VEGA C
USER'S MANUAL

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Vega C User’s Manual

Issue 1 Revision 0

September 2025

Preface

This User's Manual provides essential data on the Vega C launch system, which is necessary:

- To assess compatibility of a spacecraft and spacecraft mission with Vega C launch system,
- To constitute the general launch service provisions and specifications, and
- To initiate the preparation of all technical and operational documentation related to a mission on Vega C launch vehicle.

Inquiries concerning clarification or interpretation of this manual should be directed to Avio's Launch Service Provider Branch in Paris.at the French address listed below. Comments and suggestions on all aspects of this manual are encouraged and appreciated.

As reference, Avio is operating its activities from the following addresses:

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This document will be revised periodically. In case of modification introduced after the present issue, the updated pages of the document will be provided on Avio's website (www.avio.com) before the next publication.

Foreword

Avio: lifting off space assets since 60 years

Focused on Customer needs

Avio is a commercial and industrial company providing complete, personalized launch services, covering the entire period from initial formulation of the project with the customer and its satellite manufacturer, up to the launch.

Thanks to its control on the Vega C value chain, from production to launch operation and program management, Avio is able to provide reliable and flexible lift capabilities to its customers.

Avio combines low risk and flight-proven launch system with financing, insurance and back-up services to craft tailor-made solutions for start-ups and established players.

With our Launch Service Provider office in Europe and our state-of-the-art launch facilities in French Guiana, Avio is committed to forging service packages that meet Customer's requirements.

An experienced and reliable company

Avio has been established in the early years of the 20th century to manufacture ammunition. Building on its expertise in gun powder, the company later specialized in solid propulsion motors for missile and space launchers.

On the defense side, Avio has produced over 150,000 Solid Rocket Motors over the past 60 years for both US and European missile systems. Throughout Avio's entire history, no failures during operation has been recorded for its missile propulsion systems.

Avio has been a partner and key supplier of the European Space programs since its beginning in the 1970s by delivering the first-stage strap-on boosters of the Ariane-family of launchers and being the prime contractor of the Vega-family of launchers. Lately, the company has taken over the responsibility of commercializing and operating the Vega C launcher, which it was already producing and integrating at the European Space Center in Kourou.

As of September 2025, Avio has contributed to lift off more than 260 Ariane and 27 Vega-family launchers.

Configuration control sheet

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1 / 0	**September 2025**	First issue (as Avio Launch Service Provider)	C. Dupuis / X. Lansel

Approvals

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1 / 0	**September 2025**	Marino Fragnito CCO & Launch Services Director	Giulio Ranzo CEO

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Appendixes:

Acronyms, abbreviations and definitions

ω_p	*Argument of perigee*	
Ω	*Ascending node*	
Ω_D	*Descending node*	
a	*Semi-major axis*	
e	*Eccentricity*	
g	*Gravity (9.81 m/s²)*	
i	*Inclination*	
$V\infty$	*Infinite velocity*	
Z_a, h_a	*Apogee altitude*	
Z_p, h_p	*Perigee altitude*	
A		
ADSM	**A**irbus **D**efence & **S**pace **M**adrid (Spain)	
AIT	**A**ssembly, **I**ntegration and **T**esting	
AQO	Quality Responsible for S/C Campaign (CNES/CSG)	**A**djoint **Q**ualité **O**pérations (CNES/CSG)
ARS	Satellite ground stations network Assistant (Customer)	**A**djoint **R**éseau **S**tations sol Satellite (Customer)
AVUM+	**A**ttitude & **V**ernier **U**pper **M**odule **+**	
C		
CAD	**C**omputer **A**ided **D**esign	
CBOD	**C**lamp-**B**and **O**pening **D**evice	
CCAM	**C**ollision & **C**ontamination **A**voidance **M**aneuvers	
CCTV	**C**losed-**C**ircuit **T**ele**V**ision network	
CCU	Payload Container	**C**onteneur **C**harge **U**tile
CDC	Mission Control Centre	**C**entre **D**e **C**ontrôle
CDL	Launch Centre	**C**entre **D**e **L**ancement
CFRP	**C**arbon **F**iber **R**einforced **P**lastic	
CEO	**C**hief **E**xecutive **O**fficer (Avio)	
CLA	**C**oupled **L**oads **A**nalysis	
CNES	French National Space Agency	**C**entre **N**ational d'**É**tudes **S**patiales
COE	Electrical Umbilical Cable	**C**âble **O**mbilical **É**lectrique
CoG	**C**enter **of** **G**ravity	
COTE	**C**heck-**O**ut **T**erminal **E**quipment	
CPO	**C**hief **P**roduct **O**fficer (Avio)	
CPS	Spacecraft Project Manager (Customer)	**C**hef de **P**rojet **S**atellite (Customer)
CRAL	Post-flight debriefing	**C**ompte-**R**endu **A**près **L**ancement
CRE	Operational Reporting Network	**C**ompte-**R**endu d'**É**tat
CSG	Guiana Space Centre	**C**entre **S**patial **G**uyanais
CT	Technical Center	**C**entre **T**echnique
CTO	**C**hief **T**echnical **O**fficer (Avio)	
CTS	**C**SG **T**elephone **S**ystem	
CU	Payload	**C**harge **U**tile

	CVCM	**C**ollected **V**olatile **C**ondensed **M**ass	
	CVI	Real Time Flight Evaluation	**C**ontrôle **V**isuel **I**mmédiat
D			
	DCI	Interface Control Document	**D**ocument de **C**ontrôle d'**I**nterface
	DDO	Range Operations Manager (CNES/CSG)	**D**irecteur **D**es **O**pérations (CNES/CSG)
	DMS	Spacecraft Mission Director (Customer)	**D**irecteur de la **M**ission **S**atellite (Customer)
	DOM	French Overseas Department	**D**épartement d'**O**utre-**M**er
E			
	ECSS	**E**uropean **C**ooperation for **S**pace **S**tandardization	
	EDC	**E**ffective **D**ate of **C**ontract	
	EGSE	**E**lectrical **G**round **S**upport **E**quipment	
	EMC	**E**lectro-**M**agnetic **C**ompatibility	
	EPCU	Payload Preparation Complex	**E**nsemble de **P**réparation **C**harge **U**tile
	EPDM	**E**thylene **P**ropylene **D**iene **M**onomer	
	ESA	**E**uropean **S**pace **A**gency	
F			
	FEM	**F**inite **E**lement **M**odel	
	FM	**F**light **M**odel	
	FMA	**F**inal **M**ission **A**nalysis	
	FMAR	**F**inal **M**ission **A**nalysis **R**eview	
	FRR	**F**light **R**eadiness **R**eview	
G			
	GMT	**G**reenwich **M**ean **T**ime	
	GHe	*Gaseous helium*	
	GN_2	*Gaseous nitrogen*	
	GRS	**G**eneral **R**ange **S**upport	
	GSE	**G**round **S**upport **E**quipment	
H			
	HEPA	**H**igh **E**fficiency **P**articulate **A**ir	
	HPF	**H**azardous **P**rocessing **F**acility	
	HSS	**H**orizontal **S**eparation **S**ubsystem	
	HTPB	**H**ydroxyl-**T**erminated **P**oly**B**utadiene	
I			
	IO	Operational Intersite Intercom System	**I**ntercom **O**pérationelle
	IRD	**I**nterface **R**equirements **D**ocument	
	ISCU	Payload Safety Officer (CNES/CSG)	**I**ngénieur **S**auvegarde **C**harge **U**tile (CNES/CSG)
	I_{sp}	*Specific impulse*	
L			
	LBC	Check-out equipment room	**L**ocal **B**anc de **C**ontrôle
	LCOM	**L**aunch **C**omplex **O**perations **M**anager (Avio)	
	LEO	**L**ow-**E**arth **O**rbit	
	LPSS	**L**auncher **P**ayload **S**eparation **S**ystem (from ADSM)	
	LRR	**L**aunch **R**eadiness **R**eview	
	LSA	**L**aunch **S**ervice **A**greement	

LTAN	**L**ocal **T**ime of **A**scending **N**ode	
LV	**L**aunch **V**ehicle	

M

MCC	**M**ission **C**ontrol **C**entre	
MD	**M**ission **D**irector (Avio)	
MOM	**M**ission **O**perations **M**anager (Avio)	
MEA	**M**ain **E**ngine **A**VUM+	
MEOP	**M**aximum **E**xpected **O**perating **P**ressure	
MGSE	**M**echanical **G**round **S**upport **E**quipment	

N

N/A	**N**ot **A**pplicable	
NEA	**N**on-**E**xplosive **A**ctuators	
NTO	**N**itrogen **T**etr**O**xide	

O

OASPL	**O**verall **A**coustic **S**ound **P**ressure **L**evel	
OCOE	**O**verall **C**heck **O**ut **E**quipment	

P

PABX	**P**rivate **A**utomatic **B**ranch e**X**change	
PAC	**P**ayload **A**ssembly **C**omposite (S/C + adapter + any carrying system + fairing)	
PFCU	Payload access platform	**P**late-**F**orme **C**harge **U**tile
PFM	**P**roto-**F**light **M**odel	
PFRCS	Platform for Payload Assembly Composite transfer to Launch Pad	**P**late-**F**orme **R**outière **C**omposite **S**upérieur
PMAR	**P**reliminary **M**ission **A**nalysis **R**eview	
POC	Combined Operations Plan	**P**lan d'**O**pérations **C**ombinées
POC RR	Combined Operationd **R**eadiness **R**eview	
POE	Electrical Umbilical Plug	**P**rise **O**mbilicale **É**lectrique
POI	Interleaved Spacecraft Operations Planning	**P**lan d'**O**pérations **I**mbriquées
POP	Pneumatic Umbilical Plug	**P**rise **O**mbilicale **P**neumatique
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	
PSD	**P**ower **S**pectral **D**ensity	

Q

QSL	**Q**uasi-**S**tatic **L**oad	

R

RAAN	**R**ight **A**scension of the **A**scending **N**ode	
RACS	**R**oll and **A**ttitude **C**ontrol **S**ystem	
RCU	Table Payload Links Interface Cabinet	**R**épartiteur **C**harge **U**tile
RF	**R**adio **F**requency	
RMCU	Payload facilities manager (CNES/CSG)	**R**esponsable des **M**oyens **C**harge **U**tile (CNES/CSG)
RML	**R**evovered **M**ass **L**oss	
RPS	Spacecraft Preparation Manager (Customer)	**R**esponsable de la **P**réparation **S**atellite (Customer)
RSB	Launch Base Safety Officer (CNES/CSG)	**R**esponsable **S**auvegarde **B**ase (CNES/CSG)

RSP	Security Officer (CNES/CSG)	**R**esponsable **S**ûreté **P**rotection (CNES/CSG)
RSV	Flight Safety Officer (CNES/CSG)	**R**esponsable **S**auvegarde **V**ol (CNES/CSG)

S

S/C	**S**pace**C**raft	
SLV	Vega C launch site	**S**ite de **L**ancement **V**ega C
SSMS	**S**mall **S**atellite **M**ission **S**ystem	
SOW	**S**tatement **O**f **W**ork	
SRM	**S**olid **R**ocket **M**otor	
SRS	**S**hock **R**esponse **S**pectrum	
SSO	**S**un-**S**ynchronous **O**rbit	
STFO	Optical fibre transmission system	**S**ystème de **T**ransmission par **F**ibre **O**ptique
STM	**S**tructural **T**est **M**odel	

T

TBA	**T**o **B**e **A**nnounced
TBC	**T**o **B**e **C**onfirmed
TBD	**T**o **B**e **D**efined
TC	**T**ele**C**ommand
TM	**T**ele**m**etry
TS	**T**elephone **S**ystem
TV	**T**ele**v**ision
TVC	**T**hrust **V**ector **C**ontrol

U

UDMH	**U**nsymmetrical **D**i**M**ethyl **H**ydrazine
UPCOM	**U**pper **P**art **C**ombined **O**perations **M**anager (Avio)
UT	**U**niversal **T**ime

V

VESPA	**Ve**ga **S**econdary **P**ayload **A**dapter
VLAN	**V**irtual **L**ocal **A**rea **N**etwork
VSS	**V**ertical **S**eparation **S**ubsystem

W

wrt	**w**ith **r**eference **t**o / **w**ith **r**espect **t**o

Z

Z9	**Z**efiro **9**	
Z40	**Z**efiro **40**	
ZLV	Vega Launch pad	**Z**one de **L**ancement **V**ega
ZSE	Propellant storage area	**Z**one de **S**tockage d'**E**rgols
ZSP	Pyrotechnic storage area	**Z**one de **S**tockage **P**yrotechnique

INTRODUCTION Chapter 1

1.1. PURPOSE OF THE USER'S MANUAL

This User's Manual is intended to provide essential information on Avio's launch services using the Vega C launch system operated from the Guiana Space Centre, which are necessary:

- To assess compatibility of a spacecraft and spacecraft mission with Vega C launch system, and to check the suitability of the proposed launch services;
- To initiate the preparation of all technical and operational documentation related to a mission on the Vega C launch vehicle.

