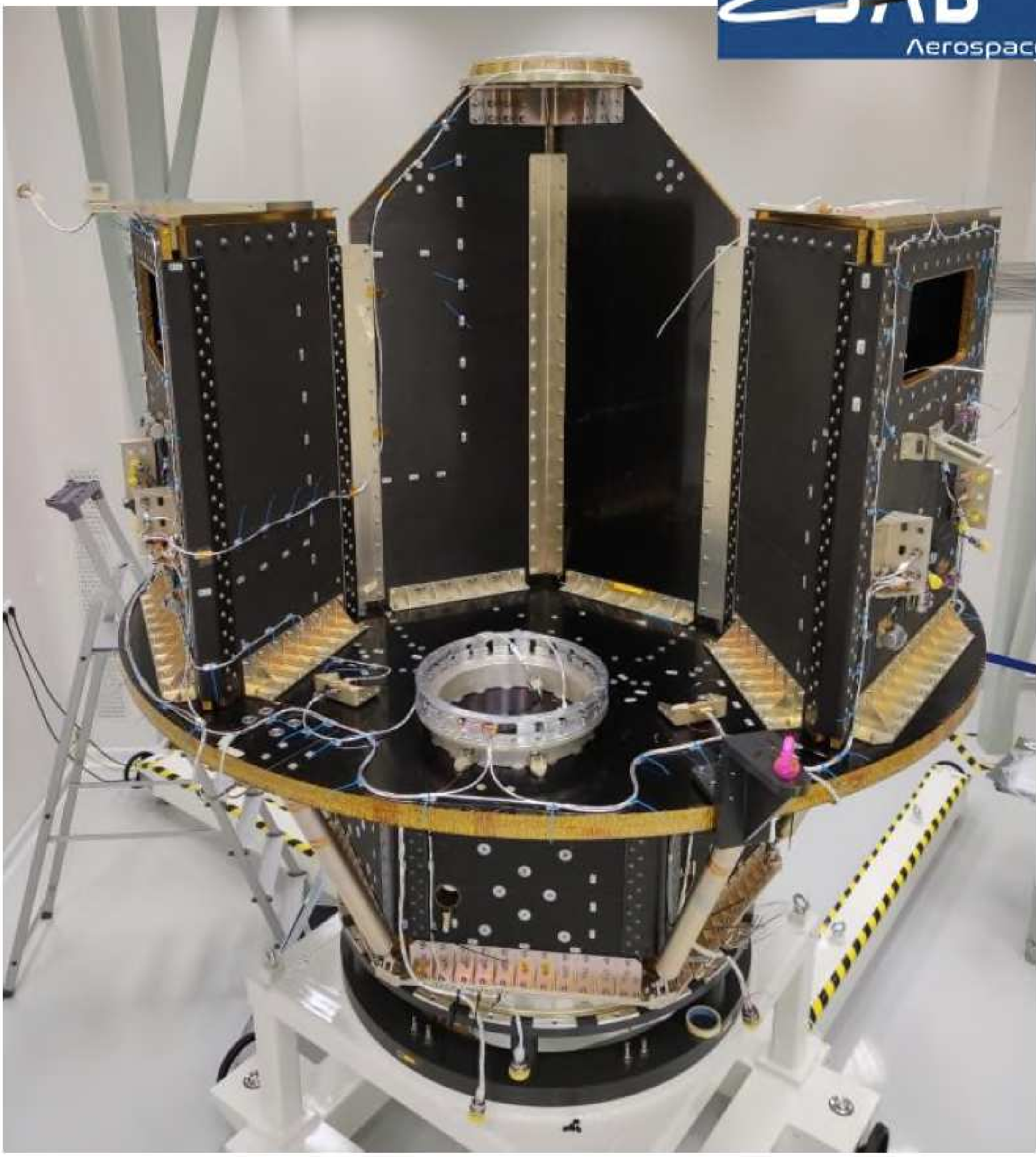


Figure 1.4.2c - SSMS PoC carrying system on Vega - VV16 preparation

1.4.3. VESPA+R carrying system

The VESPA+R carrying system is inherited from the VESPA+ carrying system on Vega (which flew 3 times as of Sept. 2020).

It allows to embark one large passenger in upper position, together with, in lower position, one Mini S/C or a cluster of Small S/C of various size. It is mated on the AVUM+ upper stage.

The VESPA+R is manufactured by AIRBUS DS Spain. It consists of the upper part, the boat tail, the inner cone and the inner platform. It also provides the interface and separation system to the main passenger (Ø937 mm or Ø 1194 interface).

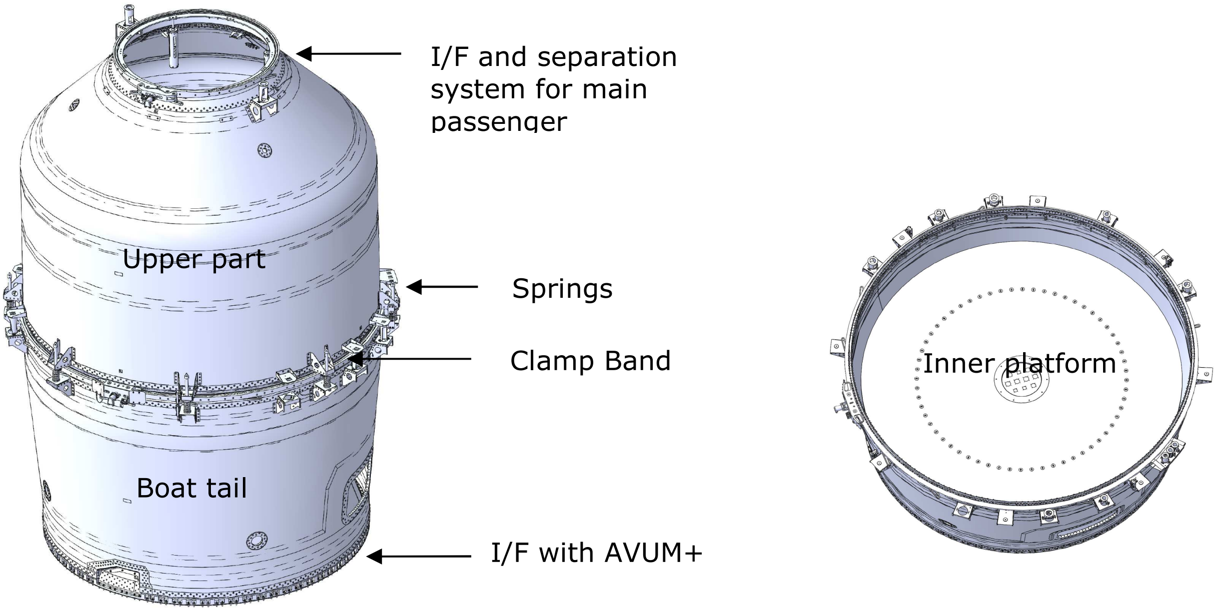


Figure 1.4.3a - VESPA+R configuration

The separation of the upper part of the VESPA structure is achieved by means of a Clamp Band and 8 springs.

Figure 1.4.3b - VESPA+ - VV10 launch campaign

1.4.4. VAMPIRE 937 MPL carrying system

Amongst the different so-called VAMPIRE Vega-C adapter versions for large S/C (refer to Vega-C User's Manual), the VAMPIRE 937 MPL allows to embark up to 6 Nanosatellites on 6 towers, in addition to one large Spacecraft using a Ø 937 clamp band interface.

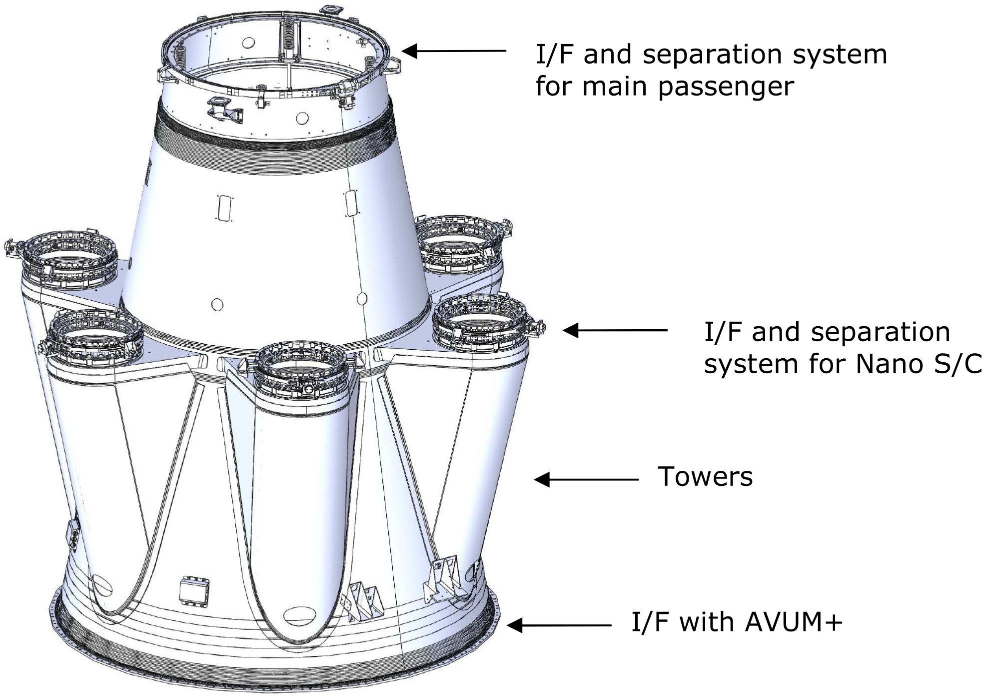


Figure 1.4.4a - VAMPIRE 937 MPL

1.5. Main conditions applicable to Small S/C

1.5.1 General

The standard conditions are defined in Launch Service Agreement (LSA), Terms & Conditions (T&C) and Statement of Work (SOW).

This chapter briefly summarizes the main conditions in each case (rideshare mission, piggyback mission).

Specific and even more simplified SOW are defined for Cubesat Deployers.

1.5.2 Main conditions for rideshare mission

The following chapter describes the main conditions for a rideshare mission.

Launch Schedule

The launch period (3 months), launch slot (1 month) and launch date are defined by Arianespace. The launch period is notified once Arianespace has secured a sufficient number of Customers for a given rideshare mission. The launch period is defined at the latest 12 months in advance for Mini, Micro and Nano S/C and at the latest 6 months in advance for Cubesats Deployers.

Dummy payload

A dummy payload has to be made available in case the actual Small S/C is not ready for the launch.

The dummy payload provided by the Customer must be representative of the Small S/C in terms of mass and mechanical interface. The dummy payload must be smaller than the actual Small S/C volume, with no CoG offset and be compatible with the flight environment. No electrical interface is required.

Proof of availability of the dummy will be made by the Small S/C Customer for the Flight Readiness Review (RAV) and the dummy shall be provided at the beginning of the launch campaign.

As an option, available at Customer request, Arianespace can procure the dummy.

Targeted orbit

The targeted orbit is defined by Arianespace taking into account the preferences expressed by every Customer.

Thanks to AVUM+ last stage re-ignition capabilities, up to three different altitudes can be targeted.

Separation time and orientation

The time and attitude at S/C separation are defined by Arianespace.

Small S/C status during final countdown and flight

The Small S/C shall be inert (S/C OFF, no RF emission, no status changes) during the final countdown and ascent phase until after the small S/C separation. The actual delay after separation will be determined by Arianespace in the frame of the mission analysis process and will depend on the type of orbit and overall mission timeline.

Small S/C battery charge

The Small S/C battery operating life shall be at least 45 days after the last battery charge, usually performed just before S/C mating on the carrying structure. Alternatively, battery trickle charges shall be possible via umbilical links.

Small S/C preparation at the launch site

S/C arrival date to French Guiana shall be coordinated with Arianespace, with the objective that all the Small S/C for a given mission were transferred the same day.

The CSG facilities are shared with the other Small S/C on the same flight. This includes Spacecraft Preparation Clean Room, and when necessary, Filling hall and Lab for Check-out stations (LBC).

The Small S/C shall be ready for integration on the carrying structure. Refer to chapter 5 for an extensive description of the integration work flow.

No access to the satellite is authorized after fairing encapsulation.

1.5.3 Main conditions for piggyback mission

The following chapter describes the main conditions for a piggyback mission with a main passenger.

Main passenger approval

For a piggyback mission, the launch of a Small S/C is subject to the approval of the main passenger. The Small S/C shall be able to answer to any inquiry aiming at demonstrating technical and programmatic innocuousness for main passenger.

Launch Schedule

The Launch schedule is totally subordinated to the launch schedule of the main passenger and the Small S/C shall in no case be entitled to affect the launch schedule. The consequence is that, should the Small S/C not be ready for the launch, it will fly as it is if already mounted on the Payload Assembly Composite or, it will be replaced by a dummy payload.

Dummy payload

A dummy payload has to be made available in case the actual Small S/C is not ready for the launch.

The dummy payload provided by the Customer must be representative of the Small S/C in terms of mass and mechanical interface. The dummy payload must be smaller than the actual Small S/C volume, with no CoG offset and be compatible with the flight environment. No electrical interface is required.

Proof of availability of the dummy will be made by the Small S/C Customer for the Flight Readiness Review (RAV) and the dummy shall be provided at the beginning of the launch campaign.

As an option, available at Customer request, Arianespace can procure the dummy.

Targeted orbit

The targeted orbit is defined by Arianespace taking into account the main passenger technical requirements. In particular, for Sun synchronous Orbit (SSO) mission, the local time of ascending node (LTAN) is defined by the main passenger.

Thanks to AVUM+ last stage re-ignition capabilities, the Small S/C can be released on a different orbit altitude to cope as much as possible with Small S/C preferred orbit.

Separation time and orientation

The separation timeline and orientation are defined by Arianespace.

For Mini Auxiliary Passenger, and depending on overall mission, the customer preferred separation conditions can be considered.

Small S/C status during final countdown and flight

The Small S/C shall be inert (S/C OFF, no RF emission, no status changes) during the final countdown and ascent phase until after the Small S/C separation. The actual delay after separation will be determined by Arianespace in the frame of the mission analysis process and will depend on the type of orbit and overall mission timeline.

Small S/C battery charge

The Small S/C battery operating life shall be at least 45 days after the last battery charge, usually performed just before S/C mating on the carrying structure. Alternatively, battery trickle charges shall be possible via umbilical links.

Small S/C preparation at the launch site

S/C arrival date to French Guiana shall be coordinated with Arianespace, with the objective that all the auxiliary passengers for a given mission were transferred the same day.

The CSG facilities are shared with the other Small S/C on the same flight. This includes Spacecraft Preparation Clean Room, and when necessary, Filling hall and Lab for Check-out stations (LBC).

The Small S/C shall be ready the day before the start of the Combined Operations (POC) 18 days before the launch date (L-18) for integration on the carrying structure.

No access to the satellite is authorized after mating on the carrying structure.

1.5.4 Additional specific conditions for Cubesats Deployers

The following chapter describes the main conditions for Cubesats Deployers.

Preparation and integration facility

The preparation facilities for Cubesats Deployers are located in Brno, Czech Republic, Continental Europe (refer to Annex 3 for facility description). The Deployers fully integrated with the Cubesats shall be ready for integration on the SSMS Hexa module at the latest 7 weeks before launch date.

Deployer procurement & Cubesats integration

As a standard, Customer shall procure the Deployer(s) and deliver to Arianespace fully integrated Deployer(s) with the Cubesats already integrated inside the Deployer(s). It means the management of the interfaces between the Cubesats and Deployer(s) is Customer responsibility.

As an option, available at Customer request, Arianespace with the support of our partners, can procure the Deployer(s) and manage Cubesats integration. For more information on this option, please contact Arianespace.

Deployer compatibility to Vega-C last stage avionics

The Cubesats separation is managed either directly by the Vega-C Multi-Functional Unit (MFU) or, when necessary, by a dedicated electrical interface unit called "Sequencer" and provided by Arianespace. Compatibility between Deployer and Vega-C last stage avionics shall be brought by the Customer. Refer to chapter 3 for details.

Transport

The Cubesats and Cubesats Deployer(s) shall be compatible with a shipment by regular commercial airplane. Refer to chapter 5 for details.

1.6. Procuring Small S/C Launch Services

A template of the Application to Use Arianespace's Launch Vehicle for Small Spacecraft is attached in Annex 1.

Two versions are available:

- Full MS Word version,
- Simplified MS Excel version.

It is used by Arianespace to identify the possible launch opportunities, to build the Small S/C aggregate and provide preliminary mission and pricing information. Later on, once the Launch Service Agreement (LSA) is effective, it will be used to initiate the Interface Control Document (DCI).

Arianespace is committed to maintain a list of launch opportunities for Small S/C on Vega-C. The corresponding missions are mainly Sun Synchronous Orbit (SSO) and Low Earth Orbit (LEO).

SMALL SPACECRAFT MISSION

Chapter 2

2.1 General

The mission profile is defined by Arianespace, including:

- ascent profile, number and durations of the upper stage boost phases and of the coast phases, visibility from ground stations, etc....
- Small S/C separation timeline,
- attitude pointing at Small S/C separation.

The re-ignition capabilities of the Vega-C upper stage (so-called AVUM+ stage) allow typically to inject Small S/C on two (2) or three (3) different altitudes with a multiple AVUM+ boosts profile.

The customer preferred separation orientation might be considered, depending on overall mission timeline.

2.2 Typical mission profile

The ascent **ground track** for a typical SSO mission is shown here below:

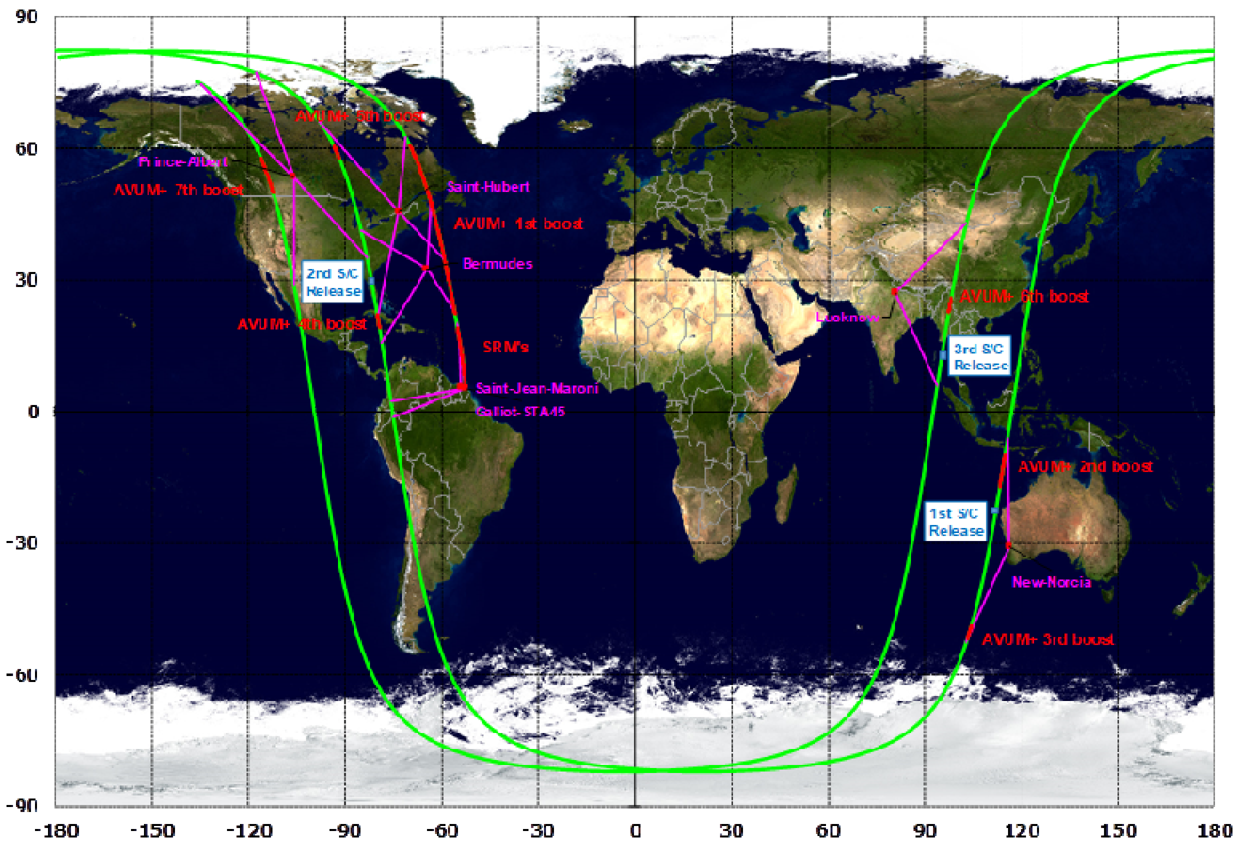


Figure 2.2a - Typical ground track and flight sequence for Vega-C SSO missions

The corresponding **launch sequence** comprises:

- Solid stages ascent phase,
- 1st AVUM+ boost,
- Coast phase,
- 2nd AVUM+ boost to reach the targeted orbit,
- Separation of a first batch of Small Satellites (rideshare mission) or of the main passenger (piggyback mission),
- CCAM (Contamination and Collision Avoidance Maneuvers),
- 3rd and 4th AVUM+ boosts to change the SSO altitude (and inclination correspondingly),
- Separation of a second batch of Small Satellites,
- CCAM maneuvers,
- 5th and 6th AVUM+ boosts to change the SSO altitude (and inclination correspondingly),
- Separation of a third batch of Small Satellites,
- CCAM maneuvers,
- Last AVUM+ boost to trigger the controlled reentry of the AVUM+ in the Ocean.