The content encompasses:

- Description of the Vega C launch vehicle and Avio's launch service organisation;
- Performance and mission design;
- Environmental conditions imposed by the launch vehicle and ground operations;
- Spacecraft design and verification requirements;
- Description of interfaces between spacecraft and launch system;
- Description of the facilities at CSG, Spacecraft processing and ground operations flow at the launch site;
- Mission integration and management, including support carried out throughout the duration of the launch service contract.

This version of the Vega C User's Manual describes the current configuration of the Vega C launcher (with P120 first stage and current fairing) and is applicable to spacecraft with a mass above 500 kg and a 1194 mm interface diameter.

Vega C upgrades are currently in development (larger fairing, Vega C block II). Other spacecraft interface diameters (610 mm, 937 mm…) can also be adapted on Vega C.

For more detailed information, the reader is encouraged to contact Avio.

[NB: For satellites with a mass below 500 kg, the reader shall refer to the SSMS Vega C User's Manual applicable to Small Spacecraft.]

1.2. AVIO LAUNCH SERVICES

Vega C is Avio's medium-lift launcher, evolving the proven Vega platform with increased performance and greater flexibility across a wide range of missions.

Backed by strong institutional support, Avio now operates under a streamlined, vertically integrated organization, overseeing not only launcher manufacturing but also commercialization and launch campaign operations from the Guiana Space Centre (CSG). Benefiting from an ideally located sea-facing launch pad close to the equator and Europe's state-of-the-art ground infrastructure, Vega C is optimized for deploying medium-sized spacecrafts into Sun-Synchronous Orbit (SSO), Low Earth Orbit (LEO) and beyond.

At the heart of its mission capability lies the AVUM+ upper stage, designed for exceptional orbital precision and operational versatility. Its re-ignitable engine allows for multiple burns, enabling complex mission profiles such as multi-payload deployment into different altitudes and fine-tuned final orbit targeting. This flexibility ensures that Vega C can adapt to a wide variety of mission requirements, from constellation launches to bespoke single-payload scenarios, while maintaining the sub-kilometre injection accuracy that has consistently characterized the Vega family.

The system is fully operational and built with a strong emphasis on in-house manufacturing, with a minimal number of subcontractors, ensuring tighter control, greater reliability and industrial efficiency.

Behind Vega C is a dedicated team of highly competent and motivated professionals, bringing decades of experience in solid propulsion from both the Ariane's strap-on boosters and the Vega program.

Avio offers to its Customers reliable and proven launch services that include:

- Exclusive marketing, sales and management of Vega C launch service and launch operations;
- Dedicated support for feasibility analysis of spacecraft compatibility with launch vehicle;
- Mission management and support that cover all aspects of launch activities and preparation from contract signature to launch;
- Production of the launch vehicle and all associated hardware and equipment, including any adaptations required to meet Customer requirements;
- Systems engineering support and analysis;
- Ground facilities and support (GRS) for Customer activities at launch site;
- Combined operations at launch site, including launch vehicle and spacecraft integration and launch;
- Launcher telemetry and tracking ground station support and post-launch activities;
- Assistance and logistics support, which may include transportation and assistance with insurance, customs and export licenses;
- Quality and safety assurance activities;
- Insurance and financing services upon Customer request.

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)**.

At the LSA signature, Avio provides the Customer with a project-oriented management system, based on a single point of contact (the Mission Director) for all launch service activities, in order to simplify and streamline the process, to provide adequate configuration control for the interface documents and hardware, and to provide visibility on the mission preparation progress and activities schedule.

1.3. VEGA C LAUNCH VEHICLE – HISTORY

Vega

The Vega program (Vettore Europeo di Generazione Avanzata) has its origins back in the early 1990s, when studies were performed to investigate the possibility of complementing the Ariane family with a small launch vehicle using Ariane solid booster technology.

After about ten years of definition and consolidation activities, the Italian Space Agency and Italian industry proposed Vega as a European project based on their know-how in solid propulsion inherited from development and production of Ariane's solid strap-on boosters.

In April 1998, ESA's Council approved a Resolution authorizing pre-development activity. The Vega program was approved by ESA Programme Board on 27-28 November 2000, and the project officially started on 15 December 2000.

Vega had been operated between 2012 and 2024 at the Guiana Space Centre in French Guiana.

Avio was in charge of the Vega launcher development and production. The Vega launch system was developed for a launch rate up to four launches per year.

Vega C

Following the decisions taken during the December 2014 and December 2016 ESA Ministerial Councils, ESA and European industry developed an upgraded and more powerful version of the Vega launcher: Vega C. The main objective was to increase the launch vehicle performance, the usable volume for the spacecraft and to increase the flexibility for multiple payloads missions.

Vega C has a carrying capacity of nearly 2500 kg to SSO at 500 km and more than 3000 kg to LEO, which represent a 60% increase of the Vega. Moreover, in the first stage, the Vega C uses the powerful P120. This Avio-manufactured stage is also used as strap-on boosters for the Ariane 6 launcher). The launch vehicle also holds upgraded version of the Zefiro 40 engine in the second stage and the AVUM+ in the fourth stage, while the Zefiro 9 of the third stage remains the same to Vega.

Figure 1.3.a – Evolution from Vega to Vega C

The diverse range of customers that Vega C served underlines the launcher's ability to address both institutional and commercial customers.

The Vega C has debuted in July 2022. Since then, Avio is in charge of the manufacturing of the launcher and, following ESA's decision in July 2024, became responsible of Vega C commercialization since September 2024. Avio will take over full responsibility of the Vega C launch operations at the Guiana Space Centre starting from Q2 2026.

1.4. LAUNCH VEHICLE DESCRIPTION

Avio offers a complete launch system including the vehicle, the launch facilities and the associated services.

1.4.1. Launch vehicle general data

The Vega C launch vehicle consists primarily of the following components:

- A lower composite consisting of three solid propellant stages;
- A re-ignitable AVUM+ (Attitude and Vernier Upper Module) upper stage;
- A payload fairing;
- Depending on the mission requirements, a variety of different adapters and carrying systems may be used.

The Vega C configuration and relevant vehicle data are presented in Figure 1.4.1.a.

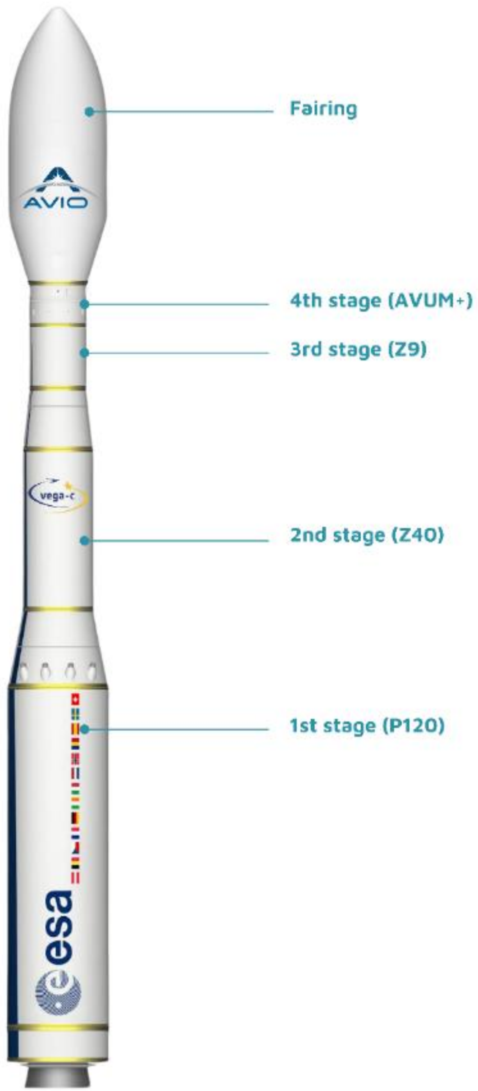


Figure 1.4.1.a – Launch vehicle general data

PAYLOAD FAIRING

Diameter:	3.317 m
Length:	9.374 m
Mass:	860 kg
Structure:	Two halves - Sandwich panels CFRP sheets and aluminium honeycomb core
Separation:	Vertical separations by means of leak-proof pyrotechnical expanding tubes and horizontal separation by a clamp-band

PAYLOAD ADAPTERS, MULTIPLE LAUNCH STRUCTURE

VAMPIRE 1194	
Height (mm):	1 861
Mass (kg):	113
VESPA+R	
Height (mm):	3 065
Diameter (mm):	2 260
Mass (kg):	340-447
SSMS Piggy-Back HEX-1	
Mass (kg):	211
CLESSIDRA	
Height (mm):	2 256
Diameter (mm):	922
Mass (kg):	289

AVUM+ UPPER STAGE

Size:	2.18-m diameter × 2.04-m height
Dry mass:	695 kg
Propellant:	492 kg/248 kg of NTO/UDMH
Subsystems:	
Structure:	Aluminium cylindrical case with 4 Aluminium propellant tanks and supporting frame
Propulsion:	MEA (evolution of RD-869) – 1 chamber
- Thrust	2.45 kN – Vacuum
- Isp	315.8 s – Vacuum
- Feed system	Regulated pressure-fed 108 l (4.8 kg) GHe tank MEOP 328 barA
- Burn time/restart	Up to 612.5 s (max. cumulative firing time: 924.8 s) / up to 5 controlled or depletion burns
RACS:	Six 240 N hydrazine thrusters N_2H_4 ; 39 l (38.6 kg) N_2H_4 tank MEOP 26 barA
Avionics:	Inertial 3-axis platform, on-board computer, TM & RF systems, Power
Attitude control:	
- Pitch, yaw	*Main engine ±10 deg gimbaled nozzle ® boosted phases* *Six RACS thrusters ® ballistic phases*
- Roll	*Roll rate and attitude controlled by four of the six RACS thrusters*

	1st STAGE (P120)	2nd STAGE (Z40)	3rd STAGE (Z9)
Size:	3.40-m diameter × 13.38-m length	2.40-m diameter × 8.07-m length	1.90-m diameter × 4.12-m length
Gross mass:	155 027 kg	40 477 kg	12 000 kg
Propellant:	143 634 kg of HTPB	36 239-kg of HTPB	10 567-kg of HTPB
Subsystems:			
Structure	Carbon-epoxy filament wound monolithic motor case protected by EPDM	Carbon-epoxy filament wound monolithic motor case protected by EPDM	Carbon-epoxy filament wound monolithic motor case protected by EPDM
Propulsion	P120 Solid Rocket Motor (SRM)	ZEFIRO 40 Solid Rocket Motor (SRM)	ZEFIRO 9 Solid Rocket Motor (SRM)
- Thrust	4 650 kN Max Vac thrust	1 304 kN Max Vac thrust	317 kN – Max Vac thrust
- Isp	279 s – Vac	293.5 s – Vac	295.9 s – Vac
- Burn time	135.7 s	92.9 s	119.6 s
Avionics		Actuators I/O electronics, power	Actuators I/O electronics, power
Attitude control:			
- Pitch, yaw	*Gimbaled ±5.9 deg nozzle with electro-mechanical actuators*	*Gimbaled ±5.9 deg nozzle with electro-mechanical actuators*	*Gimbaled ±6 deg nozzle with electro-mechanical actuators*
- Roll	*Roll rate limited by four of the six RACS thrusters*	*Roll rate limited by four of the six RACS thrusters*	*Roll rate and attitude controlled by four of the six RACS thrusters*
Interstage:	**0/1 interstage:** Structure: Cylinder aluminium shell/inner stiffeners Housing: Actuators I/O electronics, power, safety/destruction subsystem **1/2 interstage:** Structure: Conical aluminium shell/inner stiffeners Housing: TVC local control equipment; safety/destruction subsystem		**2/3 interstage:** Structure: Composite grid structure Housing: TVC local control equipment; safety/destruction subsystem **3/AVUM+ interstage:** Structure: Aluminium cylinder with integral machined stringers Housing: TVC control equipment; safety/destruction subsystem, power distribution, RF and telemetry subsystems
Stage separation:	Linear cutting charge/Retro rocket thrusters		Linear cutting charge/springs Pyrotechnic tight expansible tube/springs

1.4.2. Launch configurations

The Vega C launch configurations presented in this User's Manual are defined here below.

- **Single launch configuration**

This launch configuration consists in only one spacecraft to be integrated on Vega C, using an off-the-shelf adapter, called the "VAMPIRE 1194".

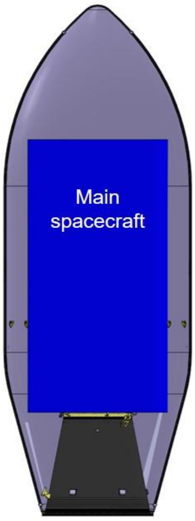


Figure 1.4.2.a – Vega C single launch configuration

- **Launch configuration with main spacecraft and auxiliary passenger(s)**

This launch configuration consists in one main spacecraft and several nano satellites to be integrated, using a multiple launch structure.

This multiple launch structure can be:

- a "SSMS" (Small Spacecraft Mission System) in Piggy-Back configuration (HEX-1).

Specifications presented in this user's manual are applicable only to the main spacecraft illustrated in [blue box] in the Figure 1.4.2.b, whose mass is above 500 kg.

Specifications related to cubesat deployers and nano (30-60 kg) (illustrated in [orange box] in the Figure 1.4.2.b) are part of the SSMS Vega C User's Manual for Small Spacecraft.

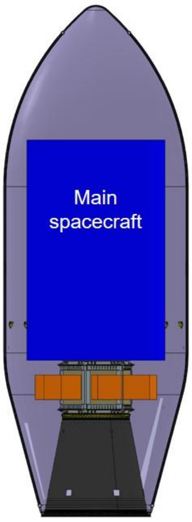


Figure 1.4.2.b – Vega C launch configuration with main spacecraft and auxiliary passenger(s)

- **Dual launch configuration**

This launch configuration consists in one upper spacecraft and one lower spacecraft to be integrated on Vega C, using the VESPA+R dual launch structure.

Specifications presented in this user's manual are applicable to the upper spacecraft illustrated in ■ in the Figure 1.4.2.c, whose mass is above 500 kg.

Specifications related to micro (60-200 kg) or mini (200-500 kg) satellites (illustrated in ■ in the Figure 1.4.2.c) are part of the SSMS Vega C User's Manual for Small Spacecraft.

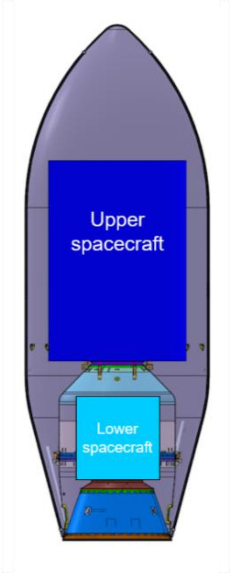


Figure 1.4.2.c – Vega C dual launch configuration

- **Other multiple launch configuration**

Other multiple launch configuration can be contemplated with an upper passenger and up to four Mini Satellites accommodated with the CLESSIDRA carrying system.

The maximal mass of the upper spacecraft on the CLESSIDRA carrying system is 1200 kg.

Specifications related to the CLESSIDRA carrying system are To Be Announced. The reader is asked to contact Avio for more information.

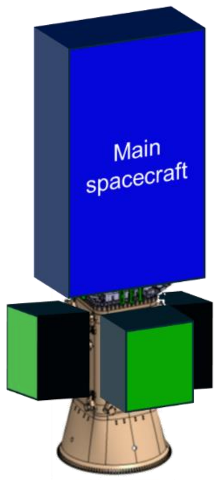


Figure 1.4.2.d – Vega C launch configuration with CLESSIDRA carrying system

1.4.3. European spaceport and CSG facilities

Avio launch services are carried out at the Guiana Space Centre (CSG "Centre Spatial Guyanais") – European spaceport in operation since 1968 in French Guiana. The spaceport accommodates several launch facilities, included Vega C launch pad (ZLV "Zone de Lancement Vega") and shared Payload Preparation Complex (EPCU "Ensemble de Préparation Charge Utile") and launch support services.

The CSG is governed under an agreement between France and the European Space Agency (ESA). Day-to-day operations at CSG are managed by the French National Space Agency (CNES "Centre National d'Études Spatiales") on behalf of the European Space Agency (ESA). CNES provides range support to Avio, for spacecraft, launch vehicle preparation and launch.

The CSG provides state-of–the-art Payload Preparation Facilities (EPCU) recognized as a high-quality standard in space industry. The facilities are capable to process several satellites of different Customers at the same time, thanks to large clean rooms and supporting infrastructures. Designed for multiple launch capability and high launch rates, the EPCU capacity is shared by the Customers of launch vehicles operated from the CSG.

The satellite / launch vehicle integration and launch are carried out at launch sites dedicated to the Vega C launch system.

Vega C is operated from the Vega Launch Site (ZLV). The ZLV provides high-standard quality of services for combined launch vehicle operations with spacecraft.

The moderate climate, regular air and sea connections, accessible local transportation, and excellent accommodation facilities for both business and recreation are all dedicated to supporting the Customer's team and contributing to the success of the launch mission.

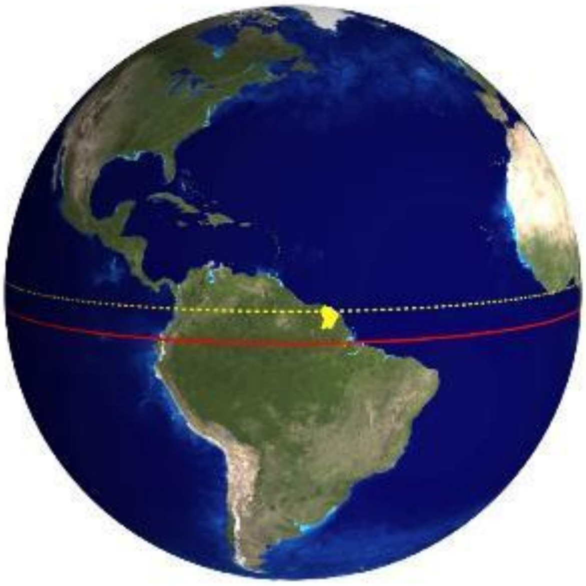


Figure 1.4.3.a – CSG overview

1.4.4. Launch service organization

Avio is organized to offer launch services based on a continuous interchange of information between a Spacecraft Interface Manager (Customer), and the Avio Mission Director (Avio) who is appointed at the time of the Launch Services Agreement signature. From that date onwards, the Avio Mission Director is responsible for the execution of the Launch Services Agreement.

For the preparation and execution of the Guiana operations, the Avio launch team is managed by a assigned Mission Operations Manager who works directly with the Customer's operational team.

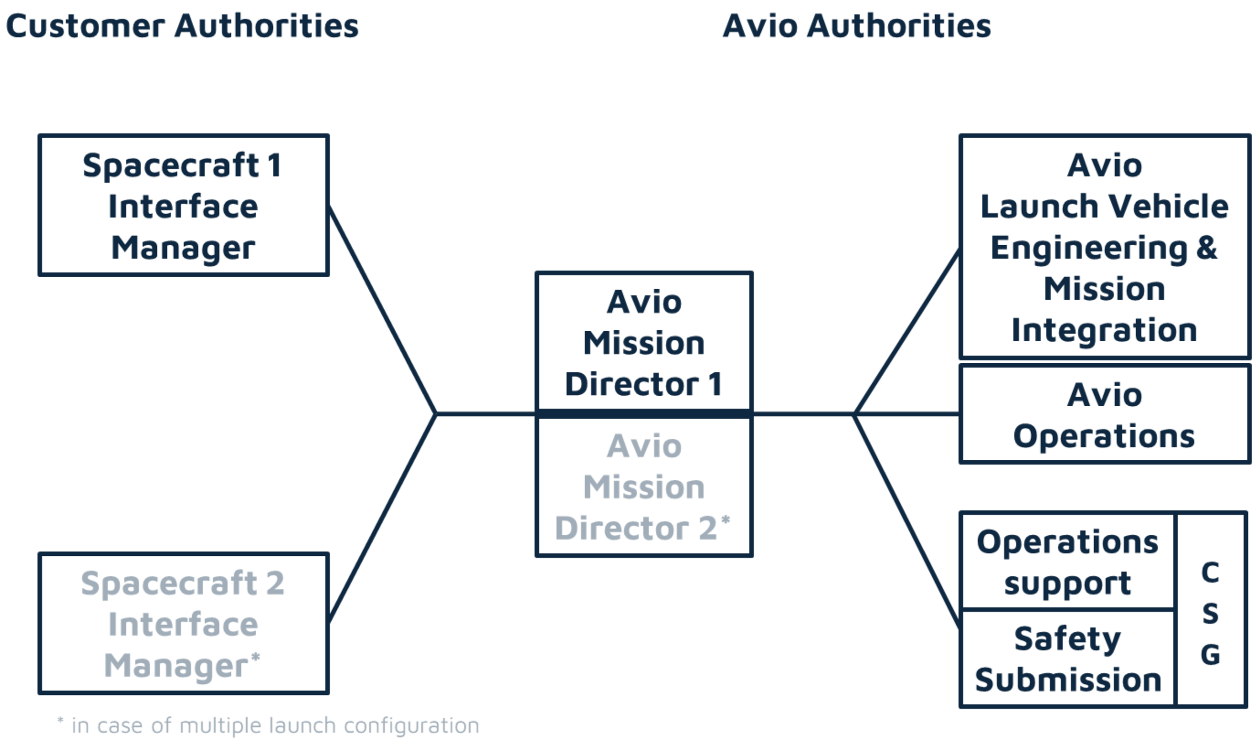


Figure 1.4.4.a – Principle of Customers / Avio relationship

1.5. CORPORATE ORGANIZATION

1.5.1. Avio

The Avio S.p.A. company, based in Colleferro, Italy, manages the Vega C development, production, commercialization and operation. Its business relies on the experience gained by the shareholders in the field of the solid propulsion as suppliers of the Ariane-family launchers boosters.