2.3 Aerothermal flux at fairing jettisoning

Jettisoning of the payload fairing can take place at different times depending on the passengers aerothermal flux requirements.

Typically, for SSO missions, the fairing separation takes place 5s after Z9 ignition around 270 seconds from lift-off and the aerothermal flux is lower than 300 W/m^2.

The actual aerothermal flux at fairing jettisoning will be determined in the frame of the mission analysis.

2.4 Conditions at Small S/C separation

The separation conditions (time, orientation, …) are defined by Arianespace.

For Mini S/C, the customer preferred separation orientation might be considered, depending on overall mission timeline.

Separation conditions (depointing, residual angular velocities after separation) is determined in the frame of the mission analysis. In order to counteract the effect of spacecraft nominal static unbalance at spacecraft separation, and improve the Small S/C tip-off rates after separation, the number, position and/or energy of the springs on the adapter can be tuned.

SMALL SPACECRAFT INTERFACES — Chapter 3

3.1 Introduction

This chapter addresses the interface requirements: volume, mechanical interfaces, electrical interfaces, other interfaces and interface verification tests.

This chapter assumes that:

- for Mini/Micro/Nano S/C, the adapter is one of the standard adapters (refer to Annex 2 for detailed descriptions), procured by Arianespace ;
- for Cubesats Deployer(s), the interface stands between the Deployer and the launcher systems (carrying system and launcher avionics), this means it is assumed that the Deployer is procured by the customer.

3.2 Small S/C reference axes & clocking

All Small S/C data and models (CAD, FEM, thermal if any) shall be given in the same reference axis system, with the origin of the reference system in the mounting plane.

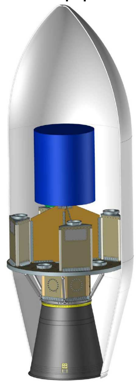
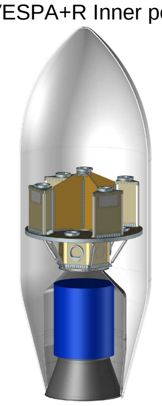
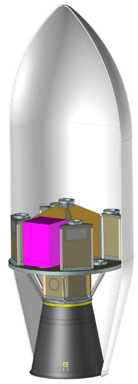
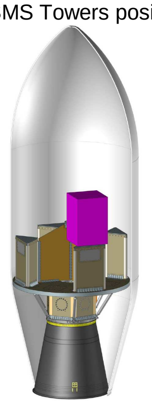
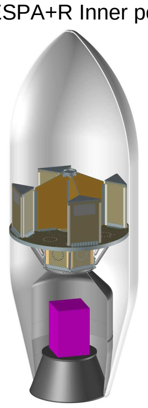
The clocking of the spacecraft with regard to the adapters, carrying structure and launch vehicle axes are defined by Arianespace taking into account the overall upper part configuration.

3.3 Small S/C dimensions

As described in chapter 1, the available carrying systems and the wide spectrum of possible SSMS carrying system configurations allows to accommodate Small S/C of any dimensions.

ARIANESPACE has defined standard dimensions depending of the Small S/C class. For each class, dedicated positions are also defined on the available carrying systems.

In case of spacecraft with wider dimensions or with protruding elements, ARIANESPACE is ready to run dedicated accommodation analysis.

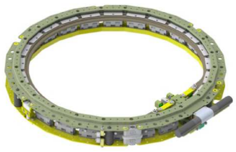
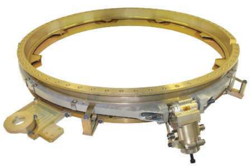
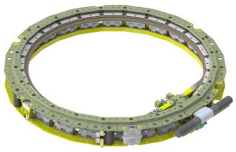
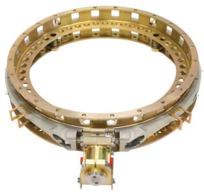
	Mini S/C	Micro S/C	Nano S/C	Cubesat Deployers
Mass	**400 – 200 kg**	**200 – 60 kg**	**60 – 30 kg**	**35 – 10 Kg**
Max. dimensions*	**H1800 Ø1500**	**H1200 L800 W800**	**H1000 L600 W600** (or H800 L500 W 600)**	**H600 L300 W300**
Available Positions	1. SSMS Top posit°  2. VESPA+R Inner posit° 	1. SSMS Main deck  2. SSMS Towers posit°  3. VESPA+R Inner posit° 	1. SSMS Towers posit°  2. SSMS Hexa  3. VESPA+R Inner posit°  4. VAMPIRE 937 Towers 	1. SSMS Hexa  2. VAMPIRE 937 Towers 

* NOTE 1: H represents the dimension of the S/C in the direction of separation.

** NOTE 2: On SSMS Hexa or VAMPIRE 937

3.4 Mechanical Interface

The mechanical interface is function of the Small S/C class.

	Mini S/C	Micro S/C	Nano S/C	Cubesat Deployers
Mass	**400–200 kg**	**200–60 kg**	**60–30 kg**	**35–10 Kg**
Interface with the LV	**MLB 24''**  or **PAS 610 S** 	**MLB 15 or 13''**  or **PAS 381 S** 	**MLB 11,732'' or 8''** 	**Bolted IF**

For Mini/Micro/Nano S/C:

For Mini/Micro/Nano S/C, Arianespace offers a wide range of standard adapters, provided by Arianespace:

- Motorized LightBand (MLB MkII) from Planetary Systems Corporation (PSC) with 24 inches diameter (610 mm), or 15 inches (381 mm), or 13 inches (330 mm), or 11,732 inches (298 mm), or 8 inches;
- Payload Adapter System (PAS) from RUAG Sweden, PAS 610 S (610 mm - 24 inches diameter), or PAS 381 S (381 mm - 15 inches diameter).

They are equipped with a separation & distancing system (opening device, springs, etc…) and, as a standard, with one electrical connector and two separation detection devices.

They comprise the so-called passive ring and the active ring. The passive ring remains attached on the S/C after S/C separation, while the active ring with the separation system remains attached on the LV.

The general characteristics of the standards adapters are presented in the table below. More details can be found in Annex 2.

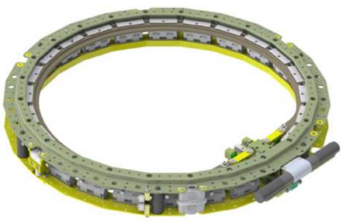
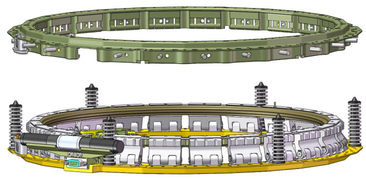
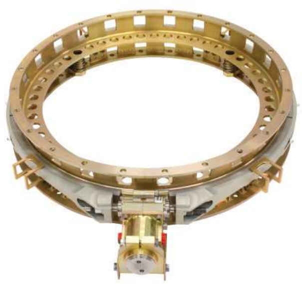
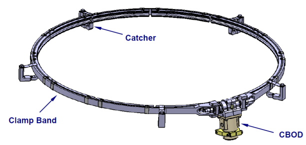
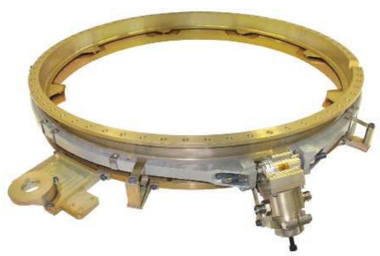
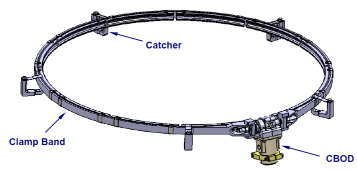
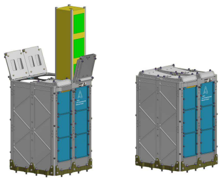
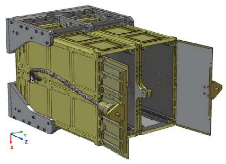
Adapter / Manufacturer	Description	Separation system
MLB series PSC 	S/C interface : MLB 11.732": 18 bolts MLB 13": 20 Bolts MLB 15": 24 bolts MLB 24": 36 bolts Total height: 53 mm Total mass: MLB 11.732": 2.1 kg MLB 13": 2.3 kg MLB 15": 2.6 kg MLB 24": 4.0 kg Mass retained on the S/C: MLB 11.732": 0.5 kg MLB 13": 0.6 kg MLB 15": 0.7 kg MLB 24": 1.1 kg	It is composed of a retaining ring, leaves, spring plungers and motors which allows to retract the leaves when the motors are powered + up to 16 springs for MLB 11.732" or up to 24 springs for MLB 13" or larger 
PAS 381 S RUAG Space AB 	S/C interface: 24 bolts at Ø381 mm Total height: 79 mm Total mass: 3.7 kg Mass retained on the S/C: 1.0 kg	Clamp-band ∅381 mm with low shock separation system (CBOD-LT) + up to 24 springs 
PAS 610 S RUAG Space AB 	S/C interface: 36 bolts at Ø609.6 mm Total height: 73 mm (w.o. springs) Total mass: 5.8 kg Mass retained on the S/C: 1.0 kg	Clamp-band ∅610 mm with low shock separation system CBOD-LT) + up to 10 springs 

Table 3.4a - Standard Adapters for Mini/Micro/Nano S/C

For Cubesats Deployers:

The Deployer for Cubesats shall be brought by Customer. However, as an option, Arianespace, with the support of our partners, can manage the Deployers procurement and the Cubesats integration into the Deployers.

Arianespace built close relations with all the Deployer manufacturers worldwide. Some of the most popular 12U and 16 U Deployers are illustrated below.

Astro- und Feinwerktechnik Adlershof GmbH	ISL	Tyvak A Terran Orbital Corporation	EXO LAUNCH
			

For Cubesats Deployers, the standard mechanical interface is composed of 8 bolts, located as shown on the sketch below:

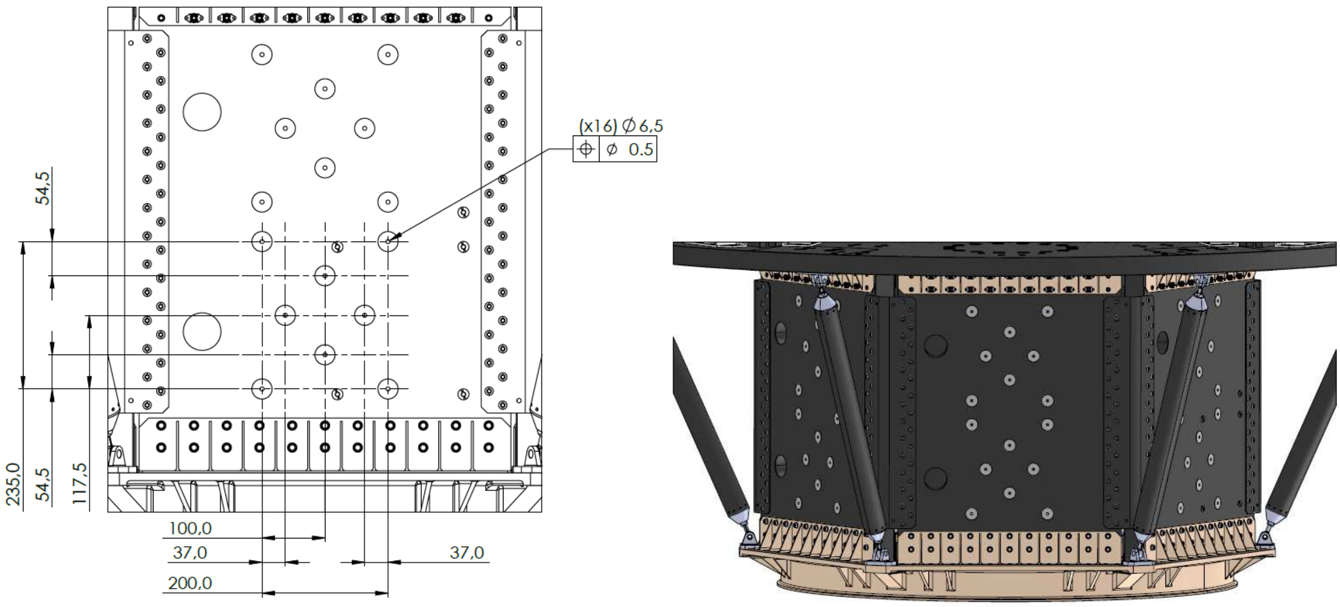


Figure 3.4a - Standard attachments pattern for two Deployers on each face of the SSMS Hexa module

In case of Deployers with different bolt pattern, an all-aluminum interface plate can be added between the SSMS hexa face and the Deployers.

3.5 Electrical interfaces

3.5.1 General

For Mini/Micro/Nano S/C:

For Mini/Micro/Nano S/C, as a standard, the electrical interface is composed of:

- one umbilical connector for S/C monitoring and battery trickle charge on ground, when the S/C is on top of the launcher on the launch pad, using links between the spacecraft and the Customer's EGSE located at the preparation facilities and launch pad basement (Refer to Vega-C Users' Manual for the wiring diagram on the launch pad).

- two separation switches (or microswitches) for S/C separation detection on the LV side. [S/C separation detection on S/C side uses as a standard, straps integrated on the LV side of the S/C – LV umbilical connector.]

For Cubesats Deployers:

For Cubesats deployers there is no umbilical lines.

The sequence of Cubesats separation (Deployers' doors opening) is ensured either directly by the Vega-C Multi-Functional Unit (MFU) or, when necessary, by a dedicated electrical interface unit called "Sequencer" and provided by Arianespace. These units also retrieve the telemetry from the Cubesats Deployers (door opening acknowledge and/or Cubesat release acknowledge) and send the data to the launcher Central Telemetry Unit (CTU).

	Mini S/C	Micro S/C	Nano S/C	Cubesat Deployers
Mass	**400–200 kg**	**200–60 kg**	**60–30 kg**	**35–10 Kg**
Umbilical lines (for S/C monitoring & battery charge)	**≤ 34 lines ***	**≤ 12 lines ***	**≤ 12 lines ***	**None**
S/C Separat° monitoring (on LV side)	**2 separation switches or microswitches ****	**2 separation switches or microswitches ****	**2 separation switches or microswitches ****	***
S/C Separat° monitoring (on S/C side)	**Straps in connector ****	**Straps in connector ****	**Straps in connector ****	

* NOTE 1: The total number of lines for the overall stack (for all small passengers and for main passenger if any) can be up to 200 lines.

** NOTE 2: refer to chapter 2.5.3 above for details

*** NOTE 3: refer to chapter 2.5.5 above for details

3.5.2 Umbilical links for Mini/Micro/Nano S/C

Connectors:

The table below provides a brief description of the standard connectors:

Adapter type	Connector *	Nb of pins **	Connector reference
MLB PSC		1 x 15	spacecraft side: PSC part number 4000107 launcher side: PSC part number 4000106
PAS RUAG		1 x 12	spacecraft side: DBAS 74 12 OSN 059 DBAS 74 12 OSY 059 launcher side: DBAS 025 8210 12 DBAS 025 8214 12
		1 x 37	spacecraft side: DBAS 70 37 OSN 090 DBAS 70 37 OSY 090 launcher side: DBAS 025 8210 37 DBAS 025 8214 37

* NOTE 1: Even if no umbilical links is required, one connector shall be present to ensure electrical continuity and S/C separation detection on S/C side.
** NOTE 2: As a standard, two pins are reserved for separation detection on S/C side.

Timeline limitation:

Battery trickle charge is authorized up to J-1.

[Note: as described in chapter 1.5, in case trickle charge is not possible through umbilical lines, the S/C battery charge operating life shall be at least 45 days after last battery charge and S/C integration on the carrying system.]

The Small Spacecraft shall be inert (no RF emission, no status changes, …) during the final countdown and ascent phase until after the Small S/C separation from the launcher. The actual delay after separation will be determined by Arianespace in the frame of the mission analysis process and will depend on the type of orbit and overall mission timeline.

3.5.3 S/C Separation monitoring for Mini/Micro/Nano S/C

S/C Separation detection on S/C side:

On S/C side, as a standard, S/C separation status indication is provided by straps integrated on the LV side of the spacecraft/LV connector. As a standard, two pins of the umbilical connector shall be reserved for this purpose.

The main electrical characteristics of these straps are:

strap "closed": $R \leq 1\ \Omega$

strap "open": $R \geq 100\ k\Omega$

S/C Separation detection on LV side:

On LV side, as a standard, S/C separation status indication is provided by two redundant separation switches (or microswitches).

NOTE: As an alternative to the separation switches (or microswitches), S/C separation status indication could be provided by two straps located on the S/C side of the spacecraft/LV connector.

3.5.4 Electrical Continuity Interface for Mini/Micro/Nano S/C

Bonding:

The spacecraft is required to have an "Earth" reference point close to the separation plane, on which a test socket can be mounted. The resistance between any metallic element of the spacecraft and a closest reference point on the structure shall be less than 10 mΩ for a current of 10 mA.

The spacecraft structure in contact with the LV shall not have any treatment or protective process applied which creates a resistance greater than 10 mΩ for a current of 10 mA between spacecraft earth reference point and that of the LV (adapter or carrying system).

Shielding:

The umbilical shield links shall be grounded at both ends of the lines (the spacecraft on one side and EGSE on the other). The spacecraft umbilical grounding network diagram is shown in Vega-C Users' Manual.

3.5.5 Electrical Interface for Cubesats Deployers

The Cubesats Deployers configuration and the electrical interface with the launcher shall be frozen at L – 6 months at the latest.

Cubesat separation:

The sequence of Cubesats separation (Deployers' doors opening) is ensured either directly by the Vega-C Multi-Functional Unit (MFU) or, when necessary, by a dedicated electrical interface unit called "Sequencer" and provided by Arianespace.

Cubesat separation detection:

The telemetry from the Cubesats Deployers (door opening acknowledge and/or Cubesat release acknowledge) is transferred to LV TM system.

3.6 Interface verifications for Mini/Micro/Nano S/C

3.6.1 Prior to the launch campaign

Customer shall provide evidence of the compliance with launch system interfaces at the latest at Flight Readiness Review (RAV). This includes compliance to usable volume, compliance to mechanical interface requirements and compliance to electrical interface requirements.

For this purpose, the following information & measurements will be required for review and approval:

Compatibility to Usable Volume:

The Volume compatibility verification is done by mean of a "virtual" fit-check based on CAD models: Customer will have to provide a representative CAD model of its S/C to verify that no interference might occur with adjacent S/C or with LV structure and that there is proper access to the bolted interfaces and harness connectors for integration operations.