As industrial prime contractor, launcher design authority and launch service provider and operator, Avio is ensuring continuity is all preparatory activities including the acceptance of the launcher's components and integration in French Guiana, final preparations and launch operations.

In order to complete all its activities, Avio has established a presence in several parts of the world: in Europe, with headquarters and production facilities located at Colleferro near Rome, Italy; Launch Service Provider's directorate in Paris, France; in North America with Avio USA Inc., its subsidiary in Arlington, VA, and in French Guiana, with fully-owned and shared-owned subsidiaries for launcher integration and operation activities.

Avio provides each Customer a true end-to-end service, from manufacturing of the launch vehicle to mission preparation at the Guiana Space Centre and successful in-orbit delivery of payloads for a broad range of missions.

Avio as a unique commercial operator oversees the marketing and sales, production and operation at CSG of Vega launch vehicles.

Figure 1.5.1.a – Avio worldwide

1.5.2. Institutional support

The European Space Agency provides financing, technical and political support for Vega C development and operation. The Vega C program is financed by the following participating European states: Austria, Belgium, Czech Republic, France, Germany, Ireland, Italy, the Netherlands, Norway, Romania, Spain, Sweden and Switzerland. The ESA's technical supervision is provided in the same way as it was made for all past ESA's families of launchers, bringing more than 40 years of previous experience. The ESA and the participating states decisions provide the formal base for the Vega C integration in European space transportation fleet and its access to the institutional market insuring long term prospects.

1.5.3. European space transportation system organization

Vega C benefits from direct and simplified procurement organization as: the manufacturing, the integration, the commercialization and the operation of the launch vehicle all fall under Avio's responsibilities and management. Therefore, each launch is streamlined and made more efficient.

For the Vega C operation, range support is provided by CNES CSG.

Figure 1.5.3.a shows this simplified launch vehicle procurement organization:

Figure 1.5.3.a – The launch vehicle procurement and range support organization

1.5.4. Avio main suppliers

Avio establishes close working relations with well-known European suppliers and partners.

Among them: Europropulsion (a joint venture between Avio and ArianeGroup), Airbus Defence & Space, SABCA, Beyond Gravity, CIRA, etc. As a result, the number of direct subcontractors is limited.

To illustrate the industrial experience concentrated behind the Vega C prime supplier, the Figure 1.5.4.a shows subcontractors and their responsibilities.

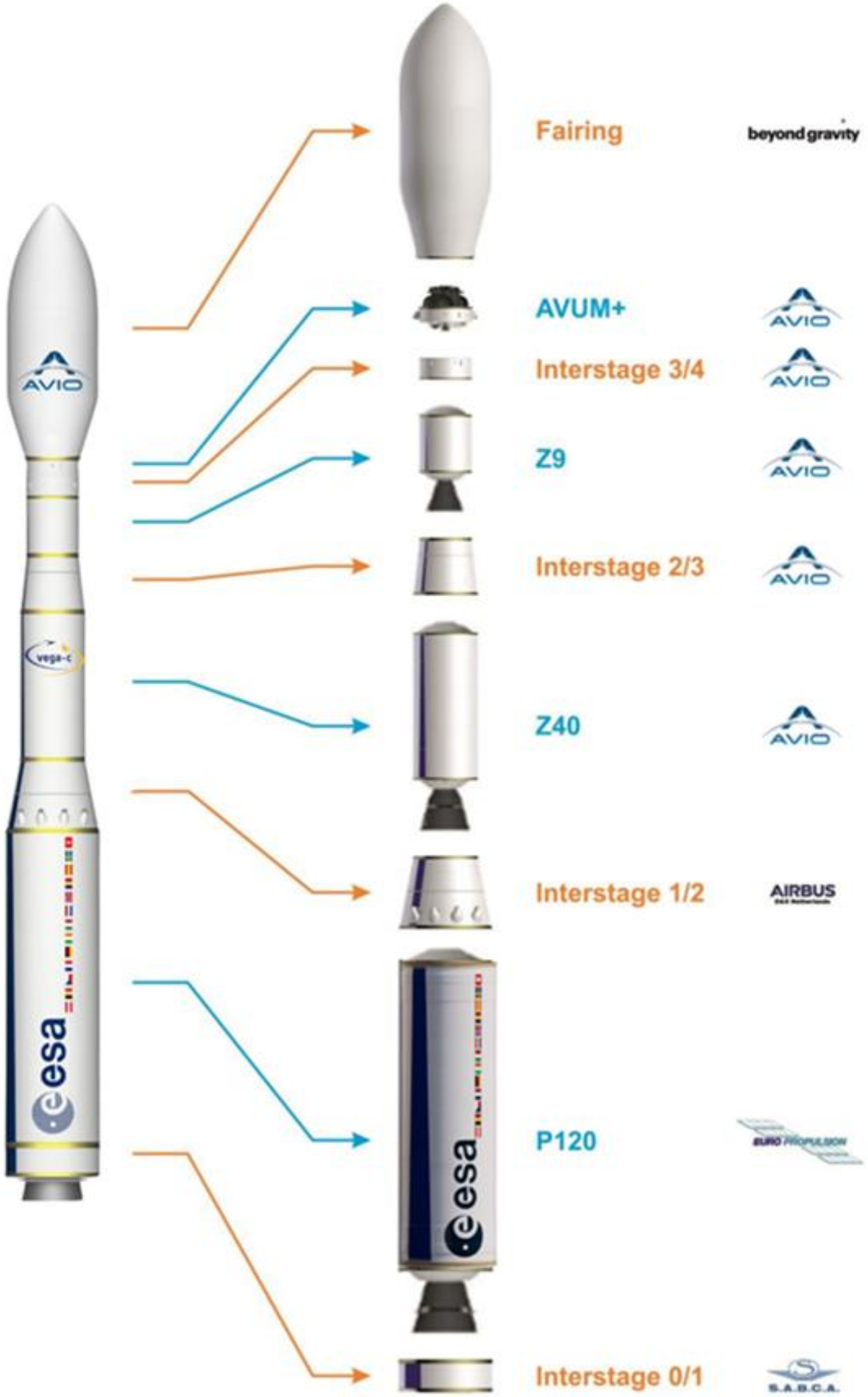


Figure 1.5.4.a – The Vega C subcontractors

PERFORMANCE AND MISSION DESIGN — Chapter 2

2.1. INTRODUCTION

Vega C launch system is perfectly adapted for a broad range of missions (Earth observation, meteorological or scientific satellites, in-orbit demonstration/validation…), from the launch of large optical and radar observation spacecraft to the launch of nanosatellites. Thanks to the re-ignition capabilities of the AVUM+ upper stage (so called AVUM+ stage), Vega C can inject several spacecraft on different orbits (on SSO for instance, up to three different altitudes, with a mission profile comprising eight AVUM+ boots).

This section provides the information necessary to define a mission with a Vega C launch vehicle and to make a preliminary performance assessment. The following paragraphs present the launch vehicle performance, the typical timeline of events and mission duration, ground tracks and telemetry stations network, typical orbit injection accuracy and spacecraft separation conditions.

It covers a wide range of Low Earth Orbit missions, covering inclinations from quasi-equatorial to sun-synchronous types.

Performance data presented in this manual are generic. For a given Customer's mission, the actual performance will be determined in the scope of a mission analysis loop (refer to § 7.4.2 for an extensive description of the mission analysis activities).

2.2. PERFORMANCE DEFINITION

The performance figures given in this chapter are expressed in terms of payload mass including:

- The separated mass of all embarked satellites;
- The mass of their adapters;
- The mass of the carrying system, if any.

Available payload adapters and carrying systems are presented in Chapter 5.

Performance computations are based on the following main assumptions:

- Launch from the CSG (Centre Spatial Guyanais in French Guiana) taking into account the relevant CSG safety rules.
- Sufficient propellant reserve is assumed from last stage (AVUM+) propellant budget to compensate for any dispersions during the flight and reach the targeted orbit.
- In addition, a part of the last stage propellant is allocated to perform a last AVUM+ boost in order to trigger a controlled re-entry of the last stage in the Earth atmosphere or to transfer it to a graveyard orbit, as required by space debris mitigation rules.
- Maximal aerothermal flux is lower than or equal to 1 135 W/m^2 at and after fairing jettisoning.

Data presented herein do not take into account any additional equipment or services that may be requested.

2.3. TYPICAL MISSION PROFILE

2.3.1. Ascent profile

A Vega C mission includes the following phases:

- An ascent phase with the three solid propellant stages: P120C, Zefiro 40 (Z40), Zefiro 9 (Z9);
- A series of AVUM+ boosts and coasting phases to inject the Spacecraft on the required orbit(s);
- A last AVUM+ boost to trigger a controlled re-entry of the last stage into the Earth's atmosphere.

The AVUM+ last stage is a re-ignitable upper stage (up to seven re-ignitions) offering great flexibility for servicing a wide range of orbits and allowing delivery of the payloads to different orbits in case of shared launch.

For a typical Sun-Synchronous Orbits (SSO) or Low Earth Orbit (LEO) mission, two AVUM+ boosts are necessary to reach the targeted orbit: a first AVUM+ boost is used to reach an intermediate transfer orbit, followed by a coast phase of duration determined by the altitude of targeted orbit and a second AVUM+ boost for injection into the final orbit.

After spacecraft separation, a final AVUM+ boost is performed to trigger a deorbitation of the AVUM+ upper stage or an orbital disposal maneuver, in accordance with CSG regulations.

The flight profile is optimized for each mission and its definition is coordinated with the Customer during the mission analysis process.

The typical Vega C ascent profile is presented in figure 2.3.1.a. below.

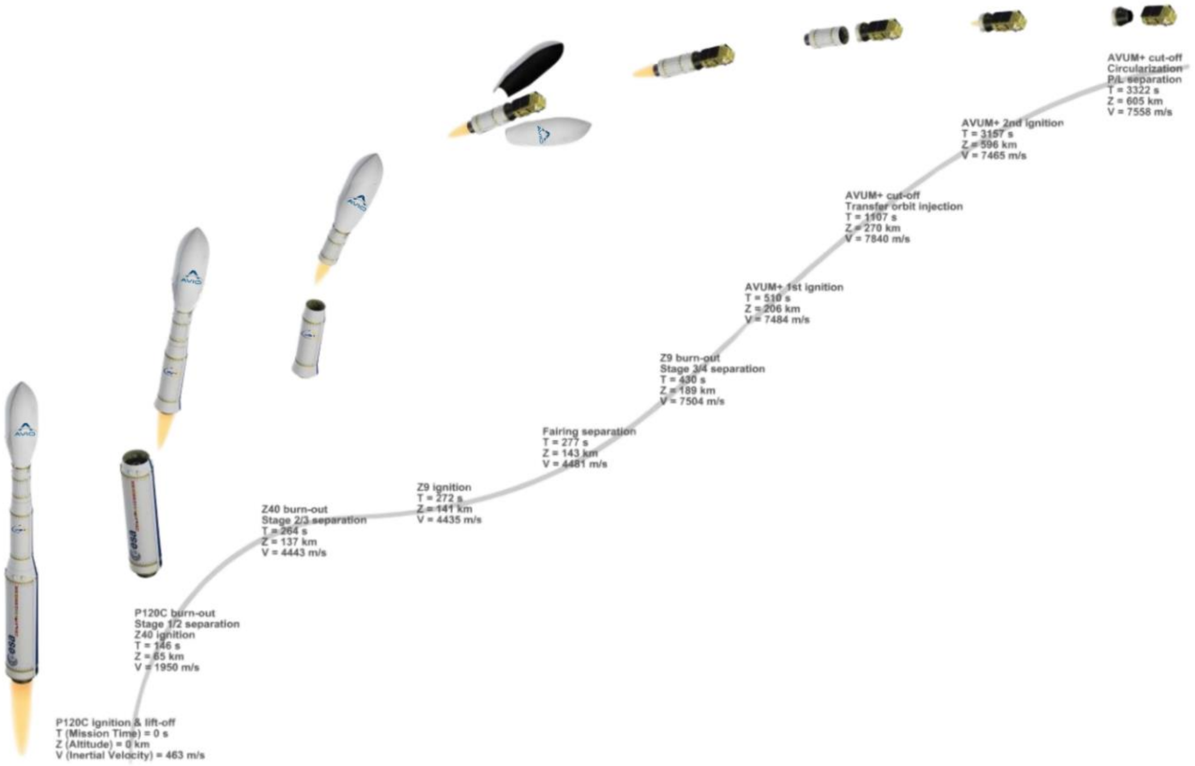


Figure 2.3.1.a - Typical ascent profile (two AVUM+ boosts mission profile)

- **Solid propellant propelled phase**

For the three solid propellant stages, the ascent profile comprises:

- 1st stage flight (P120C) with initial vertical ascent, programmed pitch over maneuver and the following near-zero incidence flight;
- 2nd stage (Z40) flight with a dog leg maneuver;
- 3rd stage (Z9) flight, with fairing separation and injection into sub-orbital trajectory.