The model shall be fully representative of the actual S/C and shall include provisions for MLI, harness, etc…

In case late access (that is access after integration of the S/C on the carrying system) is needed to remove some non-flight items (covers, etc…), a CAD model of each remove-before-flight item shall be provided, as well as a description of the operations and associated ground equipment, if any.

Mechanical & Electrical compatibility:

For Small S/C, the standard approach is to perform the fit check (mechanical and electrical interface verification) the first day of the S/C launch campaign just after the arrival of the S/C to the CSG facilities.

However, in order to secure the launch campaign planning, the customer shall provide, at the latest at Flight Readiness Review (RAV), evidences that the S/C rear panel meets the mechanical interface requirements, including a report with the geometric measurements of the S/C as-built rear panel.

As an option to be ordered by customer, a mechanical and electrical fit check can be performed prior to the launch campaign, at Customer or manufacturer premises. Specific LV hardware for these tests is loaned according to the contractual provision.

3.6.2 Pre-launch validation of the electrical links (when applicable)

This chapter is applicable when umbilical links are needed.

3.6.2.1 Definition

The electrical links between each Small S/C and launch vehicle is validated on each phase of the launch preparation where its configuration is changed or the harnesses are reconnected. These successive tests ensure the correct integration of the Small S/C with the launcher and help to pass the non reversible operations. There are up to three major configurations:

- Spacecraft mated to its adapter;
- Spacecraft with adapter mated to LV carrying structure;
- Payload Assembly Composite mated to launch vehicle.

Depending on the test configuration, the flight hardware, the dedicated harness and/or the functional S/C simulator will be used.

3.6.2.2 Spacecraft simulator / break-out-box

The spacecraft simulator / break-out-box is used to simulate spacecraft functions / interface during pre-integration tests: it shall be representative of the spacecraft output/input circuit that communicates with the adapter umbilical line. It will be provided by the Customer.

It shall be integrated in a portable unit with a weight not higher than 25 kg and dimensions less than L600 × P600 × H800 mm. The simulator can be powered from external source.

3.6.2.3 Spacecraft EGSE

The following Customer's EGSE will be used for the interface validation tests:

- OCOE, spacecraft test and monitoring equipment, linked with the spacecraft during all preparation phases and during launch, and permanently located in PPF Control rooms (LBC).
- COTE, Specific front end Check-out Equipment, providing spacecraft monitoring and control, ground power supply and hazardous circuit's activation. The COTE follows the spacecraft during preparation activity in PPF, HPF (when necessary) and Upper Composite Integration Facility. During launch pad operation the COTE is installed in the launch pad rooms. The spacecraft COTE is linked to the OCOE by data lines to allow remote control.
- set of ground patch panel cables for satellite electrical umbilical lines verification.

The installation interfaces as well as environmental characteristics for the COTE are described in the Chapter 7 of Spacecraft Processing Facilities at CSG User's Manual.

3.7 On-fairing mission insignia

One mission insignia designed by Arianespace, based on Customers supplied artworks, can be placed by Arianespace on the cylindrical section of the fairing. The artwork shall be supplied not later than 6 months before launch.

DESIGN, COMPATIBILITY VERIFICATION REQUIREMENTS & ENVIRONMENTAL CONDITIONS

Chapter 4

4.1 Introduction

The design, compatibility verification requirements and environmental conditions that shall be taken into account by any Customer intending to launch a Small S/C are described in this chapter. They may depend on the class of the Small Satellite.

	Mini S/C	Micro S/C	Nano S/C	Cubesat Deployers
Mass	**400–200 kg**	**200–60 kg**	**60–30 kg**	**35–10 Kg**

4.2 Design Requirements

4.2.1 Safety Requirements

The Customer is required to design the spacecraft in conformity with the CSG Safety Regulations, refer to the Payload Safety Handbook, CSG-NT-SBU-16687-CNES, Edition 1, Revision 1 dated 06 May 2015.

4.2.2 Selection of spacecraft materials

The spacecraft materials must satisfy the following outgassing criteria:

- Total Mass Loss (TML) ≤ 1 %;
- Collected Volatile Condensable Material (CVCM) ≤ 0.1 %.

measured in accordance with the procedure "ECSS-Q-70-02A".

In case of Piggyback mission, some additional non contamination requirements might arise, for a given mission.

4.2.3 Mass Properties

	Mini S/C	Micro S/C	Nano S/C	Cubesat Deployers
Mass	400–200 kg	200–60 kg	60–30 kg	35–10 Kg
Center of Gravity height	X_G < **900 mm**	X_G < **450 mm**	X_G < **450 mm**	-
Static unbalance	d ≤ **30 mm**	d ≤ **30 mm**	d ≤ **30 mm**	-

NOTE 1: Center of Gravity height counted from the mounting plane of the spacecraft.

NOTE 2: Large nominal CoG offset can be counteracted by an adequate tuning of the separation system. However, the dispersion on the CoG offset shall be no more than 5 mm at the time of Final Mission Analysis Kick-off.

NOTE 3: Small S/C mass properties shall be measured before Small S/C shipment. For Cubesats Deployers, it applies to each Cubesat and to the fully integrated Deployers.

4.2.4 Frequency Requirements

To prevent any dynamic coupling with fundamental modes of the Launch Vehicle and Carrying System, the Spacecraft shall be designed with a structural stiffness which ensures that the following requirements are fulfilled. In that case, the design limit loads given in next paragraph are applicable.

	Mini S/C	**Micro S/C**	**Nano S/C**	**Cubesat Deployers**
Mass	400–200 kg	200–60 kg	60–30 kg	35–10 Kg
Main frequencies	Lat > **30 Hz** Longi > **60 Hz**	Lat > **60 Hz** Longi > **90 Hz**	Lat > **115 Hz** Longi > **115 Hz**	Lat > **115 Hz** Longi > **115 Hz**

No secondary mode should be lower than the first primary mode, apart from sloshing modes, if any.

4.2.5 Design Loads

For a Spacecraft complying with the stiffness requirements defined above, the limit levels of quasi-static loads applicable at the spacecraft center of gravity, to be taken into account for the design and dimensioning of the spacecraft primary structure, are defined in the table here below.

	Mini S/C	**Micro S/C**	**Nano S/C**		**Cubesat Deployers**
Mounting	Vertical mounting	Vertical mounting	Vert. mount.	Cant. mount.	Cantilevered mounting
QSL (FLL)	Lat **±3g** Longi **±8.5g**	Lat **±5g** Longi **±10g**	Lat **±8g** Longi **±10g**	Lat **±10g** Longi **±10g**	Lat **±10g** Longi **±10g**

A qualification factor of 1.25 shall be applied (refer to §4.3.2).

In addition, the upper part structures (adapters and/or carrying structures) may produce local variations of the uniform line loads distribution and a value of **15%** over the average line loads seen by the spacecraft shall be taken into account.

4.2.6 Dynamic loads

The secondary structures and flexible elements (e.g., solar panels, antennas, and propellant tanks) must be designed to withstand the dynamic environment with the appropriate safety factors as defined in paragraph 4.3.

4.2.7 Other loads

Local loads

In addition of the global loads described in the above paragraphs, local loads shall be considered for spacecraft dimensioning, including payload adapter separation spring forces and flatness effect at spacecraft-to-adapter interface.

Handling loads during ground operations

During the PAC integration, the spacecraft is lifted and handled with its adapter and spacer: for this reason, the S/C and its handling equipment must be able to sustain an additional mass.

Mini S/C	Micro S/C	Nano S/C	Cubesat Deployers
Add. mass < **12 kg**	Add. mass < **10 kg**	Add. mass < **9 kg**	Add. mass < **4 kg**

4.2.8 Line loads peaking induced by the Small S/C

The maximum value of the peaking line load induced by the spacecraft is allowed in local areas to be up to 50% over the average line loads seen by the launcher for the MicroS/C and up to 35% over the average line loads seen by the launcher for the MiniS/C.

4.3 Compatibility verification requirements

During the preparation for launch and during the flight, the spacecraft is exposed to a variety of mechanical, thermal and electromagnetic environments. The present Chapter describes the requested demonstrations applicable to Small S/C.

4.3.1 Verification Logic

The spacecraft authority shall demonstrate that the spacecraft structure and equipment are capable of withstanding the maximum expected LV ground and flight environments.

The spacecraft compatibility must be proven by means of adequate tests. The verification logic with respect to the satellite development program approach is shown in Table 4.3.1a below:

S/C development approach	Model	**Static**	**Sine**	**Random & Acoustic** (1)	**Shock**
With Structural Test Model (STM)	STM	Qual. test	Qual. test	Qual. test	Shock test characterizat° and analysis
	FM1	By heritage from STM (2)	Protoflight test (3)	Protoflight test (3)	Shock test characterizat° and analysis or by heritage (2)
	Subsequent FM's (4)	By heritage from STM (2)	Acceptance test (optional)	Acceptance test	By heritage and analysis (2)
With ProtoFlight Model (PFM)	PFM = FM1	Qual. test or by heritage (2)	Protoflight test (3)	Protoflight test (3)	Shock test characterizat° and analysis or by heritage (2)
	Subsequent FM's (4)	By heritage (2)	Acceptance test (optional)	Acceptance test	By heritage and analysis (2)

Table 4.3.1a - Spacecraft verification logic

Note (1) For MiniS/C, random test not required pending it is covered by acoustic test. For MicroS/C, NanoS/C or Cubesat Deployers, acoustic test not required pending a random test is performed.

Note (2) If qualification is claimed by heritage, the representativeness of the structural test model (STM) with respect to the actual flight unit must be demonstrated.

Note (3) Protoflight approach means qualification levels and acceptance duration/sweep rate.

Note (4) Subsequent FM: spacecraft identical to FM1 (same primary structure, major subsystems and appendages).

The mechanical environmental test plan for spacecraft qualification and acceptance shall comply with the requirements presented hereafter and shall be reviewed by Arianespace prior to implementation of the first test.

The purpose of ground testing is to screen out unnoticed design flaws and/or inadvertent manufacturing and integration defects or anomalies. It is therefore important that the satellite be mechanically tested in flight-like configuration. In addition, should significant changes affect the tested specimen during subsequent AIT phase prior to spacecraft shipment to CSG, the need to re-perform some mechanical tests must be reassessed. If, despite of notable changes, complementary mechanical testing is not considered necessary by the Customer, this situation should be treated in the frame of a Request For Waiver, which justification shall demonstrate, in particular, the absence of risk for the launcher.

4.3.2 Safety factors

Spacecraft qualification and acceptance test levels are determined by increasing the limit loads by the safety factors given in Table 4.3.2a below. The spacecraft must have positive margins with these safety factors.

	Qualification (1)		**Protoflight**		**Acceptance**	
S/C tests	Factors	Duration/ Rate	Factors	Duration/ Rate	Factors	Duration/ Rate
Static (QSL)	1.25	N/A	1.25	N/A	N/A	N/A
Sine vibrations	1.25	2.0 oct./min (2)	1.25	4.0 oct./min (2)	1.0	4.0 oct./min (2)
Random vibrations	2.25 (3)	120 s per axis	2.25 (3)	60 s per axis	1.0 (3)	60 s per axis
Acoustics	+3 dB (or 2.0)	120 s	+3 dB (or 2.0)	60 s	+0 dB (or 1.0)	60 s
Shock	+3 dB (or 1.41)	2 actuations	+3 dB (or 1.41)	1 actuation	+0 dB (or 1.0)	1 actuation

Table 4.3.2a - Test Factors, rate and duration

Note (1) If qualification is not demonstrated by test, it is reminded that a safety factor of 2 is requested with respect to the design limit.

Note (2) See paragraph 4.3.3.2.
Note (3) Factor by which to multiply the Power Spectral Density.

4.3.3. Spacecraft compatibility tests for Small S/C

4.3.3.1. Static tests

Static load tests (in the case of an STM approach) are performed by the Customer to confirm the design integrity of the primary structural elements of the spacecraft platform. Test loads are based on worst-case conditions, i.e. on events that induce the maximum mechanical line loads into the main structure, derived from the table of maximum QSLs and taking into account the additional line loads peaking (paragraph 4.2.5) and the local loads (paragraph 4.2.7).

The qualification factors (paragraph 4.3.2) shall be considered.

4.3.3.2. Sinusoidal vibration tests

The objective of the sine vibration tests is to verify the spacecraft secondary structure dimensioning under the flight limit loads multiplied by the appropriate safety factors.

The spacecraft qualification test consists of one sweep through the specified frequency range and along each axis.

The levels to be applied are presented below.

Sine environment (0-peak) **[g]**			
Longitudinal direction			
Frequency band [Hz]	5 - 70	70 - 110	110 - 125
Qualification levels (O-peak) [g]	2.5	1.25	1.25
Acceptance levels (O-peak) [g]	2.0	1.0	1.0
Lateral direction			
Frequency band [Hz]	5 - 70	70 - 110	110 - 125
Qualification levels (O-peak) [g]	2.5	1.25	1.25
Acceptance levels (O-peak) [g]	2.0	1.0	1.0

Table 4.3.3.2a – Sine levels

The qualification factor to be applied is 1.25 (refer to §4.3.2).

A notching procedure may be agreed in the frame of a request for waiver, on the basis of the latest dynamic coupled loads analysis (CLA) available at the time of the tests to prevent excessive loading of the spacecraft structure. However it must not jeopardize the tests objective to demonstrate positive margins of safety with respect to the flight limit loads, while considering appropriate safety factor.

4.3.3.3. Random vibration tests

On Vega-C with SSMS carrying system, the spacecraft might be subjected to random environment induced by the acoustic environment primarily during the atmospheric phase.

The levels depend on the S/C position on the carrying system.

On the Top central and Tower positions of the SSMS, the random Flight Limit Levels are shown in the following table:

Random levels (SSMS Top and Towers positions)	
Frequency Band [Hz]	**PSD, Power Spectral Density (1)** **(10^{-3} g^2/Hz)**
20 - 150	7.1
150 - 200	7.1 – 56.3
200 - 270	56.3
270 - 300	56.3 - 100
300 - 400	100
400 - 450	100 – 56.3
450 - 1000	56.3 – 34.0
1000 - 2000	34.0 – 29.3
GRMS	8.8 g
Duration	60 s

Table 4.3.3.3a – Random levels – SSMS Top central and Tower positions

On the Main Deck positions of the SSMS carrying system, the random Flight Limit Levels are shown in the following table:

Random levels (SSMS Main Deck Positions)	
Frequency Band [Hz]	**PSD, Power Spectral Density (1)** **(10^{-3} g^2/Hz)**
20 - 50	4.5
50 - 100	4.5 – 9.0
100 - 200	9.0 – 22.4
200 - 500	22.4
500 - 1000	22.4 – 5.7
1000 - 2000	5.7 – 4.5
GRMS	4.4 g
Duration	60 s

Table 4.3.3.3b – Random levels – SSMS Main Deck positions

On the Hexagonal module positions of the SSMS carrying system the random Flight Limit Levels are shown in the following table:

Random levels (SSMS Hexagon Positions)	
Frequency Band [Hz]	**PSD, Power Spectral Density (1) (10^{-3} g²/Hz)**
20 - 50	7.1
50 - 100	7.1 – 14.2
100 - 200	14.2 – 35.5
200 - 500	35.5
500 - 1000	35.5 – 14.2
1000 - 2000	14.2 – 7.1
G_{RMS}	5.4 g
Duration	60 s

Table 4.3.3.3c – Random levels – SSMS Hexa positions

A qualification factor of 2.25 shall be applied (refer to §4.3.2).

4.3.3.4. Acoustic vibration tests

The acoustic specification to be considered for spacecraft testing is defined in table below.

Acoustic vibration test levels [dB] (reference: 0 dB = 2 × 10^{-5} Pa) (2)				
Octave center frequency [Hz]	**Qualification levels [dB]**	**Protoflight levels [dB]**	**Acceptance levels [dB]**	**Test tolerance [dB] (3)**
31.5	123	123	120	-2 / +4
63	126	126	123	-1 / +3
125	129	129	126	-1 / +3
250	136	136	133	-1 / +3
500	139	139	136	-1 / +3
1 000	130	130	127	-1 / +3
2 000	125	125	122	-1 / +3
OASPL (1) (20 – 2 828 Hz)	141.7	141.7	138.7	
Test duration (s)	120	60	60	

Note (1) OASPL: Overall Acoustic Sound Pressure Level
Note (2) The levels provided in table above are applicable to the Average Sound Pressure Level per octave band,
Note (3) Test tolerances allow only to cover calibration dispersion of the acoustic chamber,
Note (4) For homogeneity of the acoustic field, dispersion measured between each microphone shall be within +/-3 dB around the average SPL obtained in the octave band.

Table 4.3.3.4a - Acoustic vibration test levels

Depending on S/C size and its mass/surface ratio, an acoustic test might be not necessary if a random test is performed.

4.3.3.5. Shock qualification

On Vega-C, the spacecraft is subjected to shock environment, either from launcher event (Z9 separation) or from S/C separation. The levels depend on the S/C position on the carrying system.

On the Top central and Towers positions of the SSMS carrying system, the shock environment comes from the S/C separation (the SSMS carrying system attenuates the shock from the launcher). The shock levels (flight limit levels) to be considered are the following:

Frequency (Hz)	Flight limit level (dB) – S/C separation event (SSMS Top central and Towers positions)
100	40
1 000	780
10 000	780

Table 4.3.3.5a – Shock levels – SSMS Top central and Tower positions

For Main Deck positions, S/C shall be compatible with the following LV shock level:

Frequency (Hz)	Flight limit level (dB) - Launch Vehicle event (SSMS Main Deck Positions)
100	30
2 000	1000
10 000	1000

Table 4.3.3.5b – Shock levels – SSMS Main Deck positions

For SSMS Hexagonal module positions or VESPA+R inner position or VAMPIRE 937 positions, S/C shall be compatible with the following shock level:

Frequency (Hz)	Flight limit level (dB) - Launch Vehicle event (SSMS Hexagon Positions and VESPA+R inner position and VAMPIRE 937 positions)
100	30
2 000	1500
10 000	1500

Table 4.3.3.5c – Shock levels – other positions

A qualification factor of +3dB shall be applied (refer to §4.3.2).

4.4. Thermal loads

On **ground**, the environment that the spacecraft experiences both during its preparation and once it is encapsulated under the fairing is controlled in terms of temperature, relative humidity, cleanliness and contamination.

Within the air-conditioned CSG facility, the typical thermal environment is kept around 23+/-2°c for temperature and 55 +/- 5 % for relative humidity.

Once encapsulated (in facility, in transfer or when standing on the launcher), the spacecraft are protected by an air-conditioning system provided by the ventilation through pneumatic umbilical.

The ventilation configuration and thermal conditions inside fairing are presented in Chapter 3.4.2.2 of the Vega-C user's manual.

During **flight**, the Spacecraft are subjected to the depressurization effect, to the radiation coming from the fairing ; and after fairing jettisoning, to aerothermal flux and third stage plume radiation.

Before fairing jettisoning, the average value of the thermal flux density radiated by the fairing during the ascent phase does not exceed 1 000 W/m^2 in the hottest area. A maximal value of 1 300 W/m^2 can be reached during a transient phase.

Typically, for SSO missions, the fairing separation takes place 5s after Z9 ignition around 270 seconds from lift-off and the aerothermal flux is lower than 300 W/m2.

During third stage (Z9) phase (duration ~115 seconds), the maximal thermal impingement on the payload external surfaces due to the 3rd stage (Z9) engine firing is (see figures below):

- lower than 1 500 W/m^2 on the payload surfaces "A";
- lower than 600 W/m^2 on the payload surfaces "B".