The fairing is released at the beginning of the Z9 flight phase when the aerothermal flux becomes lower or equal to 1 135 W/m^2.

- **AVUM+ upper stage phase**

After 3rd stage (Z9) separation, multiple AVUM+ boosts are used to transfer the payload to a wide variety of orbits, providing the required plane changes and orbit raising.

Up to eight boosts (i.e. seven re-ignitions) may be provided by the AVUM+ to reach the targeted orbit(s) and ensure a re-entry of the AVUM+ upper stage.

- **AVUM+ deorbitation or orbit disposal maneuver**

At the end of the mission, after spacecraft separation and after the Collision and Contamination Avoidance Maneuvers (CCAM), a last AVUM+ boost is performed, when the adequate distance between the AVUM+ upper stage and the spacecraft is attained, to clear spacecraft operational orbit and trigger a controlled re-entry of the last stage into the Earth's atmosphere or to reach a graveyard orbit, in accordance with CSG regulations.

2.3.2. Trajectory ground tracks

This section reports a selection of typical ground tracks for Vega C missions.

- **Sun-Synchronous missions**

Figure 2.3.2.a presents the ground track for a typical SSO mission. A multiple launch case is shown, with two spacecraft separation events. The first spacecraft separation typically happens during flight above Australia, with the second spacecraft separation event being located during the second fly-by of North America.

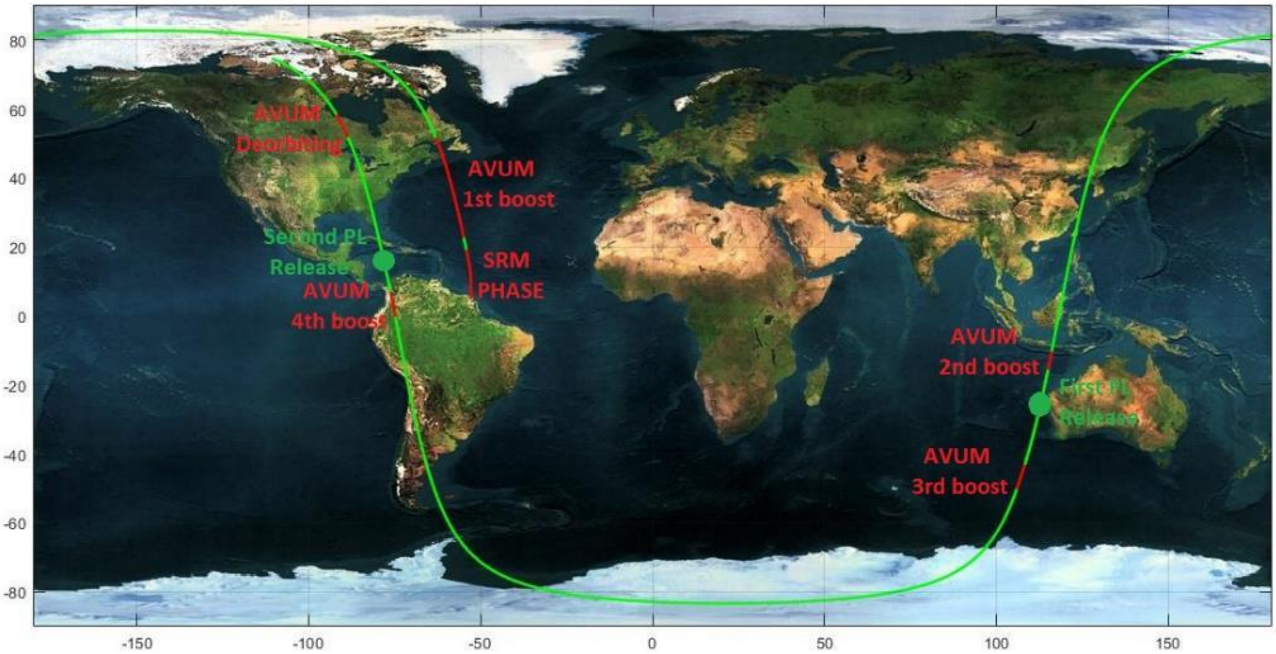


Figure 2.3.2.a – Typical ground track for Vega C mission in SSO

- **LEO missions at 70° inclination**

Figure 2.3.2.b presents the ground track for a single launch mission at 70° inclination. The spacecraft separation event takes place during flight above Australia. The deorbiting boost happens during the second flyover of Northern Europe to achieve AVUM+ reentry in a safe area in the Indian Ocean.

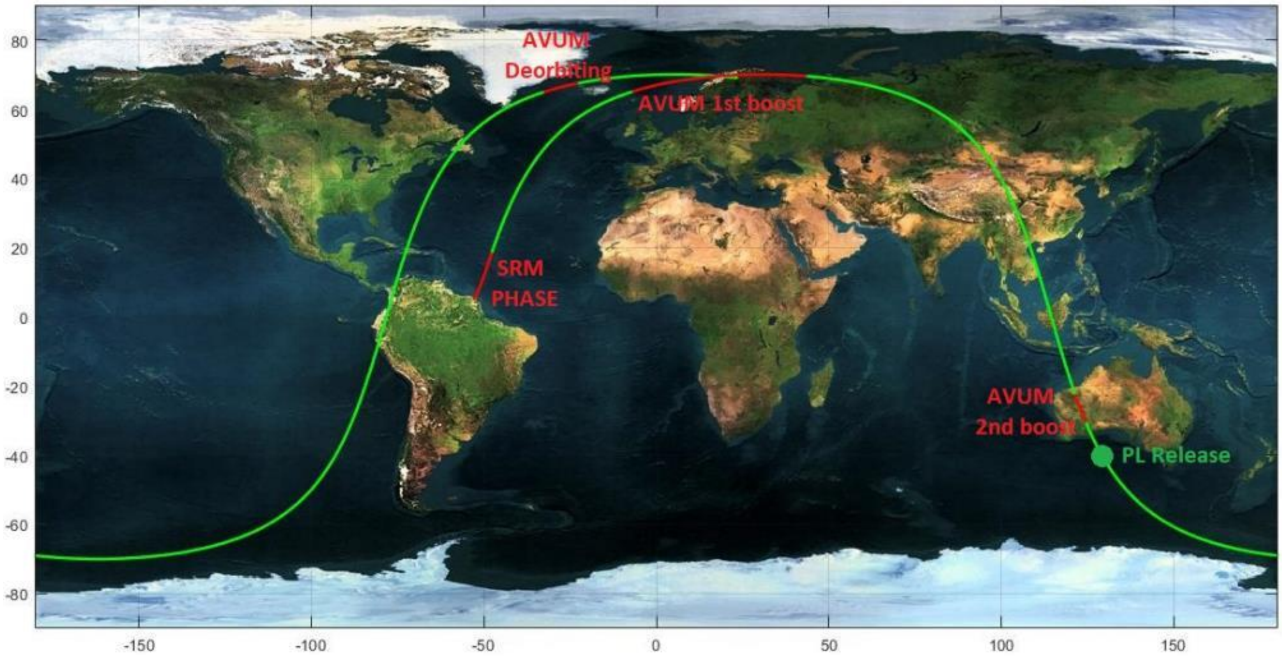


Figure 2.3.2.b – Typical ground track for Vega C mission in LEO at 70° inclination

- **LEO mission at 50° inclination**

Figure 2.3.2.c presents the ground track for a single launch mission at 50° inclination. As in the 70° inclination case, the spacecraft separation event takes place during flight above Australia. The deorbiting boost happens in visibility from the telemetry station located in India to achieve AVUM+ reentry in a safe area in the Pacific Ocean.

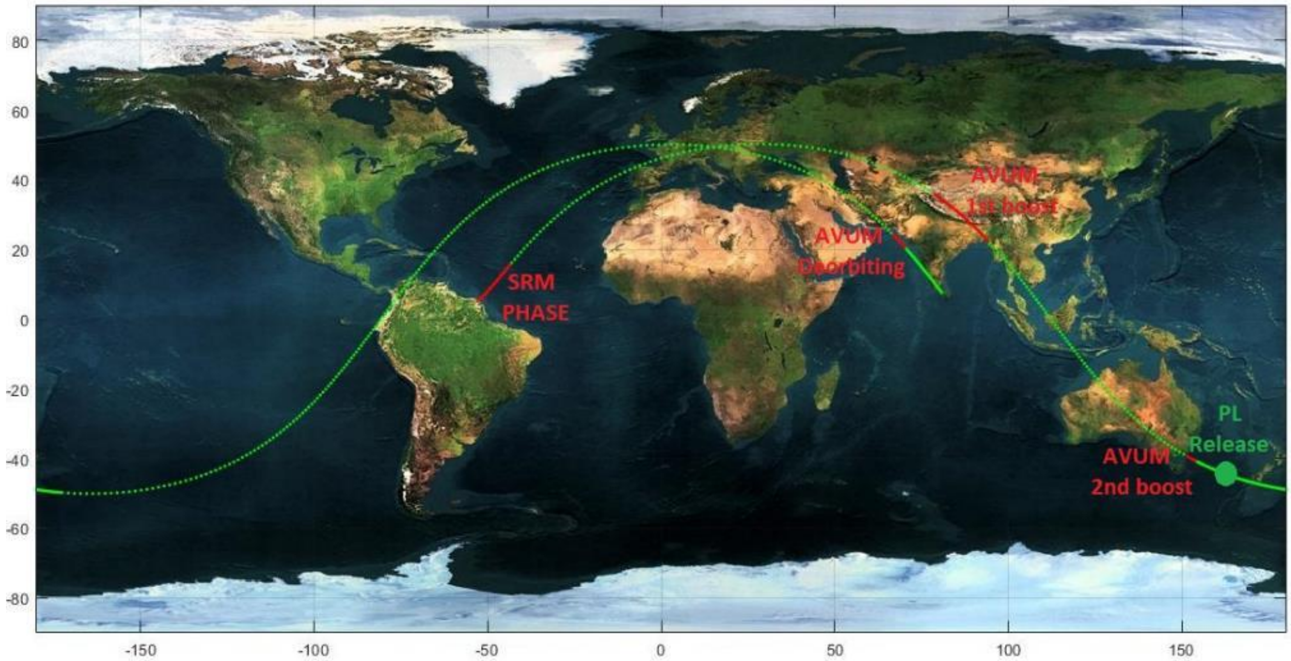


Figure 2.3.2.c – Typical ground track for Vega C mission in LEO at 50° inclination

- **LEO mission at 25° inclination**

Figure 2.3.2.d presents the ground track for a single launch mission at 25° inclination. While this is considered part of the mid-inclination domain of Vega C, the general mission profile is different compared to the 50°- and 70°-inclination mission profiles, and is closed to an equatorial mission profile. Spacecraft separation is delayed to the second fly-by of Central America, while deorbiting takes place in visibility from a telemetry station in Australia to achieve AVUM+ reentry in the Pacific Ocean.

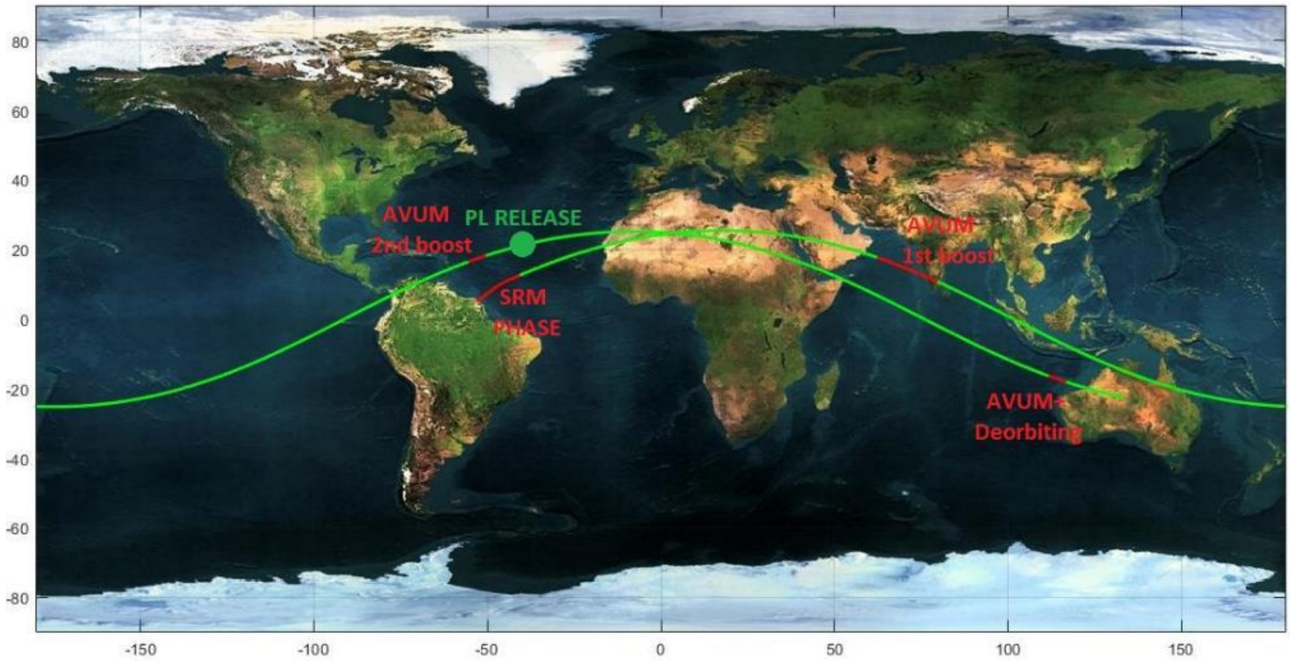


Figure 2.3.2.d – Typical ground track for Vega C mission in LEO at 25° Inclination

- **LEO mission at 5.2° inclination (TBA)**

2.4. GENERAL PERFORMANCE DATA

This version of the Vega C User's Manual provides the Vega C performance with the current Vega C configuration described in § 1.4, that is with P120 first stage and with the current AVUM+ and fairing.

The Vega C performance for Vega C most typical missions are presented in Table 2.4.a. below. As defined in § 2.2 above, these performance values refer to spacecraft, adapters and carrying system if any, and are obtained considering all typical constraints described in § 2.2, including flight safety constraints.

Orbit	Apogee alt. Z_a [km]	Perigee alt. Z_p [km]	Inclination i [deg]	Performance (S/C+Adapter+ Carrying system if any) [kg]
SSO	510	490	97.4	2423
	710	690	98.2	2266
LEO	500	500	70	2470
	700	700		2410
LEO	500	500	50	2550
	700	700		2560
LEO	500	500	25	2350
	700	700		2340
Equatorial	500	500	5.2	> 3000

Table 2.4.a – Vega C performance for typical missions

For mid-inclination missions in the altitude range considered in Table 2.4.a, the performance is not much dependent on the orbit altitude as is the case for SSO missions. This is due to the impact of safety constraints (mainly Z9 fall down area) on the trajectory profile and available performance.

For Sun-Synchronous Orbits (SSO), the Vega C performance (as defined in § 2.2) is presented in Figure 2.4.b as a function of altitude.

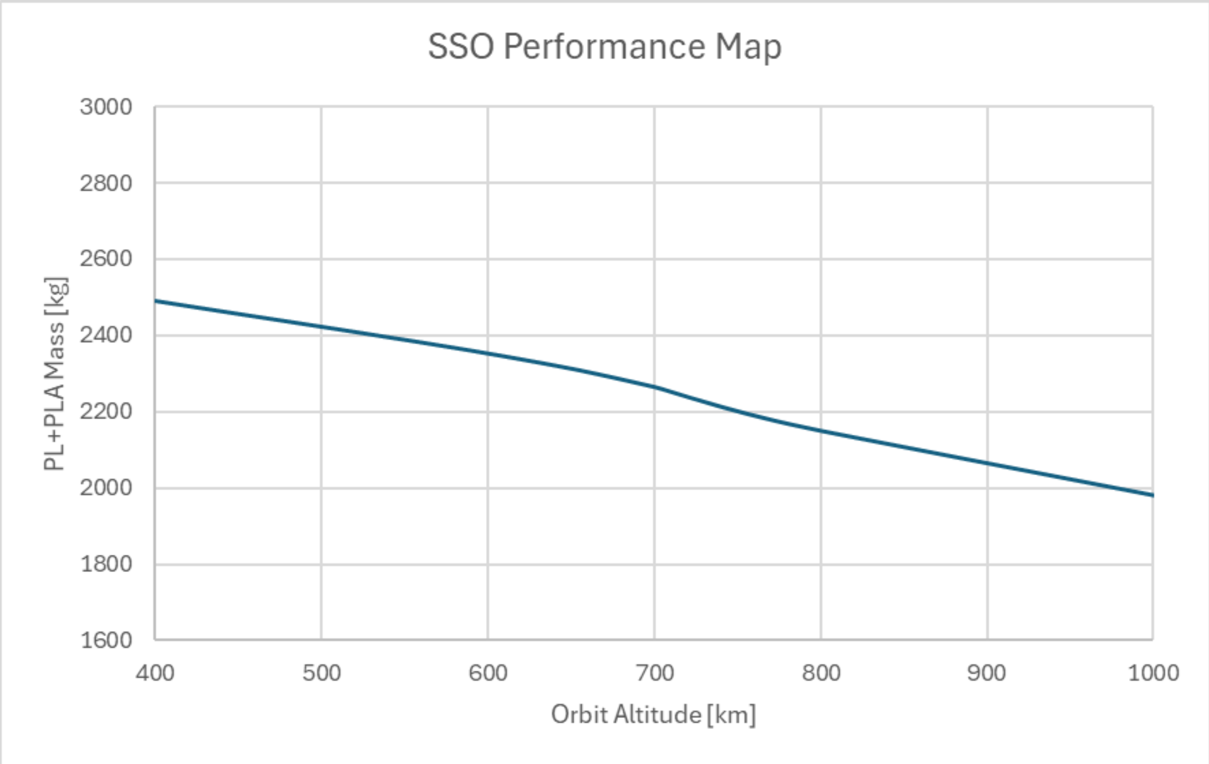


Figure 2.4.b – Vega C performance for SSO missions

Please contact Avio for other orbits.

The current first stage (P120) will be upgraded in the near future (starting from H1 2028) with a new version (P160) with an increased mass of propellant. This improvement of the first stage can be expected to increase performance by approximately +200 kg (actual number will be mission-dependent).

2.5. INJECTION ACCURACY

The orbit injection accuracy is determined mainly by the performance of the launcher navigation and guidance systems. Conservative injection accuracy figures are presented in Table 2.5.a. below. Mission-specific injection accuracy will be computed as part of the mission analysis.

	SSO or LEO
a Semi-major axis (km)	±15
e Eccentricity	±0.0012
i Inclination (deg)	±0.15
RAAN (deg)	±0.2

Table 2.5.a – Orbit injection accuracy (± 3σ)

Please contact Avio for other orbits.

2.6. MISSION DURATION

Mission duration from lift-off until separation of the spacecraft in its final orbit depends on the specified orbital parameters and the ground station visibility conditions at spacecraft separation.

Critical mission events including spacecraft separation are carried out within the visibility of launch vehicle ground stations. This allows for the reception of near-real-time information on relevant flight events, orbital parameters on-board estimation and separation conditions.

The typical durations of various missions are presented in Table 2.6.a. Actual mission duration will be determined as part of the mission analysis.

In any case, the maximal mission duration from lift-off until end of AVUM+ passivation is 12 800 seconds (3h33m20s).

Mission	**Ascent profile**	**Mission Duration (hh:mn)**
SSO single launch	Ascent with two AVUM+ burns	~ 01:00
SSO shared launch	Ascent with multiple AVUM+ burns	~ 01:00 (upper passenger) Up to ~ 03:30 (lower passenger or auxiliary passengers)
Equatorial mission	Ascent with two AVUM+ burns	~ 02:35

Table 2.6.a - Typical mission duration (up to spacecraft separation)

2.7. LAUNCH WINDOW

The Vega C launch vehicle can be launched any day of the year, any time of the day respecting the specified lift-off time. The planned launch time is set with accuracy better than ±1 second, taking into account all potential dispersions in the launch sequencing and system start/ignition processes.

For SSO missions, the launch window is usually reduced to a unique launch time (to meet the Local Time of Ascending Node – LTAN – requirement).

- **Launch window for single launch configuration**

For single launch configuration, the launch window is defined taking into account the passenger's mission requirements.

- **Launch window for dual launch configuration**

For dual launch configuration, Avio will take into account the launch window requirements of both passengers to define a common launch window/time.

- **Launch window for multiple launch configuration with auxiliary passengers**

For multiple launch with auxiliary passengers, the launch window is defined taking into account the main passenger's mission requirements.

- **Process for launch window definition**

The final launch window calculation will be based on actual orbit parameters.

The final launch window will be agreed upon by the Customer(s) and Avio at the Final Mission Analysis Review and no further modification shall be introduced without the agreement of every party.

2.8. SPACECRAFT ORIENTATION DURING ASCENT PHASE

During propulsive phases, the attitude is defined by the launch vehicle.

During coast phases, in order to smooth the thermal environment, the launcher is typically set in a so-called barbecue mode, with low spin up to 2°/s, and with the launcher longitudinal axis perpendicular to the Sun's direction.