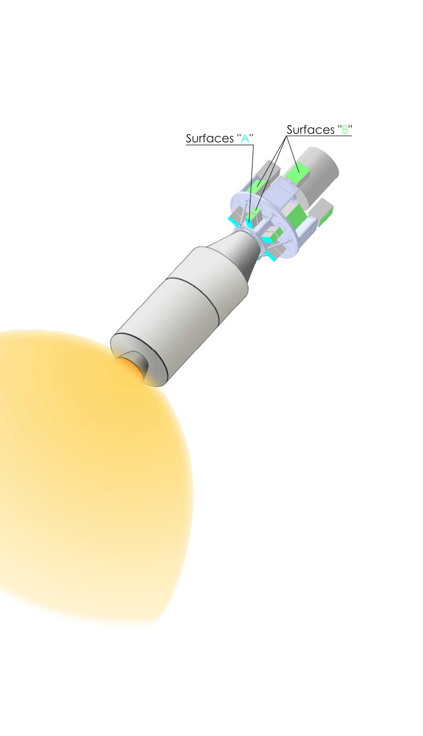
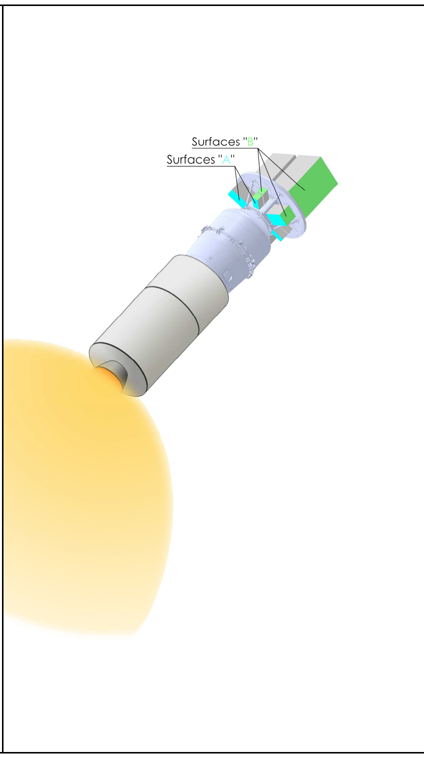
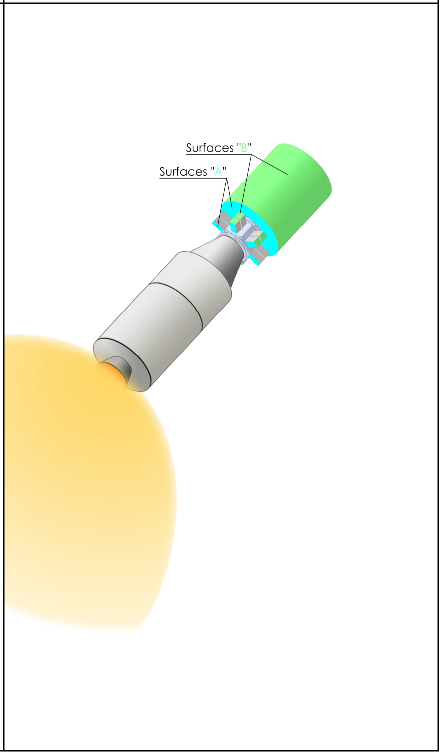
Rideshare conf.		**Piggyback conf.**
		

Figure 4.4a - Spacecraft surfaces exposed to the 3rd stage (Z9) plume radiation

The time of Small S/C separation can be up to lift-off + 4.5 Hours. It is determined by Arianespace taking into account the optimization being made for the overall mission (e.g. injection of other passengers and last stage de-orbiting at the end of mission). The S/C shall sustain the associated thermal conditions.

The coupled thermal analysis performed in the frame of the mission analysis (refer to chapter 5.3.5) will allow to provide the actual flight thermal environment and in addition, for Mini and Micro S/C, to check S/C temperature during every phases (ground and flight).

4.5. RF environment

The Small S/C emitters shall be OFF during all the combined operations, final countdown and ascent phase until after the Small S/C separation. The actual delay after separation will be determined by Arianespace in the frame of the mission analysis process and will depend on the type of orbit and overall mission timeline.

The intensity of the electrical field generated by spurious or intentional emissions from the launch vehicle and the range RF systems does not exceed the levels presented in Figure 4.5 below.

Customer shall demonstrate compatibility to these levels (by test, analysis or heritage).

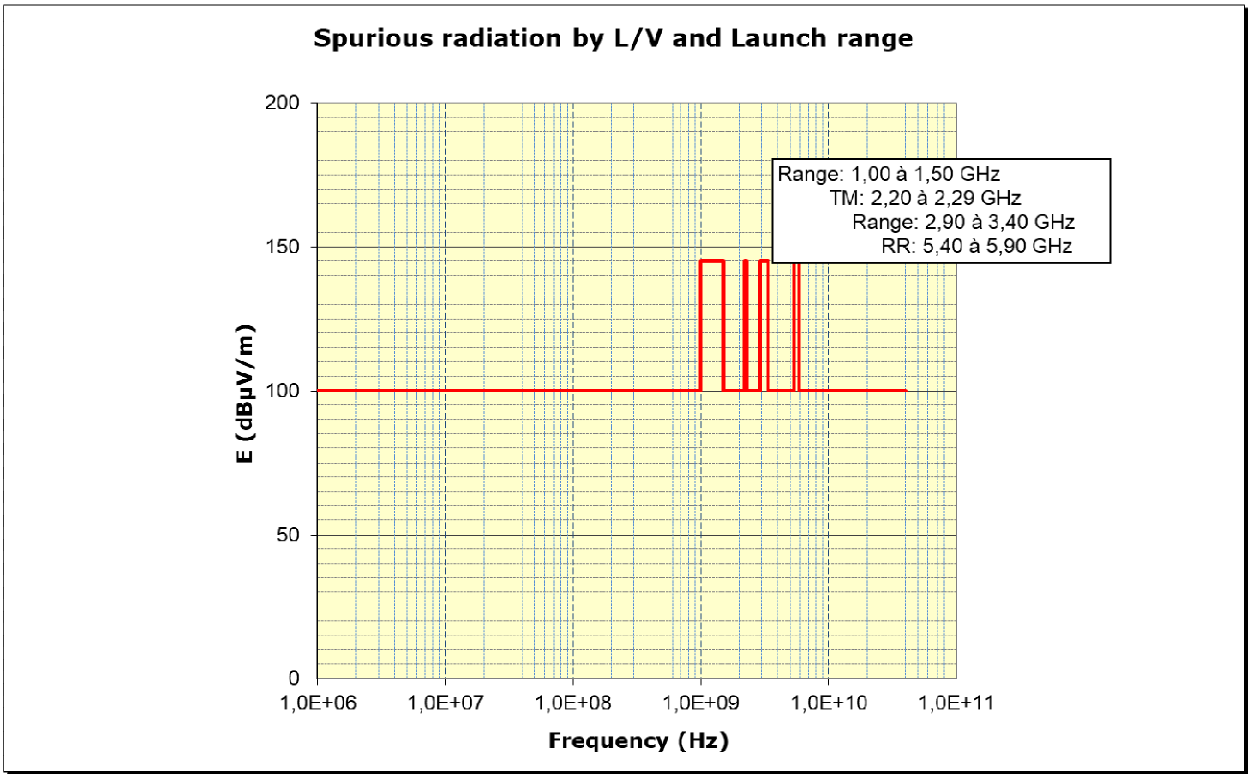


Figure 4.5a - Spurious radiation by LV and launch base narrow-band electrical field

MISSION MANAGEMENT & LAUNCH CAMPAIGN ORGANISATION FOR SMALL S/C Chapter 5

5.1. Introduction

The overall launch service for Small S/C (management, mission integration process, hardware supply, launch campaign organization, range support) is described in the present chapter.

The launch service is tailored depending on Small S/C class.

5.2. Mission management

5.2.1. Contract organization

The contractual commitments between the launch service provider and the Customer are defined in the **Launch Services Agreement (LSA)** with its **Statement of Work (SOW),** and its Technical Specification.

Based on the Application to Use Arianespace launch vehicles ("DUA " – refer to annex 1 for a template) filled out by the Customer, the Statement of Work identifies the task and deliveries of the parties, and its Technical Specification identifies the technical interfaces and requirements.

The Arianespace Program Director appointed to the given rideshare or piggyback mission will provide the organization and resources to fulfill the contractual obligations: contract amendments, payments, planning, configuration control, documentation, reviews, meetings, etc…

Additionally, during the launch campaign, the appointed Mission Director will handle the operations activities.

5.2.2. Launch schedule management

The launch schedule is established by Arianespace, in compliance with the milestones specified in the Statement of Work of the Launch Service Agreement:

- For a rideshare mission, taking into account the preparation schedule of every Small S/C and the overall Vega-C launch manifest.
- For a piggyback mission, in accordance with the main passenger requirements.

5.2.3. Meetings and Reviews

A typical content of the different meetings and reviews is given below. Most of the reviews and meetings can be held by teleconference.

For Mini/Micro/Nano S/C:

#	Title	Typical date❶	Object❷	Loc.❸
1	**Contractual Kick-off Meeting:** Project management – project milestones – organisation – security & confidentiality aspects – communications protocol	L - 24	M-E	C or T
2	**DUA Review:** Review of the Spacecraft characteristics and requirements Review of the DCI Issue 0 Revision 0	L - 22	M-E-O-S	T
3	**Prelim. Mission Analysis Review (RAMP):** As necessary, Orbit and injection accuracy – Separation and collision avoidance – Dynamic environment Review of Safety Submission status DCI review	L - 17	M-E-O-S	E or T
4	**DCI Signature Issue 1 Revision 0**	L - 16	M-E-O-S	T
5	***Option: CSG site survey / Preparation of S/C Operations Plan (POS):*** *Launch base facilities visit – CSG support – Telecommunications network -* *Safety submission phases 1 and 2* *Review of SPORT (Satellite Project Operational Requirements Tables)*	*L - 14*	*M-O-S*	*W or K*
6	**Final Mission Analysis Kick-Off:** Review and validation of the Final Mission Analysis inputs DCI review	L - 6	M-E	T
7	**Review of S/C Operations Plan (POS):** Transport and logistics – Preliminary S/C Operations Plan (POS) – Combined Operations introduction – Telecommunications network Safety submission phases 1 and 2 Review of SPORT (Satellite Project Operational Requirements Tables)	L - 6	M-O-S	W or T
8	**Final Mission Analysis Review (RAMF):** Trajectory – performance – injection accuracy – separation and collision avoidance – thermal – dynamic environment – EMC environment – authorization to start the flight program production – Spacecraft qualification status DCI review	L - 3	M-E	E or T
9	**Final Campaign Preparation Meeting:** Campaign preparation status - S/C Operations Plan (POS) – Interleaved Operations Plan (POI) – Combined Operations Plan Safety submission status DCI review (chapters 7 and 8)	L - 3	M-O-S	E or T
10	**DCI Signature Issue 2 Revision 0**	L - 2	M-E-O-S	T
11	**Combined Operations Readiness Review (BT POC):** Launch Vehicle and Launch System status Spacecraft status	❹	M-O-S	K
12	**Financial Wrap-up meeting**	L-1 day	M	K

❶ Dates are given in months, relative to L, where L is the first day of the Launch Term, Period, Slot or Day.
❷ M ⇨ Management; E ⇨ Engineering; O ⇨ Operations; S ⇨ Safety
❸ E ⇨ Evry; K ⇨ Kourou; C ⇨ Customer Headquarter; W ⇨ S/C Manufacturer Plant; T ⇨ By Teleconference/Electronic exchange
❹ To be held the day before the agreed day for starting the Combined Operations

Table 5.2.3a - Typical content of meetings and reviews for Mini/Micro/Nano S/C

For Cubesats Deployer:

#	Title	Typical date❶	Object❷	Loc.❸
1	**Contractual Kick-off Meeting**	L - 12	M-E	T
2	**Final Mission Analysis Kick-Off:** Review and validation of the Final Mission Analysis inputs Review of the safety submission inputs	L - 6	M-E	T
3	**Operation meeting #1**	L - 5	M-O-S	T
4	**Final Mission Analysis Review (RAMF) & Environment Key point**	L - 3	M-E	E or T
5	**Operation Final Preparation Meeting**	L - 3	M-O-S	E or T
6	**DCI Signature Issue 2 Revision 0**	L - 2	M-E-O-S	T
7	**Integration Readiness Review (IRR):** Carrying system status Spacecraft status	L – 8 weeks	M-O-S	B
8	**Pre Shipment Review (PSR):** Fully integrated Hex module status (to authorize shipment to CSG)	L – 7 weeks	M-O-S	B

❶ Dates are given in months, relative to L, where L is the first day of the Launch Term, Period, Slot or Day.
❷ M ⇨ Management; E ⇨ Engineering; O ⇨ Operations; S ⇨ Safety
❸ E ⇨ Evry; B ⇨ Brno; T ⇨ By Teleconference/Electronic exchange

Table 5.2.3b - Typical content of meetings and reviews for Cubesats Deployer

In parallel, **launcher reviews** take place: RAV (LV Flight Readiness Review) at L – 2 months and RAL (Launch Readiness Review) at L-2 days. The L/V-S/C interfaces will be examined with reference to the DCI.

At the LV Flight Readiness Review, the Customer shall have demonstrated S/C compatibility to mission environment and launcher interfaces (mechanical and electrical). He is also asked to provide the proof of the availability of the satellite Dummy, when applicable.

5.3. Systems engineering support

The Arianespace's launch service for Small S/C includes the engineering tasks necessary to ensure Small S/C compatibility with the launch system and, for a piggyback mission, with the main passenger mission.

5.3.1. Interface Management

The technical interface management is based on the Interface Control Document (DCI "Document de Contrôle d'Interface"), which is prepared by Arianespace using inputs from the Technical Specification of the Launch Service Agreement.

A single DCI is produced for a given rideshare or piggyback mission, with proper information confidentiality management.

5.3.2. Mission Analysis

Mission analysis is typically organized into two phases, which are:

- the Preliminary Mission Analysis; and
- the Final Mission Analysis.

The Final Mission Analysis focuses on the actual flight configuration and uses the final actual data and models of the Spacecraft.

The main outcomes of the analyses are collected in the Interface Control Document dedicated.

5.3.3. Small S/C Compatibility Verification

Compatibility to launch system environment:

In close relationship with mission analysis, Arianespace will check the Small S/C design is able to withstand the LV environment.

For this purpose, the following reports will be required for review and approval:

- **An environment test plan** correlated with requirements described in previous Chapters. Customer shall describe their approach to qualification and acceptance tests. This plan is intended to outline the Customer's overall test philosophy along with an overview of the system-level environmental testing that will be performed to demonstrate the adequacy of the Small S/C for ground and flight loads (e.g., static loads, vibration, acoustics, random and shock). The test plan shall include test objectives and success criteria, test specimen configuration, general test methods, and a schedule. It shall not include detailed test procedures.
- **An environment test file** comprising theoretical analysis and test results following the system-level structural load and dynamic environment testing. This file should summarize the testing performed to verify the adequacy of the Small S/C structure for flight and ground loads including venting. For structural systems not verified by test, a structural loads analysis report documenting the analyses performed and resulting margins of safety shall be provided.

Arianespace may request to attend environmental tests for real time discussion of notching profiles and tests correlations.

The final S/C status of compatibility shall be available for the RAV launcher review, typically at L -2 months.

Compatibility to launch system interfaces:

Customer shall provide evidence of the compliance with launch system interfaces, at the latest at RAV launcher review, typically at L -2 months. This includes compliance to usable volume, compliance to mechanical interface requirements and compliance to electrical interface requirements. Refer to chapter 2.6.

5.3.4. Post-launch analysis

After the flight, confirmation of the Small S/C or Cubesats physical separation, obtained orbit and attitude at separation will be provided to the Customer at a time which is mission dependent (from one to several hours after separation depending on the available ground stations).

Arianespace requires the Customer to provide satellite orbital tracking data on the initial Small S/C orbit, including attitude just after separation.

5.3.5. Standard activities

The table below summarizes the conducted systems engineering activities depending on Small S/C class:

	Mini S/C	Micro S/C	Nano S/C	Cubesat Deployers
Mass	**400–200 kg**	**200–60 kg**	**60–30 kg**	**35–10 Kg**
DCI	✓	✓	✓	✓
Preliminary Trajectory	✓	✓	✓	✓
Preliminary Separation (1)	✓	✓	✓	x
Preliminary Dynamic CLA (2)	✓	✓	O	x
Final Trajectory	✓	✓	✓	✓
Final Separation (1)	✓	✓	✓	x
Final Dynamic CLA (2)	✓	✓	O	x
Thermal CLA (3)	✓ (3)	✓ (3)	✓ (3)	✓ (3)
Test plan review	✓	✓	✓	✓
Support to sine tests	✓	O	O	x
Test results review	✓	✓	✓	✓
Post launch analysis	✓	✓	✓	✓

✓ Included as standard activities
O Option available at Customer request

Table 5.3.5a - Standard System engineering activities

Notes:
(1) S/C mass properties required (nominal and dispersed values). At final analysis kick off, dispersion on CSG offset shall not be more than 5mm.

(2) Condensed FEM model required, according to Arianespace FEM model specification, for Mini and Micro S/C.

(3) Condensed Thermal model required, according to Arianespace thermal model specification, for Mini and Micro S/C. For Mini and Micro S/C, the outcomes of the analysis are the computed temperatures of the S/C nodes for ground and flight phases. For NanoS/C and Cubesats Deployers, the outcome of the analysis is the actual flight environment (Flux versus time).

5.4. Launch Vehicle adaptation

Arianespace will supply the hardware and software to carry out the mission, complying with the Interface Control Document (DCI):

For Mini/Micro/Nano S/C:

- One adapter with separation system and, when necessary, umbilical interface connector(s);
- When using the SSMS carrying system, one spacer to tune the Small S/C position on the SSMS carrying system;
- The carrying system (either SSMS, VESPA+R or VAMPIRE 937 MPL);
- One mission logo installed on the fairing designed by Arianespace, based on the artworks supplied by the Customers;
- When necessary, one rack compatible with the launch pad installation, for the Check-Out Terminal Equipment (COTE).

For Cubesats Deployer(s):

- Harnesses from Cubesats Deployer(s) to launcher avionics (MFU or Sequencer unit);
- Sequencer unit, when necessary.

5.5. Launch campaign

5.5.1. Typical launch campaign for Mini/Micro/Nano S/C

The Small S/C launch campaign main phases are:

- Preparation;
- Arrival in French Guiana & transfer to the launch site;
- Small S/C autonomous preparation and checkout in PPF;
- When necessary, Small S/C autonomous hazardous operations in HPF;
- Combined Operations (S/C mating on its adapter, integration on carrying structure, fairing encapsulation, mating on launcher);
- Launch countdown;
- Transfer back of the GSE.

All the facilities (PPF and HPF Clean Rooms and Lab for check-out stations - LBC) are shared with the other Small S/C on the same flight.

5.5.1.1 Preparation phase & Operational documentation

For Mini/Micro/Nano S/C, during the launch campaign preparation phase, to ensure activity coordination and compatibility with CSG facility, Arianespace issues the following operational documentation based on Application to Use Arianespace's Launch Vehicles and the Small S/C Operations Plan (POS "Plan des Opérations Satellite"):

- An Interleaved Operation Plan (POI);
- A Combined Operations Plan (POC);
- The set of detailed procedures for combined operations;
- A simplified countdown manual.

The operational documentation and related items are discussed at technical meetings and status of the activity presented at final launch campaign preparation meeting.

When deemed necessary, as an option available at customer request, Arianespace can organize **a CSG visit**. It may comprise the visit of the facilities allocated to the Small S/C and review of operational documentation.

5.5.1.2 Spacecraft, GSE and propellant arrival & transfer to EPCU

For Mini/Micro/Nano S/C, the Spacecraft, the ground support equipment can be delivered to CSG by aircraft or by ship. The propellant, if any, can be delivered to CSG by ship.

The possible arrival areas are:

- The **Félix Eboué international airport** for freighter airplanes and regular passenger flights.