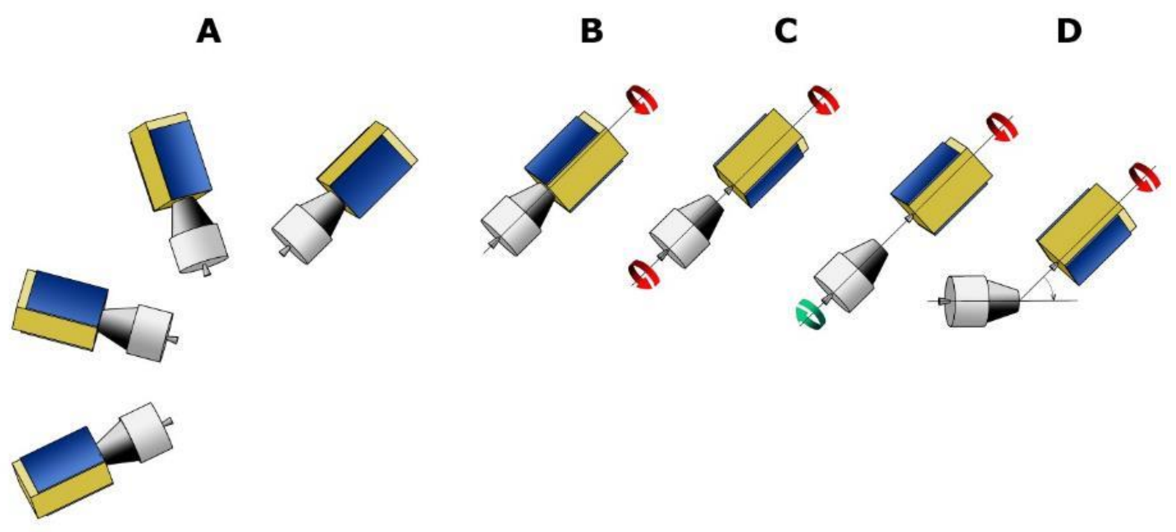
However, during the coast phases, in case of specific spacecraft requirements (sun-angle pointing constraints, for instance), the attitude of the launcher can be adapted to satisfy the spacecraft requirements, with a pointing accuracy of ± 16°. In such case, the best approach to meet spacecraft and launch vehicle constraints will be agreed during the mission analysis process.

2.9. SPACECRAFT SEPARATION CONDITIONS

After orbital injection, the AVUM+ Roll and Attitude Control System (RACS) is able to orient the upper composite to any desired attitude(s) and to perform separation(s) in various modes:

- three-axis stabilization;
- longitudinal spin.

Typical sequence of events is shown in Figure 2.9.a below.



A Orientation of composite (AVUM+ and payload) by Roll and Attitude Control System (RACS)
B Spin-up by RACS (if required by spacecraft)
C Spacecraft separation
D AVUM+ avoidance maneuver (spin down if necessary, attitude maneuver by RACS and deorbitation)

[NB: Spacecraft separation typically takes place in a three-axis stabilized mode.]

Figure 2.9.a – Typical separation sequence for single launch

2.9.1. Orientation

The attitude at spacecraft separation can be specified by the Customer in any direction. Either:

- a fixed orientation (valid during the entire launch window and for any launch date);

  or

- a day variable orientation dependent on the Sun's position.

For any other specific satellite pointing, please contact Avio.

2.9.2. Separation mode and pointing accuracy

For spacecraft complying with the static unbalance requirements defined in § 4.2.3.2, the figures below are applicable. They are given as satellite kinematic conditions at the end of separation and assume the adapter and separation system are supplied by Avio.

Possible perturbations induced by spacecraft sloshing masses are not considered in the following values.

The actual separation conditions will be determined during the Mission Analysis (see § 7.4.2).

2.9.2.1 Three-axis stabilized mode

For a Spacecraft separation in three-axis stabilized mode, if the maximum spacecraft static unbalance remains below 15 mm (see § 4.2.3.2), the typical 3σ pointing accuracies are (without taking into account any sloshing effect):

- Geometrical axis depointing ≤ 1.5 deg;
- Angular tip-off rates along longitudinal axis ≤ 1.5 deg/s;
- Angular tip-off rates along transversal axis ≤ 1.5 deg/s.

2.9.2.2 Spin stabilized mode

The AVUM+ RACS can provide a roll rate around the longitudinal axis up to 30 deg/s, clockwise or counterclockwise.

Although the spacecraft kinematic conditions just after separation are highly dependent on the actual spacecraft mass properties (including uncertainties) and the spin rate, the following values are typical results.

If the maximum spacecraft static unbalance remains below 15 mm and its maximum dynamic unbalance remains below 1 deg (see § 4.2.3), the typical pointing accuracies for a 30 deg/s spin mode are:

- Spin rate accuracy ≤ 1.5 deg/s;
- Transverse angular tip-off rates ≤ 2 deg/s;
- Depointing of kinetic momentum vector, half angle ≤ 6 deg;
- Nutation, angle ≤ 5 deg.

2.9.2.3 Separation linear velocities and collision risk avoidance

The payload adapter's separation systems are designed to deliver a minimum relative velocity between spacecraft and upper stage of 0.5 m/s.

For each mission, Avio will verify that the distances between separated bodies are adequate to avoid any risk of collision.

For this analysis, the spacecraft is assumed to have a pure ballistic trajectory. Otherwise, in case some spacecraft maneuver occurs after separation, the Customer has to provide Avio with its orbit and attitude maneuver flight plan.

2.9.2.4 Multi-separation capabilities

The Vega C launch vehicle is also able to perform multiple separations.

In this case, the kinematics conditions after spacecraft separation will be determined during the Mission Analysis (see § 7.4.2).

ENVIRONMENTAL CONDITIONS Chapter 3

3.1. INTRODUCTION

During the preparation for a launch at the CSG and then during the flight, the spacecraft is exposed to a variety of mechanical, thermal and electromagnetic environments. This chapter provides a description of the environment that the spacecraft is intended to withstand.

Without special notice, all environmental data given in the following paragraphs should be considered as limit loads applying to the spacecraft at the spacecraft mounting plane. The related probability of these figures not being exceeded is 99%.

The environments presented in this chapter are applicable for spacecraft with a mass above 500kg, fulfilling the design requirements specified in Chapter 4, and for the following configurations:

- Single launch configuration (one main passenger), using an off-the-shelf adapter VAMPIRE 1194;
- Multiple launch configuration (main passenger with auxiliary passengers), using an Interface Ring 1194 (IR 1194) on the SSMS HEX-1 carrying system;
- Dual launch configuration (two co-passengers or one main passenger with an auxiliary passenger), using an Active Ring 1194 (AR 1194) on the VESPA+R dual launch system.

For satellites with a mass below 500 kg, the reader shall refer to the SSMS (Small Spacecraft Mission System) Vega C User's Manual.

[NB: In case the adapter/separation system is provided by the Spacecraft Authority, the Customer is invited to contact Avio.]

3.2. GLOBAL MECHANICAL ENVIRONMENT

3.2.1. Quasi-static accelerations

During ground operations and flight, the spacecraft is subjected to static and dynamic loads. Such loads may be of operational origin (e.g. transportation or mating), aerodynamic origin (e.g. wind and gusts during transonic phase) or propulsion origin (e.g. longitudinal acceleration, thrust buildup or tail-off transients, or structure-propulsion coupling, etc.).

Figure 3.2.1.a illustrates a typical longitudinal static acceleration evolution over time for the launch vehicle during its ascent flight. The maximum longitudinal acceleration occurs just before the second-stage cutoff.

The maximum lateral static acceleration occurs at maximum dynamic pressure and takes into account the effect of wind and gust encountered in this phase.

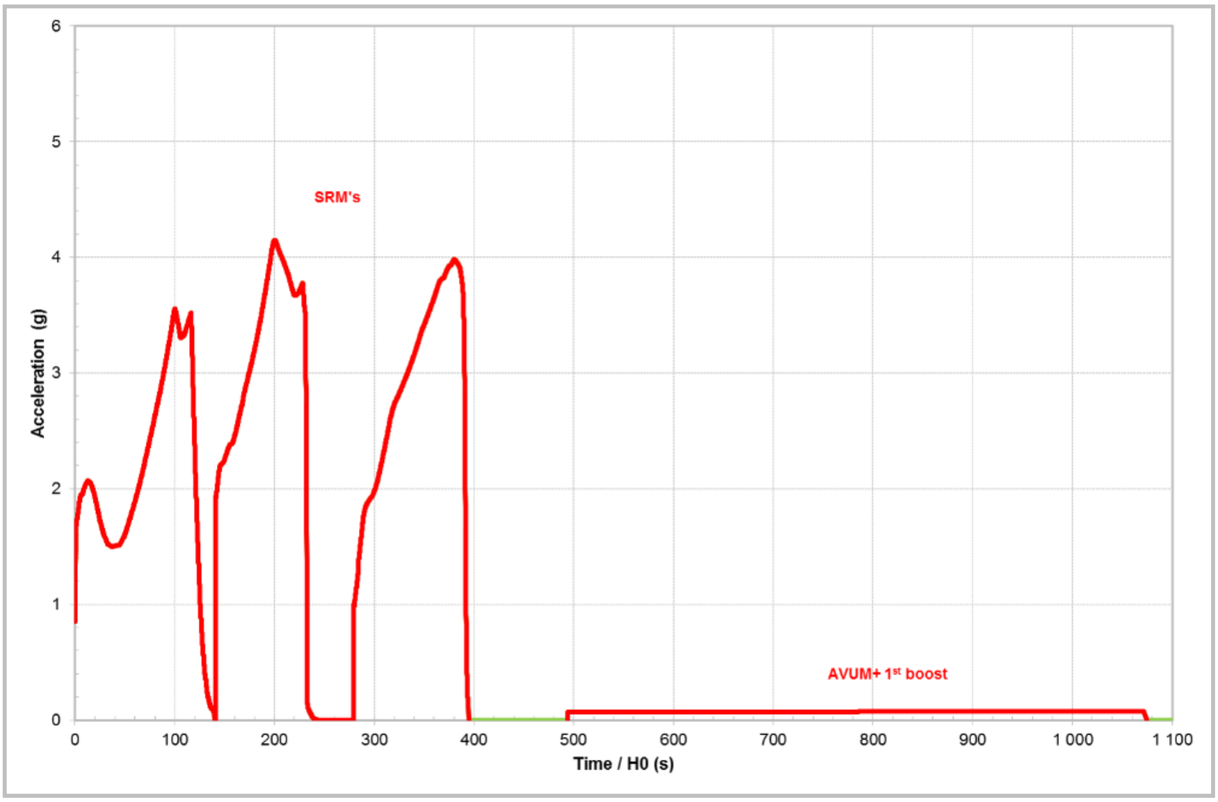


Figure 3.2.1.a – Typical longitudinal static acceleration for SSO mission

The associated loads at the spacecraft-to-adapter interface are defined by Quasi-Static Loads (QSL) that apply at spacecraft center of gravity and that are the most severe combinations of dynamic and static accelerations that can be encountered by the spacecraft at any instant of the mission.

3.2.1.1 Quasi-Static Loads in single launch configuration and multiple launch configuration

For a spacecraft, as main passenger on top of:

- VAMPIRE 1194 adapter (see Figure 1.4.2.a);
- Interface Ring 1194 (IR 1194) on SSMS HEX-1 base module (see Figure 1.4.2.b);

with mass above 500 kg and complying with the stiffness requirements defined in § 4.2.3.4, the limit levels of quasi-static loads to be taken into account for the design and dimensioning of the spacecraft primary structure are defined in Table 3.2.1.1.a and Figure 3.2.1.1.a below.