  Small freight can be shipped on regular passenger flights. The dimensions of the container shall be smaller than: height 1.55 m max. and width 2.45 m max. to be compatible with the fret doors of these passenger planes. Additionally, the S/C battery characteristics shall comply with IATA rules on passenger aircraft.
- The **Cayenne international harbor**.
- The **Pariacabo docking area** for Arianespace's ships which ensure regular LV transport.

  These ships are also available for transferring spacecraft and/or GSE from Europe to CSG (option available at customer request). The usual stop harbors in Europe for containers loading are Rotterdam and Le Havre.

Arianespace takes charge of the containers after their unloading from the plane or ship and ensures the transfer to the CSG by road.

5.5.1.3 Small S/C autonomous preparation for Mini/Micro/Nano S/C

Autonomous operations and checks of the Small S/C are carried out in the PPF.

The Clean Rooms and Lab for check-out stations (LBC) are shared with the other Small S/C on the same flight.

The allocated areas in PPF and in LBC (as well as the number of allocated offices) will be provided according to the contractual provision.

The activities shall be performed nominally within normal CSG working hours. Normal working hours at the CSG are based on 2 shifts of 8 hours per day, between 6:00 am and 10:00 pm from Monday to Saturday.

After S/C departure from PPF (to HPF or UCIF), the evacuation of Ground Support Equipment from the clean room shall be completed within 1 working day.

5.5.1.4 Small S/C hazardous operations (if necessary)

When necessary, the Small S/C is transferred in HPF for hazardous operations.

After S/C departure from HPF, the evacuation of the GSE from the filling hall shall be completed within 1 working day.

5.5.1.5 Combined Operations for Mini/Micro/Nano S/C

The Small S/C shall be made available to Arianespace for the Combined Operations with the Launch Vehicle typically 18 working days prior to the Launch, at the latest. The actual date will be defined in the Combined Operations Plan (POC) approved by the Customer.

Similarly, the representative dummy shall be available for the combined operations readiness review (BT POC) at the latest.

After delivery, verification and acceptance of all the Payload Assembly Composite parts, the BT POC authorizes the combined operations.

The first operation is the Small Sat integration on its adapter. It may occur in the PPF or in the HPF (when necessary).

It is followed by the mating of the Small S/C with its adapter onto the carrying structure.

The stack is then transferred to the Upper Composite Integration Facility (UCIF) for the mating of the main passenger (when in piggyback configuration) and fairing encapsulation. Depending on upper part configuration, the UCIF can be S3B or S5A or S5B building.

5.5.1.6 Launch pad operations for Mini/Micro/Nano S/C

If any, the Small S/C check-out equipment and specific COTE (Check Out Terminal Equipment) necessary to support the Small S/C on-pad operations shall be made available to ARIANESPACE, and validated, two days prior to operational use according to the approved operational documentation, at the latest.

After the launch, all Small S/C mechanical & electrical support equipment shall be removed from the various EPCU buildings & Launch Pad, packed and made ready for return shipment within three working days after the Launch.

5.5.2. Typical launch campaign for Cubesats Deployer(s)

The facility for Cubesats Deployer(s) integration on the SSMS Hexa module is the SAB Aerospace facility located in Brno, Czech Republic, Continental Europe. NanoSatellites without any hazardous propellant can also be integrated there. Refer to annex 3 for a detailed description of this facility.

The Cubesat Deployer(s) preparation main phases are:

- Documentation preparation;
- Arrival at SAB aerospace (by truck, and plane for non-European Customers);
- Cubesats & Cubesats Deployer(s) autonomous operations;
- Deployers Integration on the SSMS hexa module, electrical connection and checks;
- Packing of the fully integrated SSMS hexagonal module for transfer to Paris Orly airport (by truck) and then to French Guiana (by regular plane);
- In CSG, integration of the SSMS Hexa base module with the already integrated SSMS upper part, and other combined operations;
- Launch countdown.

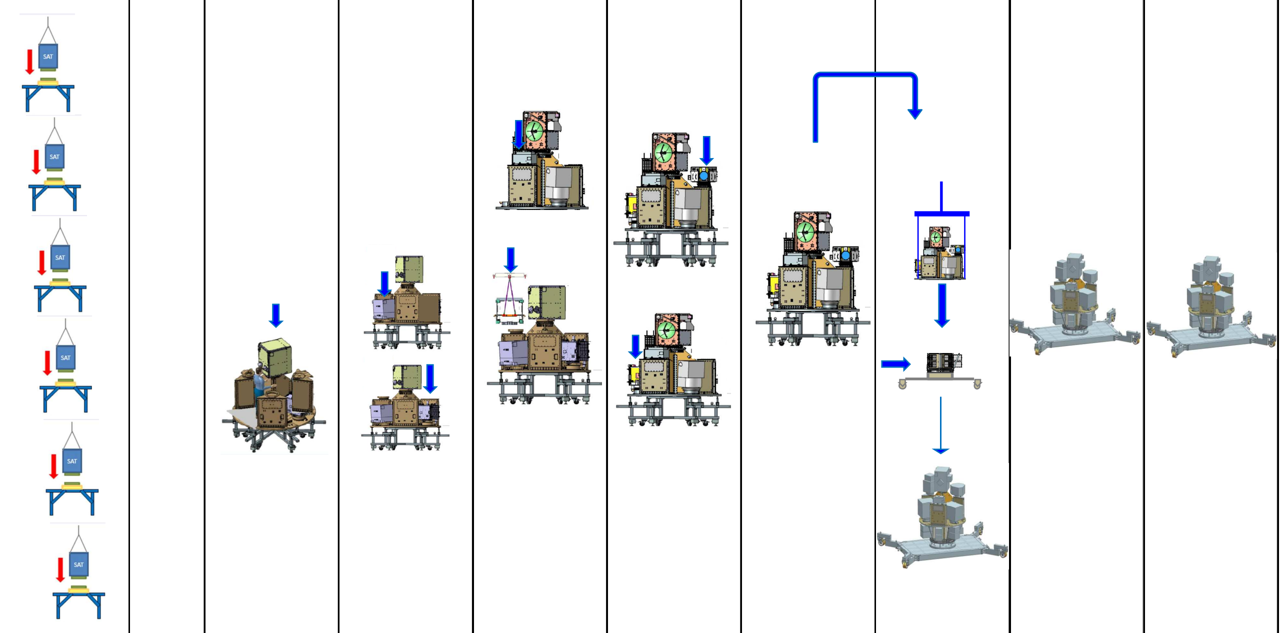
For the transfer by regular plane, from Paris Orly to Felix Eboué Airport in French Guiana, the S/C battery characteristics shall comply with IATA rules on passenger aircraft.

5.5.3. Launch campaign overview

The following diagram presents an overview for a typical SSMS Rideshare launch campaign.

Pre POC

For each S/C at arrival	…	D-17	D-16	D-15	D-14	D-13	D-12	D-11	D-10
		PPF							
		Small S/C mating on SSMS carrying structure				-	Full assembly with the HEX module		
Mating of each Small S/C on its adaptor and spacer		… on central top position	… on main deck	… on towers	… on towers and main deck	SSMS HEX module preparation (shipped from SAB Aerospace facility)	Integration on HEX module		Electrical connection & functional checks



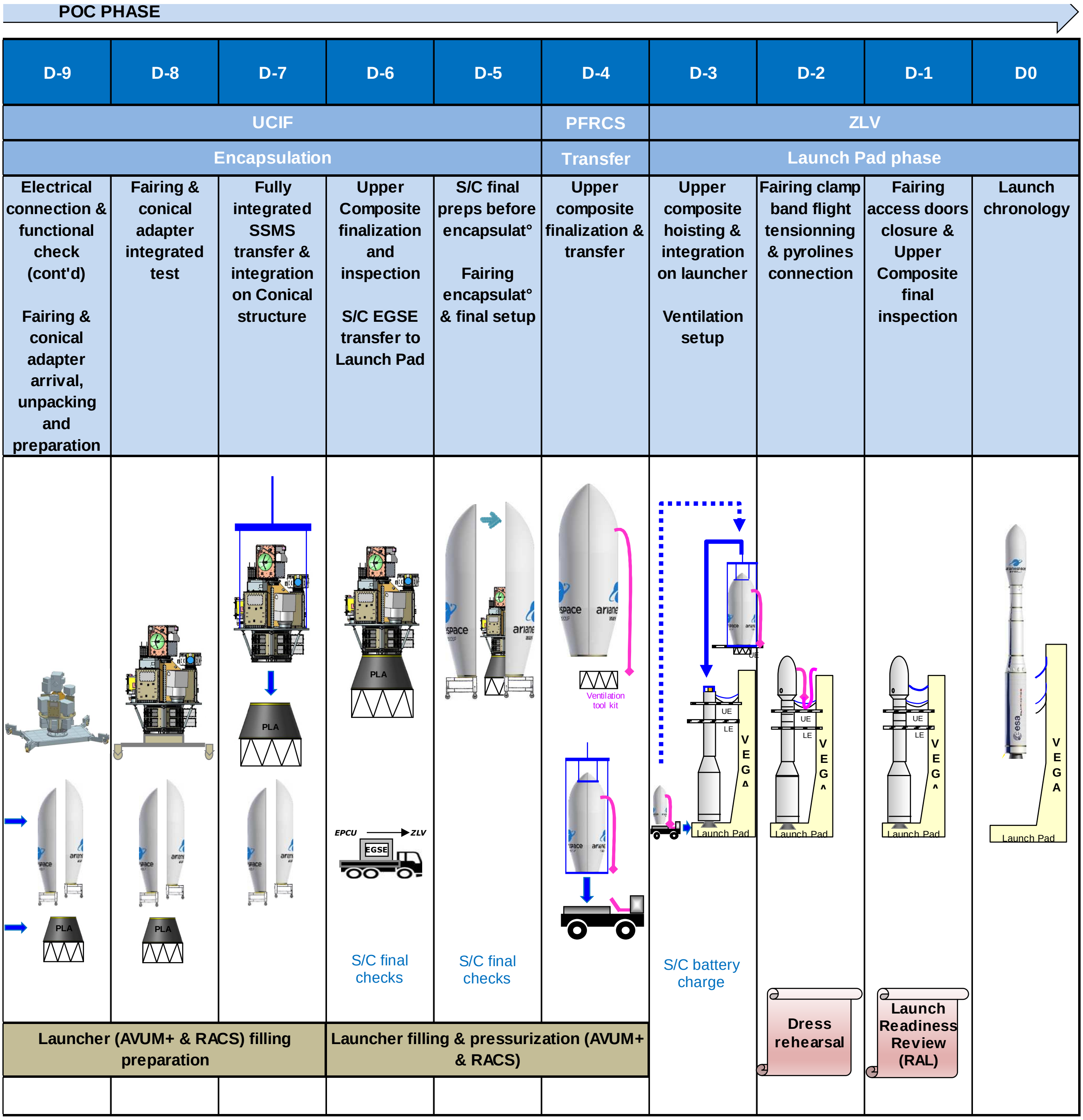


Figure 5.5.3a - Launch campaign overview

The following figures illustrate the launch campaign main events after integration of the S/C on the carrying structure.

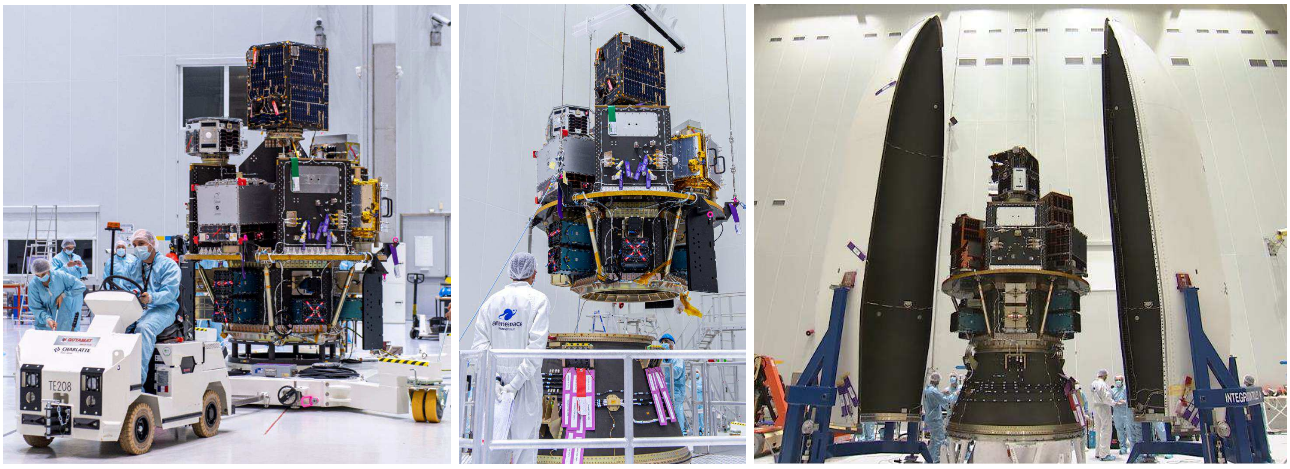


Figure 5.5.3b - VV16 Launch campaign - Transfer of the fully integrated SSMS carrying system from PPF to UCIF - Integration on the conical launcher adapter – Fairing encapsulation

Figure 5.5.3c - VV16 Launch campaign - Transfer of the Payload Assembly Composite from UCIF to Launch Pad - Hoisting of the Payload Assembly Composite to the mobile gantry upper platform – Integration of the Payload Assembly Composite on the Launch Vehicle & reconnection of the ventilation & electrical links

5.5.4. Summary of launch campaign meetings and reviews

5.5.4.1. Small S/C transport meeting

Arianespace will hold a preparation meeting with the customer before Small S/C arrival. The readiness of the facilities at entrance port and at CSG, as well as status of formal issues and transportation needs will be verified.

All the Small S/C for a given rideshare of piggyback mission should be transferred to French Guiana the same day.

5.5.4.2. Combined operations readiness review (BT POC "Bilan Technique POC")

The objective of this review is to demonstrate the readiness of the Small S/C, the flight items and the CSG facilities to start the combined operations according to POC. It addresses the following main points:

- POC presentation, organization and responsibility for combined operations;
- The readiness of the Payload Assembly Composite items (adapters, carrying structure, fairing);
- The readiness of the CSG facilities;
- The readiness of the Small S/C;
- The availability of the Small S/C representative dummy, when applicable;
- The mass of the payload in its final launch configuration.

5.5.4.3. Launch readiness review (RAL "Revue d'Aptitude au Lancement")

A Launch Readiness Review is held one day before launch and after the launch rehearsal. It authorizes to proceed with the final countdown and launch. This review is conducted by Arianespace.

5.5.4.4. Post flight debriefing (CRAL " Compte-rendu Après Lancement ")

The day after the launch, Arianespace draws up a report to the Customer, on post flight analysis covering flight event sequences, evaluation of LV performance, and if available, injection orbit and accuracy parameters.

5.5.5. Range Support at CSG

Arianespace provides a number of standard services and standard quantities of fluids described hereafter.

5.5.5.1. Transport services

Spacecraft, GSE and propellant transportation:

Transport from and to one of the arrival areas and CSG at arrival and departure is performed nominally within normal CSG working hours, and subject to advance notice.

It does not include:

- Unloading from plane or ship which is customer responsibility;
- The "octroi de mer" tax on equipment permanently imported to Guiana, if any;
- Insurance for spacecraft and its associated equipment.

Logistics support:

Support for shipment and customs procedures for the spacecraft and its associated equipment and for personal luggage and equipment transported as accompanied luggage.

Spacecraft and GSE Inter-Site Transportation:

All spacecraft transportation either inside the S/C container, and spacecraft GSE transportation between CSG facilities.

5.5.5.2. Payload preparation facilities allocation

PPF, HPF, LBC areas and meeting rooms:

The Clean Rooms and Lab for check-out stations (LBC) are shared with the other Small S/C on the same flight.

The allocated areas in PPF (and HPF when necessary) and in LBC, as well as the number of allocated offices will be provided according to the contractual provision.

The activities shall be performed nominally within normal CSG working hours.

Storage:

Any storage of equipment during the campaign.

Two additional months for propellant storage, if any.

Schedule restrictions:

The standard standalone launch campaign duration is limited to 15 working days for Mini S/C, 10 working days for Micro S/C and 5 working days for Nano S/C.

The Small S/C shall be made available to Arianespace for the Combined Operations with the Launch Vehicle 18 working days prior to the Launch, at the latest. The actual date will be defined in the Combined Operations Plan (POC) approved by the Customer.

After S/C departure from PPF (to HPF or UCIF), the evacuation of Ground Support Equipment from the clean room shall be completed within 1 working day. Similarly, after S/C departure from HPF, the evacuation of the GSE from the filling hall shall also be completed within 1 working day.

After the Launch, Spacecraft ground support equipment must be packed and removed from all EPCU facilities within maximum 3 working days.

5.5.5.3. Communication links

The following communication services between the different spacecraft preparation facilities will be provided for the duration of a standard campaign (including technical assistance for connection, validation and permanent monitoring):

Service	Type	Quantity
RF- Link	S/C/Ku/Ka band	1 TM / 1 TC through optical fiber
Baseband Link	S/C/Ku/Ka band	2 TM / 2 TC through optical fiber
Data Link	V11 and V24 network	For COTE monitoring & remote control
Ethernet	Planet network, 10 Mbits/sec	1 VLAN available per project
Umbilical Link	Copper lines	Up to 12 lines for Nano or Micro S/C Up to 34 lines for Mini S/C
Closed Circuit TV		As necessary
Intercom System		As necessary
Paging System		2 beepers per Project
CSG Telephone		As necessary
Video Conference ➊	Equipment shared with other Customers	
Internet	Connection to local provider	

Note: ➊ traffic to be paid, at cost, on CSG invoice after the campaign.

5.5.5.4. Cleanliness monitoring

Continuous monitoring of organic deposit in clean room, with one report per week.

Continuous counting of particles in clean room, with one report per week.

5.5.5.5. Fluid and gases deliveries

Gases	Type	Quantity
Compressed air	Industrial, dedicated local network	As necessary
GN2	N50, dedicated local network	As necessary available at 190 bar
GN2	N30, dedicated network in S3 area	As necessary available at 190 bar
GHe	N55, dedicated local network	As necessary, available at 410, 350 or 200 bar.
Fluid	**Type**	**Quantity**
LN2	N30	As necessary
IPA	MOS-SELECTIPUR	As necessary
Water	Dematerialized	As necessary

5.5.5.5. Safety equipment

Equipment	Type	Quantity
Safety equipment for hazardous operations (safety belts, gloves, shoes, gas masks, oxygen detection devices, propellant leak detectors, etc.)	Standard	As necessary

5.5.6. Standard support service

The table below summarizes the support service provided depending on Small S/C class:

	Mini S/C	**Micro S/C**	**Nano S/C**	**Cubesat Deployers**
Mass	**400–200 kg**	**200–60 kg**	**60–30 kg**	**35–10 Kg**
Facility	CSG	CSG	CSG or Brno	Brno
Latest delivery date for POC	L – 18 working days	L – 18 working days	L – 18 working days or L – 6 weeks	L – 6 weeks
Standalone operation duration	15 working days	10 working days	5 working days	5 working days
Propellant loading	✓	✓	O	x
S/C monitoring & battery charge via umbilical lines	34 lines	12 lines	12 lines	x
Latest access (for remove-before-flight items)	L – 5 (Rideshare mission) L – 8 (Piggyback mission)	L – 5 (Rideshare mission) L – 8 (Piggyback mission)	L – 5 (Rideshare mission) L – 8 (Piggyback mission)	x
Chemical analysis	O	O	x	x
Small S/C weighing	O	O	x	x
Cleanliness monitoring	✓	✓	✓	✓
Fluid and gases delivery	✓	✓	✓	✓
Safety equipment	✓	✓	✓	✓
CSG site survey	O	O	x	x
Fit-check prior launch campaign	O	O	O	x

✓ Included as standard activities
O Option available at Customer request

Table 5.5.6a - Standard support service

5.6. Safety assurance

5.6.1 General

The safety objectives are to protect the staff, facility and environment during launch preparation, countdown and flight. This is achieved through preventive and palliative actions:

- Safety analysis based on the spacecraft safety submission;
- Safety constraints during hazardous operations, and their monitoring and coordination;
- Training and prevention of accidents;
- Coordination of the first aide in case of accident;
- For flight, short and long range flight safety analysis based on trajectory ground track.

CSG is responsible for the implementation of the Safety Regulations and for ensuring that these regulations are observed. All launches from the CSG require approvals from Ground and Flight Safety Departments. These approvals cover payload hazardous systems design, all transportation and ground activities that involve spacecraft and GSE hazardous systems, and the flight plan.

5.6.2 Safety submission

In order to obtain the safety approval, a Customer has to demonstrate that his equipment and its utilization comply with the provisions of the Payload Safety Handbook CSG-NT-SBU-16687-CNES, Edition 1, Revision 1 dated 06 May 2015. Safety demonstration is accomplished through several submission phases of documents defining and describing hazardous elements and their processing.

The hazardous items check list is given in Annex 1 to help the customer for the establishment of the submission files.

The typical time schedule for safety submissions is shown below:

Safety submission phases	Typical schedule
Phase 0 – Feasibility (optional) A Customer willing to launch a spacecraft containing innovating systems can obtain a safety advice from CSG through the phase 0 submission.	Before contract signature
Phase 1 - Design The submission of the spacecraft and GSE design and description of their hazardous systems. It shall cover component choice, safety and warning devices, fault trees for catastrophic events, and in general all data enabling risk level to be evaluated.	L – 22 m
Phase 2 – Integration and qualification The submission of the refined hardware definition and respective manufacturing, qualification and acceptance documentation for all the identified hazardous systems of the spacecraft and GSE. The submission shall include the policy for test and operating all systems classified as hazardous. Preliminary spacecraft operations procedures should also be provided.	L - 12 m

Phase 3 – Acceptance tests and hazardous operations The submission of the final description of operational procedures involving the spacecraft and GSE hazardous systems as well as the results of their acceptance tests if any.	L - 6 m
Approval of the spacecraft compliance with CSG Safety Regulation and approbation of the procedures for autonomous and combined operations.	Before S/C fuelling at latest

Table 5.6.2a - Safety submission phases

5.6.3 Safety measures during hazardous operations

The Small S/C authority is responsible for all spacecraft and associated ground equipment operations.

The CSG safety department representatives monitor and coordinate these operations for all that concerns the safety of the staff and facilities.

Any activity involving a potential source of danger is to be reported to the CSG safety department representative, which in return takes all measures necessary to provide and operate adequate collective protection, and to activate the emergency facilities.

Each member of the spacecraft team must comply with the safety rules regarding personal protection equipment and personal activity. The CSG safety department representative permanently verifies their validity and he gives the relevant clearance for the any hazardous operations.

In case the launch vehicle, the Small S/C or other passenger imposes crossed safety constraints and limitations, the Arianespace representatives will coordinate the respective combined operations and can restrict the operations or access to the spacecraft for safety reasons.

5.6.4 Safety training

The general safety training will be provided through video presentations and documents submitted to the Customer before or at the beginning of the launch campaign. At the arrival of the launch team at CSG a specific training will be provided with on-site visits and detailed practical presentations that will be followed by personal certification.

In addition, specific safety training on the hazardous operations, like fueling, will be given to the appointed operators, including operations rehearsals.

5.6.5 S/C inputs for flight safety submission

S/C fragmentation model for Micro, Mini and Nano S/C:

In order to demonstrate that the mission complies with the requirements of safety and French Space Operations Act, Arianespace computes the "casualty risk" (far range risk of casualty in case of launch failure) for every mission. This computation is fed by fragmentation models of each element (launcher structures, adapters and spacecraft). Accordingly, a fragmentation model of the spacecraft shall be supplied by Customer for Micro, Mini and Nano S/C, in accordance with Arianespace fragmentation model guidelines.

Cubesats Deployers reliability:

In order to demonstrate the absence of risks on the mission, Customer shall conduct the functional validation of the Deployers ahead of the launch campaign by tests or heritage and shall provide evidence of Deployers reliability at the latest at Flight Readiness Review (RAV).

5.7. Quality assurance

To achieve the highest level of reliability and schedule performance, the Arianespace's Quality Assurance system covers the launch services provided to Customer, and extends up to the launch vehicle hardware development and production by major and second level suppliers.

Arianespace quality rules and procedures are defined in the company's Quality Manual. This process has been perfected through a long period of implementation, starting with the first Ariane launches more than 40 years ago, and is certified as compliant with the ISO 9000 standard.

The system is based on the following principles and procedures:

A. Appropriate management system

The Arianespace organization presents a well-defined decisional and authorization tree including an independent Quality directorate responsible for establishing and maintaining the quality management tools and systems, and setting methods, training, and evaluation activities (audits). The Quality directorate representatives provide un-interrupted monitoring and control at each phase of the mission: hardware production, spacecraft-Launch vehicle compliance verification and launch operations.

B. Configuration management, traceability and proper documentation system

Arianespace analyses and registers the modifications or evolutions of the system and procedures, in order not to affect the hardware reliability and/or interfaces compatibility with spacecraft. The reference documentation and the rigorous management of the modifications are established under the supervision of the configuration control department.

C. Quality monitoring of the industrial activities

In complement to the supplier's product assurance system, Arianespace manages the production under the following principles: acceptance of supplier's Quality plans with respect to Arianespace Quality management specification; visibility and surveillance through key event inspection; approbation through hardware acceptance and non-conformance treatment.

5.8. Optional Services

The following Optional items and Services list is an abstract of the "Tailored and optional services list" available for the Customer:

For Mini/Micro/Nano S/C:

System engineering:

- Dedicated mission analysis (as necessary depending of Small S/C characteristics or criticalities).

Interface tests:

- For Mini/Micro/Nano S/C, fit-check (mechanical/electrical) with representative flight adapter at Customer's premises;

Range Operations:

- CSG site survey;
- Spacecraft and/or GSE transport to Kourou, using an Arianespace ship to transport the spacecraft and/or its associated equipment and propellant;
- Extra working shift;
- Campaign extension above contractual duration;
- Chemical analysis (gas, fluids and propellants except Xenon);
- S/C weighing.

Hardware:

- Procurement of dummy payload (for Mini/Micro/Nano S/C);

For Cubesats Deployers:

Interface tests:

- For Cubesats Deployer(s), Electrical Fit-check with representative launcher electrical equipment (MFU or sequencer unit).

Integration:

- Procurement of Deployer(s), integration of the Cubesats into the Deployer(s), support to Cubesats qualification.

APPLICATION TO USE ARIANESPACE'S LAUNCH VEHICLE (DUA) TEMPLATE — Annex 1

The Customer interested in a launch opportunity for a small spacecraft shall provide to ARIANESPACE the information described in the present annex.

The following Application to Use Arianespace's Launch Vehicle (DUA) template, tailored for Small S/C mission, will preferably be provided, duly completed, along with a Gantt-chart of S/C preparation schedule and a CAD model (*.stp format).
The customer can use a simplified template in MS Excel or a more complete version in MS Word. A more detailed updated version of the DUA might be provided after signature of the LSA, along with FEM and thermal models, when relevant.

A1.1. MS Excel format simplified DUA template

The simplified MS Excel Word version of the DUA template is provided hereafter. The reader can also find the template attached to the present pdf.

A1.2. MS Word format DUA template

The MS Word version of the DUA template is provided hereafter. The reader can also find the template attached to the present pdf.

1. Spacecraft description and mission summary

<table>
<tr><td>Manufactured by : TBD</td><td>Platform type : TBD</td></tr>
<tr><td colspan="2">DESTINATION
Earth Observation* Scientific* Meteorological* Navigation* Telecommunication* In Orbit Test/Demonstration* Others*</td></tr>
<tr><td>MASS
Total mass at launch TBD kg</td><td>LIFETIME
TBD years</td></tr>
<tr><td>OPERATIONAL ORBIT
a × e × inclination; ω; RAAN
PREFERRED INJECTION ORBIT
a × e × inclination; ω; RAAN</td><td>DIMENSIONS
Stowed for launch
H TBD mm L TBD mm W TBD mm
Deployed on orbit
H TBD mm L TBD mm W TBD mm</td></tr>
<tr><td colspan="2">PAYLOAD
Purpose & brief description of the instrument(s)</td></tr>
<tr><td colspan="2">COMMUNICATION SUB-SYSTEM
Frequency band for TM &TC, number of receivers/antennas and location</td></tr>
<tr><td colspan="2">PROPULSION SUB-SYSTEM
Brief description: chemical/electrical prop. system, type of propellant, number of tanks, number of thrusters,...</td></tr>
<tr><td colspan="2">ELECTRICAL POWER SUB-SYSTEM
Solar array description (L x W)
Beginning of life power TBD W
End of life power TBD W
Batteries description TBD (type, capacity)</td></tr>
<tr><td colspan="2">ATTITUDE CONTROL SUB-SYSTEM
Brief description: sensors description (Sun, Stellar, …), actuators description (momentum wheels, thrusters, …)</td></tr>
<tr><td colspan="2">GROUND STATION NETWORK
For LEOP phase: TBD
For operational phase: TBD</td></tr>
</table>

Note : * to be selected.

2. Spacecraft readiness schedule

2.1 Launch period

Provide targeted launch period/launch slot.

2.2 S/C main milestones

Provide a Gantt chart of the S/C design, manufacturing and tests schedule with the following main milestones:

- System PDR,
- System CDR,
- Start/end of manufacturing for each S/C subsystems (platform subsystems, instruments, …),
- Start/end of each S/C subsystems integration,
- Start/end of S/C integration,
- Start/end of S/C test campaign,
- Flight acceptance review (FAR).

2.3 Contents of the spacecraft development plan

The Customer will prepare a file containing all the documents necessary to assess the spacecraft development plan with regard to the compatibility with the launch vehicle.

It shall include, at least:

- spacecraft test plan: define the qualification policy, vibrations, acoustics, shocks, protoflight or qualification model,
- tests configuration (S/C representativeness, tests adapter, etc…),
- test facility location (Customer's or Manufacturer's facility),
- if any, necessary additional tests at the range.

3. Mission characteristics

3.1 Orbit description

Indicate preferred injection orbit parameters and, if different, the Spacecraft operational orbit.

Indicate the acceptable orbit dispersions (at 3 σ).

		Injection orbit at S/C separation	S/C operational orbit (when relevant)
Semi major axis	a	_____ ±_____ km	__________ km
Eccentricity	e	_____ ±_____	__________
Inclination	i	_____ ±_____ deg	_________ deg
Argument of perigee	ω	_____ ±_____ deg	_________ deg
Right Ascension of Ascending Node	RAAN	_____ ±_____ deg	_________ deg

3.2 Launch time / window

For SSO mission, provide the preferred Local Time of Ascending Node (LTAN).

For any other orbit, provide the preferred launch window (preferably in an electronic file, MS Excel). Constraints on opening and closing shall be identified and justified.

3.3 Preferred flight and separation conditions

3.3.1 Preferred separation conditions

Preferred separation mode and conditions

Indicate preferred separation mode (3-axis stabilized, low axial or transverse spin, etc...).

Indicate acceptable depointing, tip-off rates and relative velocity at separation.

Preferred separation attitude

Indicate the preferred orientation at separation.

For circular or nearly circular orbits, the desired orientation at separation should be specified by the Customer with respect to the following inertial reference frame [U, V, W] related to the orbit at S/C separation time, as defined below:

U = Radius vector with its origin at the center of the Earth, and passing through the intended separation point.
V = Vector perpendicular to U in the intended orbit plane, having the same direction as the orbit velocity.
W = Vector perpendicular to U and V to form a direct trihedron (right-handed system [U, V, W]).

For 3-axis stabilized separation mode, two of the three S/C axes [U, V, W] coordinates should be specified.

3.3.2 Preferred attitude during ascent phase, prior to S/C separation

If any, indicate any particular S/C attitude limitation (solar aspect angle constraints, spin limitation, etc…), applicable during the ascent phase and/or during the coast phases.

3.3.3 Any other preferred conditions

If any, indicate any other S/C limitations including:

- maximum aerothermal flux,
- flight duration,
- ground station visibility,
- etc…

3.4 Sequence of events after S/C separation

Describe the sequence of events after the S/C separation from the launcher, including:

- on-board computer switch-on,
- TM emitters switch-on,
- attitude control system switch-on,
- any deployments (solar generators, booms, etc…),
- propellant system priming, if any,
- etc…

4. Spacecraft description

4.1 Spacecraft systems of axes

Provide a description of spacecraft system of axes (please, include a sketch). The origin of the axes shall be in the mounting plane. The axes are noted Xs, Ys, Zs and shall form a right handed trihedron.

All the S/C data and models shall be given considering the same spacecraft system of axes, including S/C mass properties, CAD model, FEM model, etc…

4.2 Spacecraft geometry in the flight configuration

Provide a CAD model (*.stp format) of the spacecraft in flight configuration together with the associated drawings.

Additionally, provide:

- detailed dimensional data (including manufacturing tolerances, any MLI, electrical harness, …) for the S/C critical elements, that is the S/C closest parts to the fairing, carrying structure and adapter: solar array panels, deployment mechanisms, etc....
- detailed drawings of the interface with adapter, with manufacturing tolerances, refer to §4.6 below.

4.3 Spacecraft mass properties

Provide the S/C nominal mass properties and associated dispersion (Min/Max) in launch configuration.

	Mass (kg)	**C of G coordinates (mm)**			**Coefficients of inertia Matrix (kg. m²)**					
	M	X_G	Y_G	Z_G	I_{xx}	I_{yy}	I_{zz}	P_{xy}	P_{yz}	P_{zx}
Nominal										
Tolerance					Min/Max	Min/Max	Min/Max	Min/Max	Min/Max	Min/Max

Notes:

- Center of Gravity coordinates are referenced in the spacecraft coordinate system. The origin is the geometrical center of the separation plane.
- Moments of Inertia are referenced in the spacecraft coordinate system where the origin is at the Center of Gravity of the spacecraft.
- Products of Inertia are calculated by the following equation: $Pxy = +\int xy \, dm$.

In the case the adapter is supplied by the Customer, provide also mass properties of spacecraft with adapter, and mass properties of adapter alone just after separation.

4.4 Fundamental modes

Indicate fundamental modes (lateral, longitudinal) of spacecraft hardmounted at interface.

4.5 Propellant/pressurant characteristics

If any, provide the propellant and pressurant tanks description, and if relevant, propellant sloshing characteristics:

Propellant tanks			#1	…
Propellant				
Density		(kg/m^3)		
Tank volume		(l)		
Fill factor		(%)		
Liquid volume		(l)		
Liquid mass		(kg)		
Center of gravity of propellant loaded tank		Xs		
		Ys		
		Zs		
Slosh model under 0 g	Pendulum mass	(kg)		
	Pendulum length	(m)		
	Pendulum attachment point	Xs		
		Ys		
		Zs		
	Fixed mass (if any)			
	Fixed mass attachment point (if any)	Xs		
		Ys		
		Zs		
	Natural frequency of fundamental sloshing mode (Hz)			
Slosh model under 1 g	Pendulum mass	(kg)		
	Pendulum length	(m)		
	Pendulum attachment point	Xs		
		Ys		
		Zs		
	Fixed mass (if any)			
	Fixed mass attachment point (if any)	Xs		
		Ys		
		Zs		
	Natural frequency of fundamental sloshing mode (Hz)			

Pressurant Tanks			#1	…
Pressurant				
Volume	(l)			
Loaded mass	(kg)			
Center of gravity (mm)		Xs		
		Ys		
		Zs		

4.6 Mechanical interfaces

Arianespace proposes a series of standard adapters for Small Satellites, provided by Arianespace. It comprises the so-called passive ring (which remains attached to the Small S/C) and the so-called active ring with the separation and distancing system (which remains attached to the LV).

Interface geometry:

Provide a drawing with detailed dimensions and nominal tolerances showing:

- The spacecraft rear panel;
- Any equipment in close proximity to the separation plane (thrusters, antennas, MLI, etc…);
- Umbilical connector preferred location.

Interface material description:

For each spacecraft mating surface in contact with the launcher adapter indicate material, flatness, surface coating and grounding.

In addition, in the frame of the launch preparation, the customer will be asked to provide evidences that the S/C rear panel meets the mechanical interface requirements, including a report with the geometric measurements of the S/C as-built rear panel.

4.7 Electrical interfaces

Provide the following:

- The location of the spacecraft ground potential reference on the spacecraft interface frame;
- If any, data link requirements on ground (baseband and data network) between spacecraft and EGSE;
- Definition of umbilical connector(s) and links in a table form (preferably in an electronic file, MS Excel):

S/C connector pin allocation number	Function	Max voltage (V)	Max current (mA)	Expected one way resistance (Ω)
1 2 3 …				

Note 1: Even if no umbilical links is required, one connector shall be present to ensure electrical continuity and S/C separation detection on S/C side.

Note 2: In case trickle charge is not possible through umbilical lines, the S/C battery charge operating life shall be at least 45 days after last battery charge and S/C integration on the carrying system.

4.8 Radioelectrical interfaces

4.8.1 S/C Telecommunication sub-system(s) general description

Provide the S/C Telecommunication system(s) main characteristics:

- description of S/C telemetry (TM) and telecommand (TC) systems;
- description of TM et TC antennas, antenna location, and antenna pattern;
- for information, brief description of payload telecommunication system(s).

4.8.2. Spacecraft ground station network

Provide the list of ground station to be used for spacecraft acquisition and early operations after S/C separation from the launcher.

4.8.3 Spacecraft telemetry (TM) and telecommand (TC) systems

Provide a detailed description of spacecraft telemetry (TM) and telecommand (TC) systems (preferably in an electronic file, MS Excel):

Source unit designation		Tx1		Tx…		Rx1		Rx…	
Function									
Band									
Carrier Frequency, F_0 (MHz)									
Bandwidth centered around F_0	-3 dB								
	-20 dB								
	-60 dB								
Carrier Modulation	Type								
	Index								
	Bit rate								
Sub Carrier (MHz)									
Minimum S/N (dB) associated bandwidth (MHz)									
Local Oscillator Frequency (MHz)									
1st intermediate Frequency (MHz)									
2nd intermediate Frequency (MHz)									
Field strength at antenna, receive (dBW/m^2)	Max								
	Nom								
	Min								
RF Output Impedance (Ohm)									
Lower Power mode availability (Yes/no)									
Antenna designation		Horn	Omni			Horn	Omni		
Antenna	Type Location X,Y,Z Pattern Gain max (dBi)								
EIRP: Output power (dBW)	Max								
	Nom								
	Min								
Antenna Input power (dBW)	Max								
	Nom								
	Min								

4.8.3 Radio link on ground & Transmission Plan

If any, provide the radio link needs between spacecraft, spacecraft check-out system and PPF facility.

Provide the spacecraft transmission plan as shown in table below:

Source unit description	Tx1	Tx...	Rx1	Rx…
Function	TBD		TBD	
During preparation on launch site (PPF)	TBD		TBD	
During HPF activities, if any	OFF		OFF	
Countdown before H0-1H30mn	OFF		OFF	
After H0–1H30mn until TBDs after separation*	OFF		OFF	
In orbit (or in transfer orbit)	TBD		TBD	

* Actual delay will be determined in the frame of mission analysis.

4.9. Other S/C characteristics

Provide any other S/C characteristics and/or limitations, if any, including:

- If any, contamination constraints and contamination sensible surfaces;
- Maximum ascent depressurization rate and differential pressure;
- Temperature and humidity limits during launch preparation and flight phase;
- If available, S/C electrical field susceptibility levels and S/C sensitivity to magnetic fields.

5. Operational requirements

5.1 Provisional range operations schedule

Provide list of main operations, with description and estimated timing. Identify all hazardous operations.

5.2 Facility requirements

For each facility needed for spacecraft preparation (PPF, HPF) provide:

- Main operations list and description
- Surface area needed for spacecraft, GSE and Customer offices
- Environmental requirements (Temperature, relative humidity, cleanliness)
- Power requirements (Voltage, Amps, # phases, frequency, category)
- RF and hardline requirements
- Support equipment requirements
- GSE and hazardous items storage requirements

5.3 Communication needs

For each facility needed for spacecraft preparation (PPF, HPF), provide need in telephone, facsimile, data lines, time code etc.

5.4 Handling, dispatching and transportation needs

Provide:

- Estimated packing list with indication of designation, number, size (L x W x H in m) and mass (kg)
- Propellant transportation plan (including associated paperworks), if any
- A definition of the spacecraft container and associated handling device (constraints)
- A definition of the spacecraft lifting device
- A definition of spacecraft GSE (dimensions and interfaces required)
- Dispatching list

5.5 Others

5.5.1 Remove-before-flight items

In case late access (that is access after integration of the S/C on the carrying system) is needed to remove some non-flight items (covers, etc…), provide a CAD model of each remove-before-flight item, and a description of the operations and associated ground equipment, if any.

5.5.2 List of fluids

Indicate type, quality, quantity and location for use of fluids to be supplied by Arianespace.

5.5.3. Chemical and physical analysis to be performed on the range

Indicate for each analysis: type and specification.

5.5.4. Safety garments needed for propellants loading

Indicate number.

5.5.5. Technical support requirements

Indicate need for workshop, instrument calibration.

5.5.6. Security requirements

If any, provide specific security requirements.

5.6. Documentation: Contents of Spacecraft Operations Plan (POS)

The Customer will be asked to provide a Spacecraft Operations Plan which will define the operations to be executed on the spacecraft from arrival at the CSG, at the launch site, and up to the launch.

A typical content is presented here below:

1. General
   - 1.1 Introduction
   - 1.2 Applicable documents
2. Management
   - 2.1 Time schedule with technical constraints
3. Personnel
   - 3.1 Organizational chart for spacecraft operation team in campaign
   - 3.2 Spacecraft organizational chart for countdown
4. Operations
   - 4.1 Handling and transport requirements for spacecraft and ancillary equipment
   - 4.2 Tasks for launch operations (including description of required access after integration on carrying structure and/or fairing encapsulation)
5. Equipment associated with the spacecraft
   - 5.1 Brief description of equipment for launch operations
   - 5.2 Description of hazardous equipment (with diagrams)
   - 5.3 Description of ground equipment (when in PPF, HPF, and Launch Pad)
6. Installations
   - 6.1 Surface areas
   - 6.2 Environmental requirements
   - 6.3 Communications
7. Logistics
   - 7.1 Transport facilities
   - 7.2 Packing list

6. Safety aspects

6.1. S/C hazardous systems and operations

Provide a list of:

- the S/C hazardous system (propellant, electro-pyrotechnic devices, batteries, laser, ionizing sources, etc…)
- the intended hazardous activities for S/C preparation during S/C launch campaign at CSG (S/C handling, propellant loading, battery charging, deployment tests, etc…)

6.2. Safety submission

The Customer will be asked to provide Safety files for safety submissions, according to Payload Safety Handbook CSG-NT-SBU-16687-CNES. These files will contain a description of the hazardous systems and operations and will respond to all questions on the hazardous items check list given in the Payload Safety Handbook here below:

A1	Solid-propellant engine
A2	Ignition module, safe and arm unit, command and control circuits
A3	Corresponding ground segment equipment and operations
B1	Electro-pyrotechnic devices - Compliance
B2	Command and control circuit
B3	Corresponding ground segment equipment and operations
C1	Monopropellant propulsion system
C2	Valve command and control circuit
C3	Corresponding ground segment equipment and fuelling equipment
AC1	Bipropellant propulsion system
AC2	Valve command and control circuit
AC3	Corresponding ground segment equipment and fuelling equipment
D1A	Non-ionizing radiation
D2A	Optical systems
D3A	Lasers
D1B	Batteries and electrical systems
D2B	Command and control
D3B	Corresponding ground segment equipment
D1C	Fluids and gases other than propellant – Cryogenic products
D2C	Command and control
D3C	Corresponding ground segment equipment
D1D	Mechanical and electromechanical equipment, structures, transport and handling equipment
D2D	Equipment and other systems
D1E	Ionizing radiation – Flight sources
D3E	Ionizing radiation – ground segment equipment
O	Documentation
GC	Miscellaneous

7. Miscellaneous

Provide any other specific requirements for the mission or S/C preparation.

Provide a list of acronyms and symbols with their definition.

STANDARD ADAPTERS FOR MINI / MICRO / NANO S/C — Annex 2

Several standard off-the-shelf adapters are available ensuring interfaces between the launcher and the Mini, Micro or Nano S/C. They are provided by RUAG Space from Sweden and/or PSC (Planetary Sciences Corporation) from USA. They comprise the so-called passive ring (which remains attached to the Small S/C) and the so-called active ring with the separation and distancing system (which remains attached to the LV). The S/C – adapter interface is a bolted interface, for which the number of attachments depends on the adapter diameter.

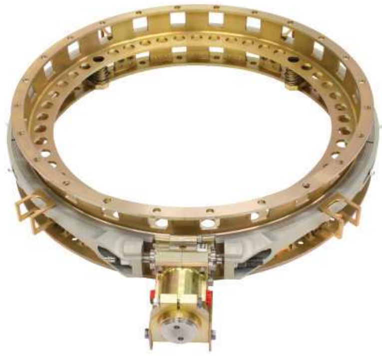
RUAG Space PAS adapters:

The family of low shock adapters from RUAG Space Company uses a down-scaled version of the existing clamp band and CBOD of the larger adapters used for Ariane, Vega-C and Soyuz passengers. They consist of the adapter structure, the clamp band assembly together with its bracket set, the separation spring set and umbilical bracket attached to the structure. The available clamp band diameters are 381 mm (15 inches) and 610 mm (24 inches).

PSC MLB MkII adapters:

The MLB MkII family from PSC offers a large range of diameters. The most commonly uses are: 24 inches (610 mm), 15 inches (381 mm), 13 inches (330 mm), 11,732 inches (298 mm), 8 inches. The separation system is composed of a retaining ring, leaves, spring plungers and motors which allows to retract the leaves when the motors are powered and of up to 16 springs for MLB 11.732'' or up to 24 springs for MLB 13'' or larger.

A2.1 RUAG PAS 381 S (15'') Separation System



The PAS 381 S is designed and qualified to support a payload of 200 kg centered at 0.5 m from the mouting plane.

The PAS 381 S is composed of two parts:

- Spacecraft Ring Assembly (so-called passive ring)
- PAF 381S (so-called active ring with the separation and distancing systems)

The Spacecraft Ring upper interface towards the spacecraft has a 381 mm diameter bolted interface with 24 holes for ¼-inch bolts.

The PAF 381 S itself is mainly composed of:

- A monolithic aluminum structure with a diameter of 381 mm at the level of the separation plane
- A clamp band assembly with a Low Tension Clamp Band Opening Device (CBOD-LT)
- A set of actuators (4 to 24)

Clamp Band release is obtained thanks to a pyrotechnically initiated Low Tension Clamp Band Opening Device (CBOD-LT). The CBOD-LT is specially designed to generate low shock levels.

The clamp band pretension is 11 kN. A set of 4 catchers secures a safe behavior and parks the clamp band on the adapter.

The spacecraft is forced away from the launch vehicle by up to 24 actuators.

The typical mass of the PAF 381 S (remaining attached to the launcher) is 2.7 kg. The typical mass of the passive ring (remaining attached to the spacecraft) is 1.0 kg

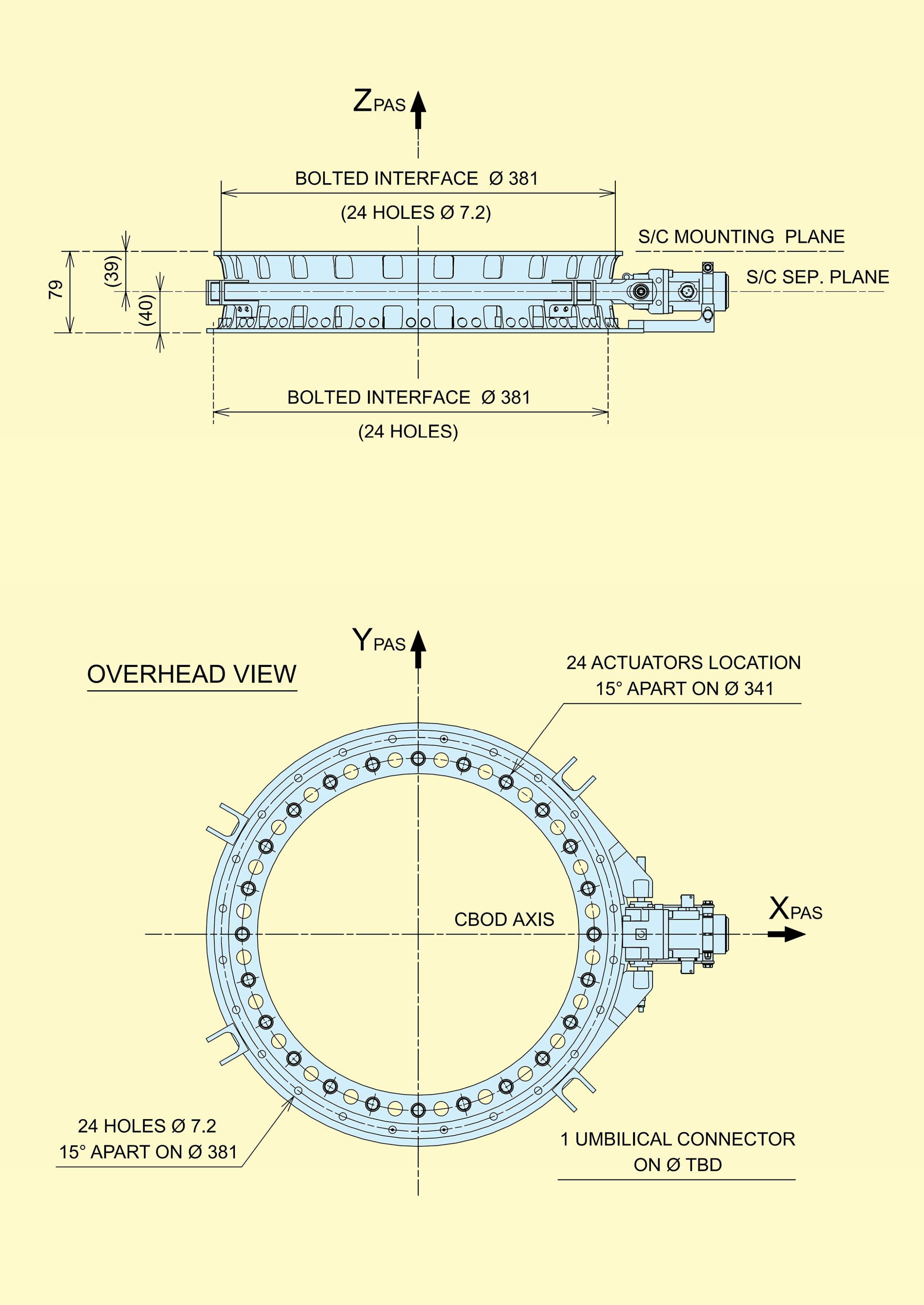


Figure A2.1a: PAS 381 S – General view

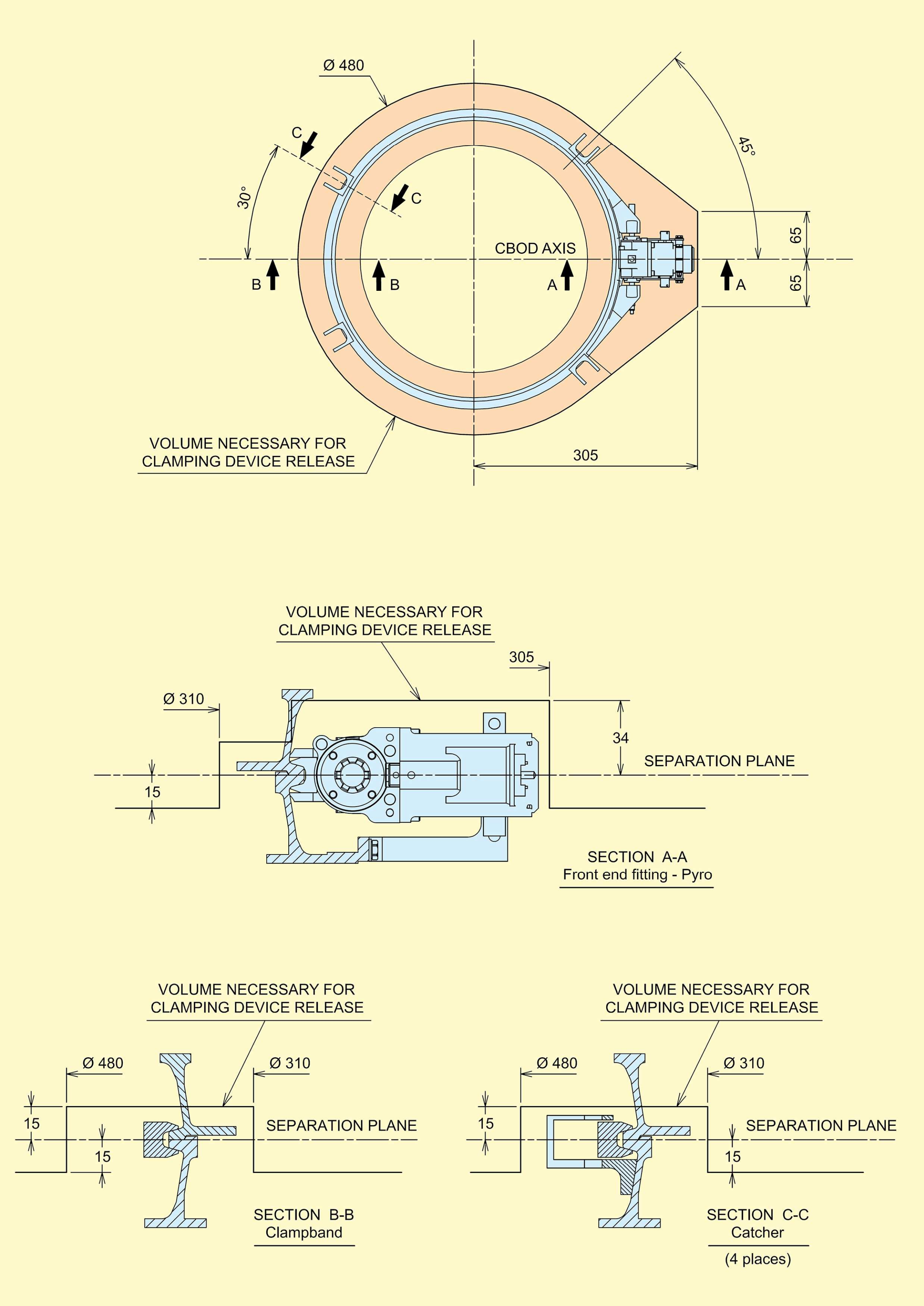
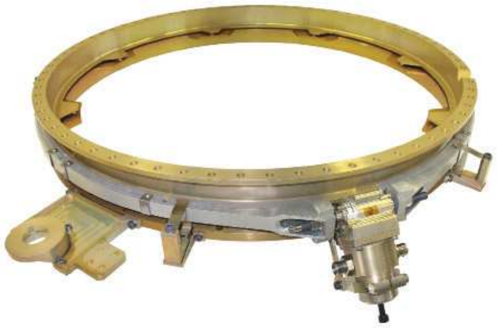


Figure A2.1b: PAS 381 S – Stay-out zone

A2.2 RUAG PAS 610 S (24'') Separation System

The PAS 610 S is designed and qualified to support a payload of 400 kg centered at 0.7 m from the mounting plane.



As the PAS 381 S, the PAS 610 S is composed of two parts:

- Spacecraft Ring Assembly (so-called passive ring)
- PAF 610 S (so-called active ring with the separation and distancing systems)

The Spacecraft Ring upper interface towards the spacecraft has a 609.6 mm diameter bolted interface with 36 holes for ¼-inch bolts.

The PAF 610 S itself is mainly composed of:

- A monolithic aluminum structure with a diameter of 610 mm at the level of the separation plane
- A clamp band assembly with a Low Tension Clamp Band Opening Device (CBOD-LT)
- A set of actuators (4 to 8)

The spacecraft is secured to the adapter interface frame by the clamp band assembly. The clamp band consists of a band with one connecting point. The tension applied to the band provides pressure on the clamp which attaches the satellite to the launcher. Release is obtained thanks to a pyrotechnically initiated Low Tension Clamp Band Opening Device (CBOD-LT). The CBOD-LT is specially designed to generate low shock levels.

The clamp band pretension is 15 kN and the corresponding maximum tension (in flight) is 19.4 kN. A set of 5 catchers secures a safe behavior and parks the clamp band on the adapter.

The spacecraft is forced away from the launch vehicle by up to 8 actuators.

The force exerted on the spacecraft by each spring does not exceed 195 N. If necessary, the stroke of each spring can be limited in order to tune the energy provided by each spring, allowing counteracting the effect of spacecraft nominal static unbalance at spacecraft separation.

The typical mass of the PAF 610 S (remaining attached to the launcher) is 4.8 kg. The typical mass of the passive ring (remaining attached to the spacecraft) is 1.0 kg.

TBD

Figure A2.2a: PAS 610 S – General view

TBD

Figure A2.2b: PAS 610 S – Stay-out zone

A2.3 PSC Mk II MLB series

The MkII Motorized LightBand (MLB) separation system is offered with a large range of diameters from 8 to 38 inches bolt circle.

The most common dimensions are:
- MLB 24'' for MiniS/C,
- MLB 15'' or 13'' for MicroS/C,
- MLB 11,732'' or 8'' for NanoS/C.

Carrying capability and main characteristics of the MLB separation systems depend on the size

Refer to PSC 2000785G MkII MLB User Manual for more details.

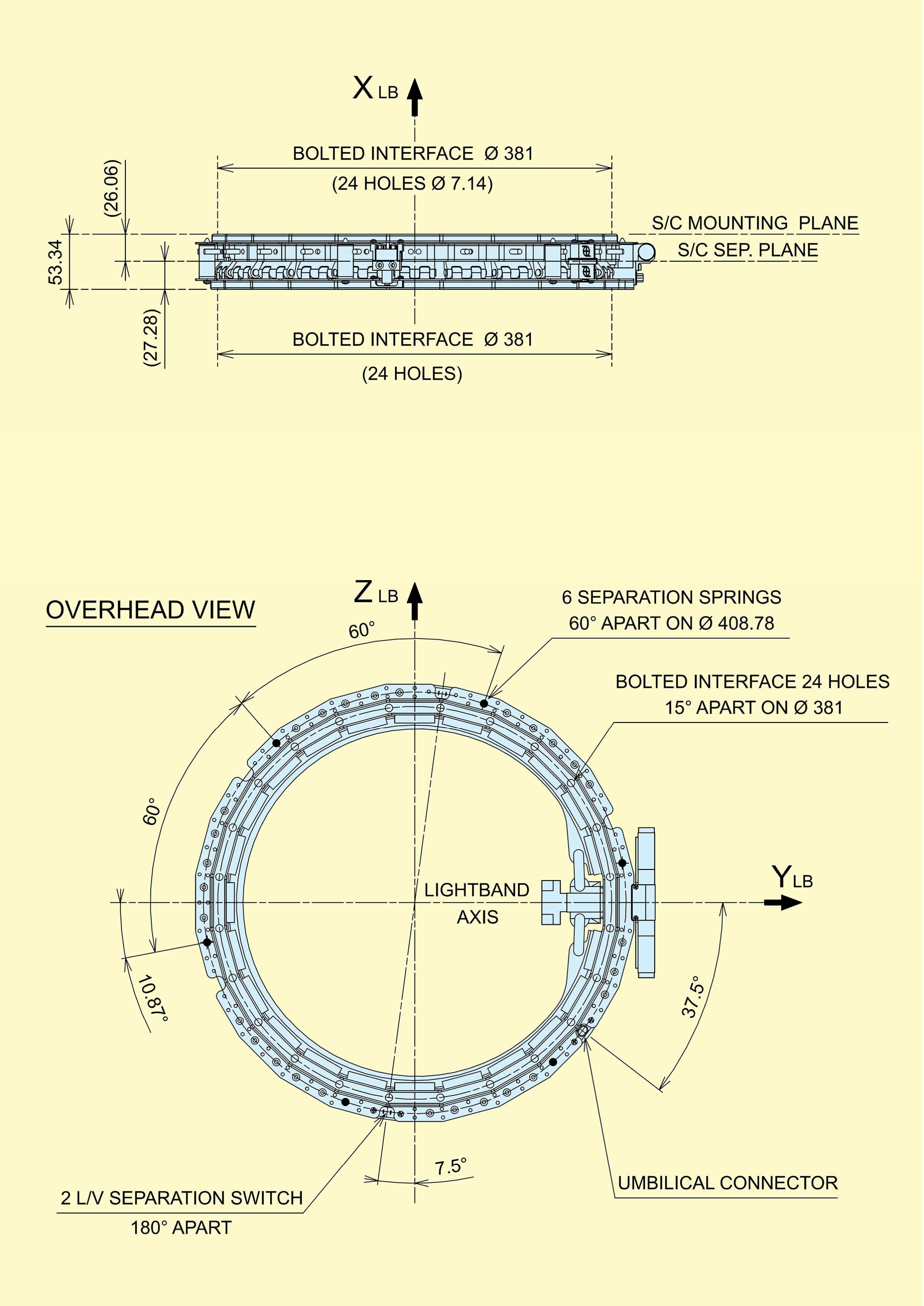


Figure A2.3a: MkII MLB – General view (15'' case)

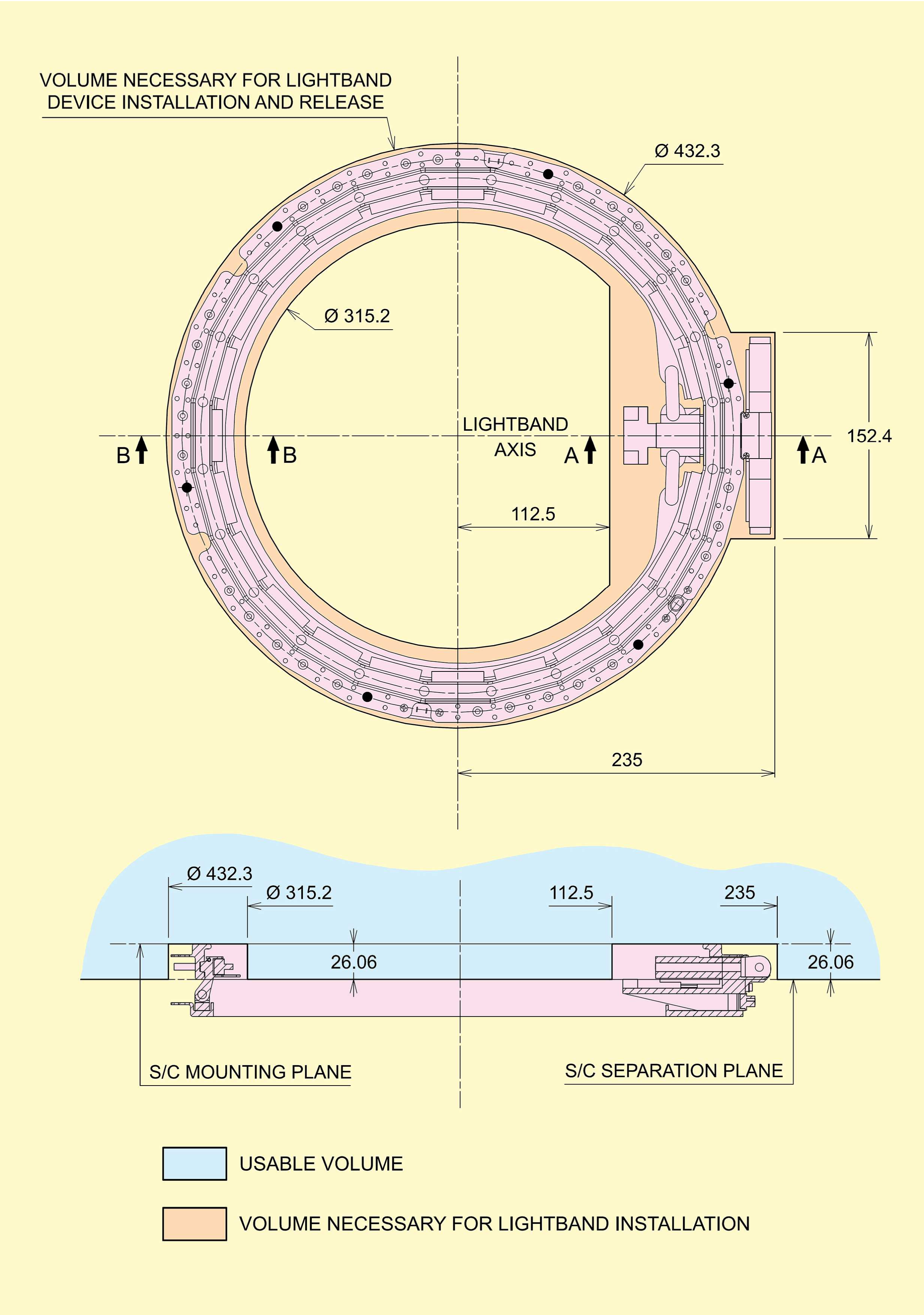


Figure A2.3b: MkII MLB – Stay-out zone (15'' case)

DESCRIPTION of SAB AEROSPACE FACILITIES in BRNO — Annex 3

A3.1. Introduction

SAB Aerospace offices and facilities are located in Continental Europe, in Brno, Czech Republic. They are dedicated to Cubesat Deployers integration on the SSMS Hexa module. NanoSatellites without any hazardous propellant can also be integrated there.

These facilities have been inaugurated in April 2018.

Once ready and checked, the SSMS Hexa module, fully equipped with the Cubesats Deployers, with the NanoSatellites if any, and with all necessary electrical equipment and harnesses, is transferred to the Guiana Space Center in Kourou where the full stack with bigger S/C is finalized and encapsulated.

This integration flow offers to Cubesat Deployers and NanoSatellites Customers a simplest, more convenient way for their launch preparation campaign.

Figure A3.1 – SAB Aerospace s.r.o. – Office building & Integration facility

The SAB Aerospace facilities accessible to customers comprise:

- Payload storage area (ISO 8 clean room),
- Assembly and integration area (ISO 8 clean room),
- Offices area for customer.

The facilities are designed to allow simultaneous operations with several Customers at the same time. Some other areas are dedicated to SAB Aerospace personnel.

The characteristics of these preparation facilities are summarized in the Table A3.1 here below.

Area/Operations	Composition	Height	Cleanliness	T (°C) / RH (%)
S/C Storage	• 1 clean hall – 38 m²	2.5 m	100 000 ISO 8	21.0 ± 2.0 °C / 55 ±10 %
Assembly and integration	• 1 clean hall – 140 m²	6 m	100 000 ISO 8	21.0 ± 2.0 °C / 55 ±10 %
	• 1 intermediate hall – 78 m²	6 m	*	*
	• 1 airlock – 55 m²	6 m	-	-
Office area	• 1 hall – 240 m²	2.5 m	-	-

* This intermediate hall is normally a grey area, it can be raised to clean room standards if necessary.

Table A3.1 – Description of Small S/C preparation facilities in SAB Aerospace

A3.1.1. Assembly and Integration area

The main characteristics of the Assembly and Integration area are:

- surface 140 m²
- usable height 6m,
- 2T lifting crane.

Some private booths are available to perform standalone operations: size are 2 per 2.5 m or 3 per 2.5 m; fully equipped with table, power supply, ESD wipes, ESD Wrist band, etc …

The adjacent areas are:

- Intermediate hall (grey area) 78 m², height 6m,
- Airlock 55 m², height 6m.

Manual forklift (max weight 2T) and manual crane (max weight 1T) are available for handling.

Figure A3.1a – SAB Aerospace facilities - Assembly and integration area

Figure A3.1b – Booths

A3.1.2. S/C storage area

The main characteristics of the S/C storage area are:

- surface 38 m^2,
- usable height 2.5m.

Figure A3.1c – SAB Aerospace facilities – S/C storage Area

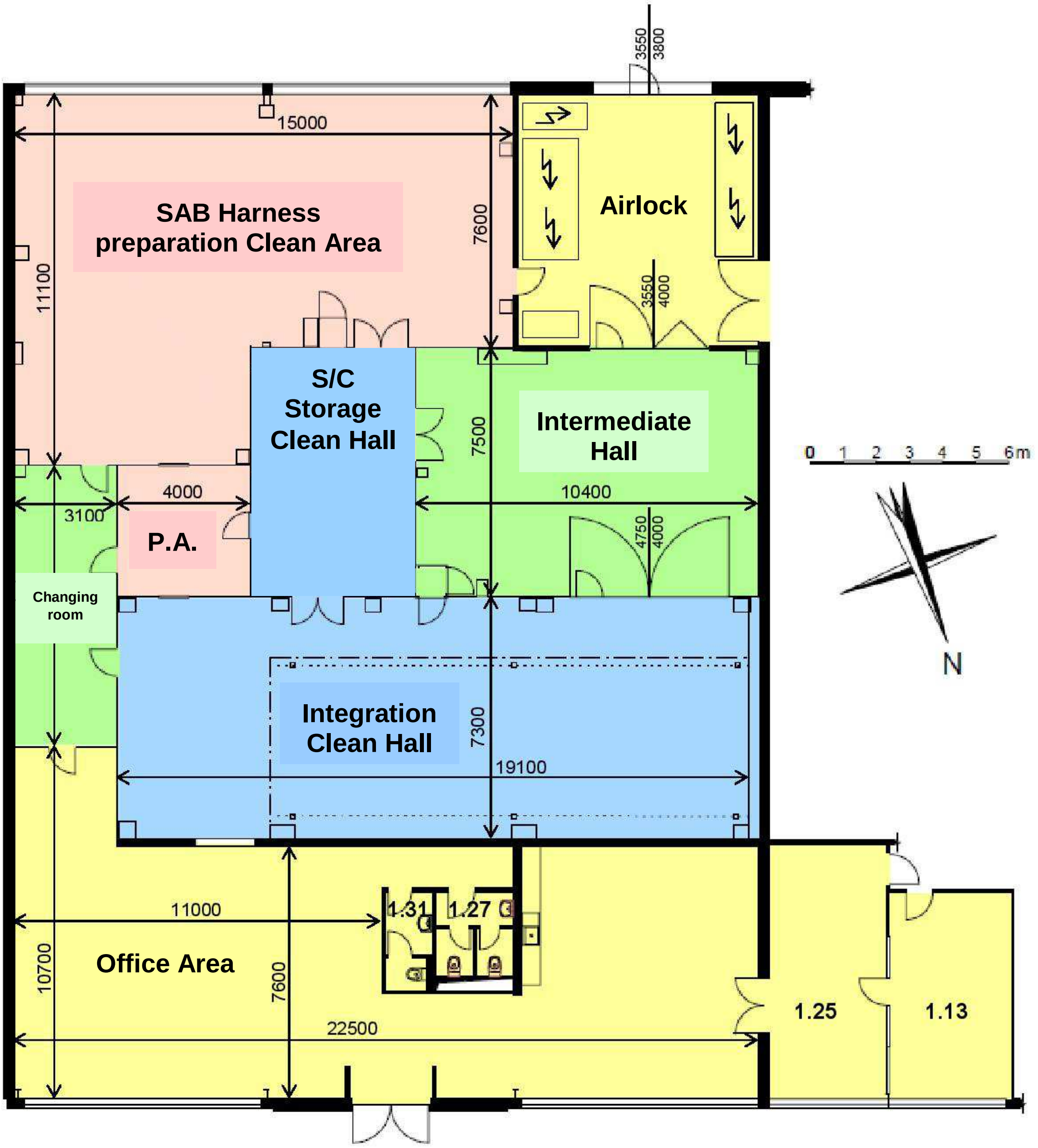
A3.1.3. Office area

The main characteristics of the Office area are:

- surface 240 m^2,
- usable height 2.5m.

Figure A3.1d – SAB Aerospace facilities – Office Area

A3.2. Facility Layout



Clean Areas

Intermediate Grey Areas

Ordinary Areas

SAB Clean Areas

Figure A3.2 – Layout of SAB Aerospace facilities

A3.3. Support Services

Full services during payload processing and integration are provided at SAB facility:

- Assembly & integration area provides all the necessary lifting equipment to allow integration of the Cubesat Deployers or NanoS/C on the carrying system (SSMS Hexagonal base module);
- The clean hall environment is controlled with continuous monitoring of temperature, pressure, hygrometry, particulate contamination;
- The following fluids are provided: pressurized air, gaseous Nitrogen, gaseous Oxygen;
- The electrical power supply comprises interrupted 230 V / 50 or 60Hz and 380 V / 50 or 60Hz supply.

A3.4. Security

The security measures include:

- Access badges are necessary to enter the facility and clean rooms / grey areas. They are delivered to Customer against signature.
- A camera system monitors the clean rooms and changing room, the grey areas, the SAB area (harness preparation) as well as the facility surroundings.

A3.5. Transportation

For Customer hardware delivery, the facility is easily accessible by trucks, via the European dense network of Highways.

For non-European Customers, hardware can be shipped via regular planes to Vienna or Prague airports, about 1,5 or 2 hours drive distance from SAB facility.

A3.6. Custom

A customs bonded warehouse is available in the Integration Clean Hall and Intermediate Hall. Imported dutiable merchandise can be stored, manipulated or undergo manufacturing operations without payment of duty for up to 5 years from the date of importation. This ease preparation of the customs documentation for non-European satellites.

A3.7. Personnel transportation & accommodation

Customer personnel can reach SAB Aerospace facilities by plane, via Vienna or Prague airports, and then by direct train or bus or rental car. The duration of the transfer from Vienna or Prague airports to SAB facility is around 1,5 to 2 hours.

SAB can also organize the transfer.

There are many international class hotels with all the necessary equipment in Brno downtown.

VEGA SSMS Proof of Concept MISSION & SMALL S/C LAUNCH RECORD — Annex 4

The Small S/C Customer on Vega-C will benefit of Arianespace's experience in processing Small S/C and in launching multiple configurations, gained successively on Ariane 4, Ariane 5, Soyuz from CSG and Vega.

The present annex describes:
- the payload configuration for the Proof of Concept Small S/C rideshare mission on Vega with 53 Small S/C (VV16, which successfully took place on 02 Sept. 2020) and,
- the Small S/C track record on Vega (as of Sept. 2020 after VV16).

A4.1. VEGA SSMS Proof of Concept MISSION

The SSMS PoC Rideshare mission on Vega embarks a total of 53 Small S/C:
- 7 Micro and NanoS/C on the top central column, deck#1 (towers) and deck#2 (main deck),
- 46 Cubesats in Deployers located on the hexagonal module.

Position	Quantity	Customer	Project	Country	Interface	Mass (kg)
Top	1	SPACEFLIGHT	SFL1	USA	MLB 15''	138
Deck #1	1	SPACE-SI	NEMO-HD	SLO	MLB 11,732''	60
Deck #1	1	ESA (for UPM)	UPMSAT-2	EU	MLB 13''	45
Deck #1	1	SFL	GHGSAT-C1	CAN	4 bolts	33
Deck #2	1	D-ORBIT Srl	IN ORBIT NOW Mk1	ITA	MLB 13''	145
Deck #2	1	SPACEFLIGHT	SFL2	USA	MLB 13''	43
Deck #2	1	ESA / ExactEarth	ESAIL SAT-AIS	EU	MLB 15''	112
Hexa	4 x 12U Deployers	SPACEFLIGHT (14 x Flock 4V for Planet Lab & 12 x Spacebee for Swarm Technologies)	ISIS Quadpack	USA	8 bolts	118
Hexa	2 x 12U Deployers	SPIRE (8 x Lemur-2)	ASTROFEIN PSL-P	USA	16 bolts	60
Hexa	1 x 12U Deployer	ISL (NAPA-1 & TARS)	ISIS Quadpack	NL	8 bolts	30
Hexa	1 x 12U Deployer	SAB LS (TRISAT, DIDO-3, SIMBA, PICASSO)	ISIS Quadpack XL	EU	8 bolts	25
Hexa	1 equ. 12 U deployer	D-ORBIT Srl (FSSCAT-A & FASSCAT-B)	Stack of two Tyvak DS-6U with bracket	EU	6 bolts	33
Hexa	1 equi. 12U deployer	TYVAK (Tyvak-0171 & OSM-1 CICERO)	Stack of two Tyvak DS-6U with bracket	USA	6 bolts	36
Hexa	2 Deployers	SAB LS (TTU100 & AMICal SAT)	ISIS Isipod 1U & ISIS Isipod 2U	EU	4 bolts	15

Table A4.1a – VV16 – SSMS PoC mission on Vega – Upper part configuration

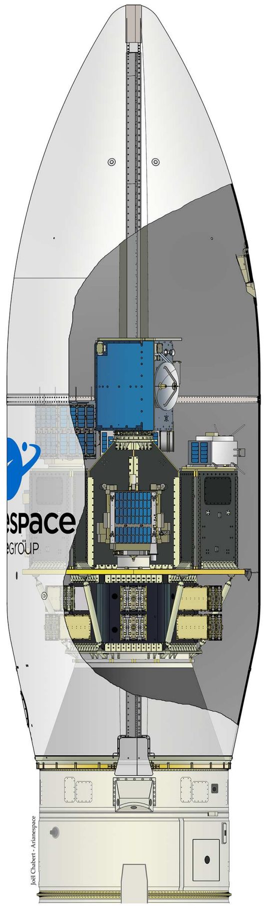


Figure A4.1a – VV16 flight preparation - SSMS PoC mission on Vega

A4.2. VEGA SMALL S/C LAUNCH RECORD

As of Sept. 2020, the Small S/C track record on Vega is as follows:

SMALL S/C LAUNCH RECORD ON VEGA

SATELLITE	FLIGHT	LAUNCH DATE	LAUNCHER VERSION	CUSTOMER	COUNTRY	MISSION	MASS	ORBIT
ALMASat 1	VV 01	13/02/2012	VEGA	University of Bologna	Italy	TECHNO	12,5	SSO
e-st@r			VEGA	Politecnico di Torino	Italy	TECHNO	1	LEO
Goliat			VEGA	University of Bucharest	Romania	TECHNO	1	LEO
MaSat 1			VEGA	Budapest University of Technology and Economics	Hungary	TECHNO	1	LEO
PW-Sat 1			VEGA	Warsaw University of Technology	Poland	TECHNO	1	LEO
ROBUSTA			VEGA	University of Montpellier II	France	TECHNO	1	LEO
UniCubeSat-GG			VEGA	GAUSS (La Sapienza University of Rome)	Italy	TECHNO	1	LEO
XaTcobeo			VEGA	INTA, Universidade de Vigo	Spain	TECHNO	1	LEO
VNREDSat-1	VV02	07/05/2013	VEGA	Vietnamese Academy of Science and Technology (VAST)	Vietnam	EARTH OBS.	115	SSO
ESTCube 1			VEGA	National University of Tartu / Estonian Space Office	Estonia	TECHNO	1	SSO
PERUSAT-1	VV07	16/09/2016	VEGA	AIRBUS DS	Peru	EARTH OBS.	430.5	SSO
SKYSAT GEN2-2				Terrabella	USA	EARTH OBS.	109.5	SSO
SKYSAT GEN2-3				Terrabella	USA	EARTH OBS.	109.5	SSO
SKYSAT GEN2-4				Terrabella	USA	EARTH OBS.	109.5	SSO
SKYSAT GEN2-5				Terrabella	USA	EARTH OBS.	109.3	SSO
VENuS	VV10	02/08/2017	VEGA	CNES	France	EARTH OBS.	264.5	SSO

Table A4.2a – Vega Small S/C launch record