Load events		**QSL (g) (+ = tension ; - = compression)**		
		Longitudinal		**Lateral**
		Min.	Max.	
1	Lift-off phase	-4.5	+3.0	±1.35
2	Flight with maximum dynamic pressure (Qmax)	-4.0	+1.5	±0.9
3	1st stage (P120C) with maximal acceleration and tail off	-5.0	+1.0	±0.7
4	2nd stage (Z40) ignition and flight, 3rd stage (Z9) ignition	-5.0	+3.0	±1.3
5	3rd stage (Z9) maximal acceleration	$-\left(6.8-\frac{M^{(1)}}{1000}\right)-0.2$	N/A	±0.2
6	AVUM+ flight	-1.0	+0.5	±0.7

(1) M: mass [kg] of the spacecraft

Table 3.2.1.1.a – Design limit loads for spacecraft (M > 500 kg) integrated as main passenger in VAMPIRE 1194 configuration (see Figure 1.4.2.a), or IR 1194 / HEX-1 configuration (see Figure 1.4.2.b)

Notes:

- The factors apply on spacecraft Center of Gravity.
- The 'minus' sign indicates compression along the longitudinal axis of the launch vehicle and the 'plus' sign tension.
- Lateral loads may act in any direction simultaneously with longitudinal loads.
- The gravity load is included.
- The above table includes both static and dynamic part of the QSL. The separated static and dynamic parts of the QSL will be delivered with CLA results.
- In case of stacked satellites configuration, these QSL are applicable at the Center of Gravity of the full stack and reflect the loads at the stack-to-adapter interface.
- For the load events 1 and 4 (i.e. transient dynamic load cases), the relevant QSL may be exceeded for a payload mass lower than 800 kg (TBC). In this case, QSL shall be analyzed on a case-by-case basis.

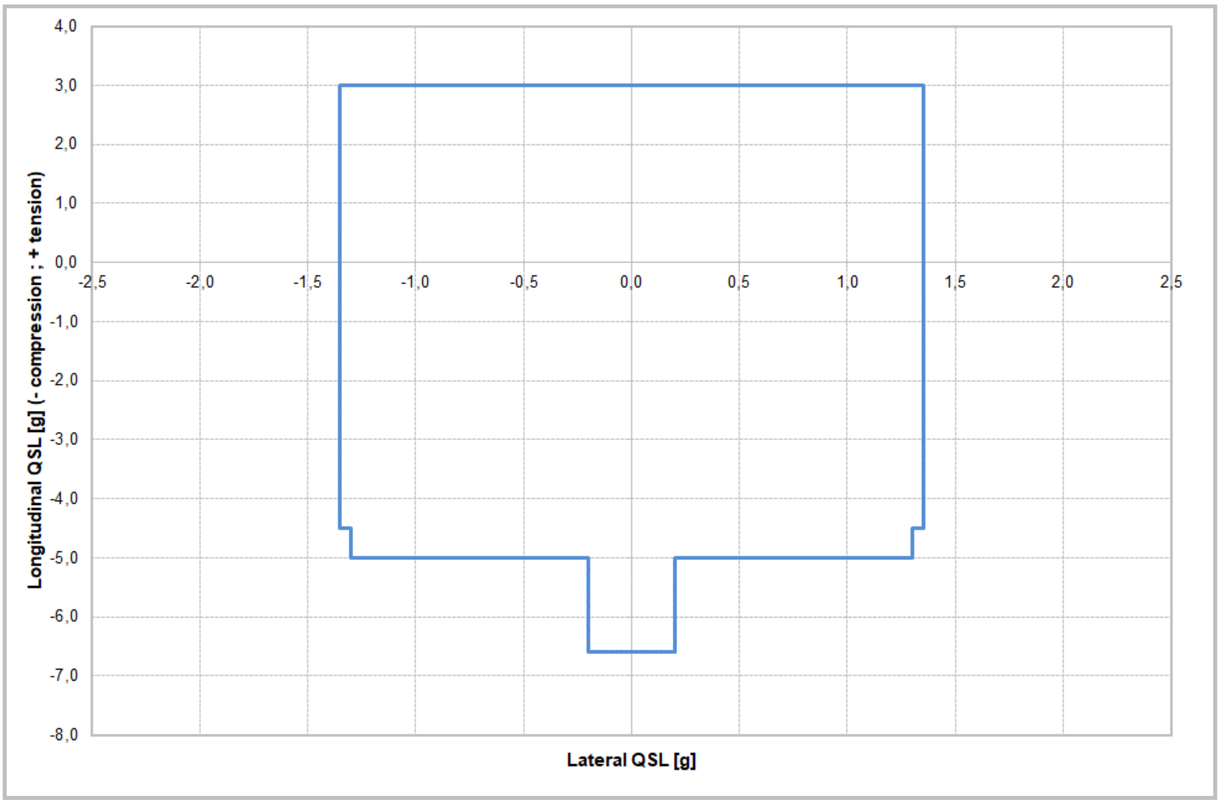


Figure 3.2.1.1.a – Design limit loads for spacecraft (M > 500 kg) integrated as main passenger in VAMPIRE 1194 configuration (see Figure 1.4.2.a), or IR 1194 / HEX-1 configuration (see Figure 1.4.2.b)

3.2.1.2 Quasi-Static Loads in dual launch configuration

For a spacecraft, in upper position of the Active Ring 1194 (AR 1194) on VESPA+R dual launch system (see Figure 1.4.2.c), with mass above 500 kg and complying with the stiffness requirements defined in § 4.2.3.4, the limit levels of quasi-static loads, to be taken into account for the design and dimensioning of the spacecraft primary structure, are defined in Table 3.2.1.2.a and Figure 3.2.1.2.a below.

Load events		**QSL (g) (+ = tension ; - = compression)**		
		Longitudinal		**Lateral**
		Min.	Max.	
1	Lift-off phase	-4.5	+3.0	±2.0
2	Flight with maximum dynamic pressure (Qmax)	-4.0	+1.5	±0.9
3	1st stage (P120C) flight with maximal acceleration and tail off	-5.0	+1.0	±0.7
4	2nd stage (Z40) ignition and flight, 3rd stage (Z9) ignition	-5.0	+3.0	±1.5
5	3rd stage (Z9) maximal acceleration	$-\left(6.8-\frac{M^{(1)}}{1000}\right)-0.2$	N/A	±0.2
6	AVUM+ flight	-1.0	+0.5	±0.7

(1) *M: mass [kg] of the upper part stack*

Table 3.2.1.2.a – Design limit loads for spacecraft (M > 500 kg) in upper position of the AR 1194 / VESPA+R dual launch configuration (see Figure 1.4.2.c)

Notes:

- The factors apply on spacecraft Center of Gravity.
- The 'minus' sign indicates compression along the longitudinal axis of the launch vehicle and the 'plus' sign tension.
- Lateral loads may act in any direction simultaneously with longitudinal loads.
- The gravity load is included.
- The above table includes both static and dynamic part of the QSL. The separated static and dynamic parts of the QSL will be delivered with dynamic CLA results.

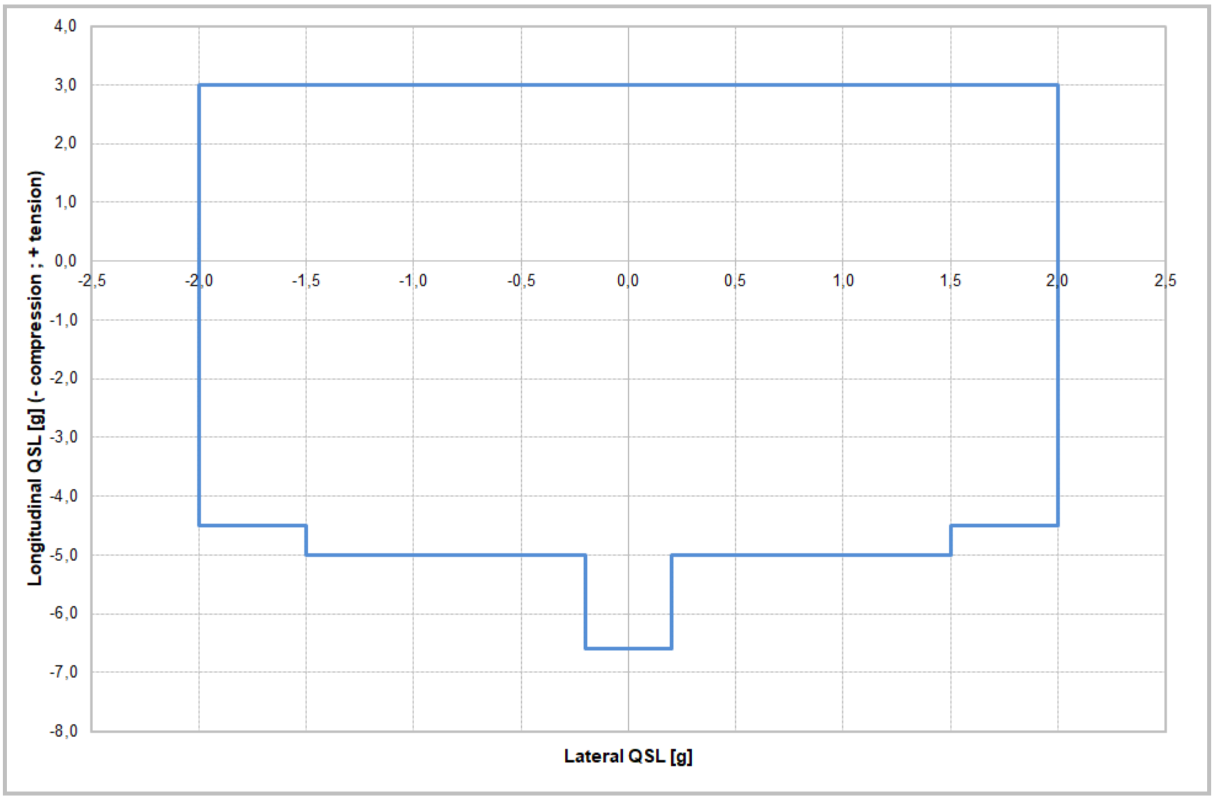


Figure 3.2.1.2.a – Design limit loads for spacecraft (M > 500 kg) in upper position of the AR 1194 / VESPA+R dual launch configuration (see Figure 1.4.2.c)

3.2.2. Line loads peaking induced by launch vehicle structure

The geometrical discontinuities and differences in the local stiffness of the launch vehicle (stiffener, holes, stringers, etc.) may produce local variations of the uniform line loads distribution at the spacecraft-to-adapter interface.

The integral of these variations along the circumference is zero, and the line loads derived from the above QSL are not affected. The dimensioning of the lower part of the spacecraft shall, however, account for these variations which have to be added uniformly at the spacecraft-to-adapter interface to the mechanical line loads obtained for the various flight events.

For the off-the-shelf adapters described in chapter 5, a value of 10% over the average line loads seen by the spacecraft is to be taken into account, with a minimum of 5 N/mm.

3.2.3. Handling loads during ground operations

During the encapsulation phase, the spacecraft is lifted and handled with its adapter and with a part of the carrying structure, if any. For this reason, the spacecraft and its handling equipment must be capable of supporting an additional mass of maximum 220 kg.

The accelerations during crane operations are not higher than:

- 0.12 g (normal stop);
- 0.20 g (emergency stop).

3.2.4. Sine-equivalent dynamics

Sinusoidal excitations affect the launch vehicle during its powered flight (mainly the atmospheric flight), as well as during some of the transient phases.

For a spacecraft with a mass above 500 kg and complying with the stiffness requirements defined in § 4.2.3.4, the limit levels of sine-equivalent vibrations at spacecraft-to-adapter interface to be taken into account for the design and dimensioning of the spacecraft are defined in Table 3.2.4.a and Figure 3.2.4.a below.

Longitudinal direction		
Frequency Band (Hz)	5 – 35	35 – 110
Sine Amplitude (g)	0.8	1.0
Lateral direction		
Frequency Band (Hz)	5 – 30	30 – 110
Sine Amplitude (g)	0.8	0.5

Table 3.2.4.a – Sine-equivalent vibrations at spacecraft interface for spacecraft with mass above 500 kg – All configurations

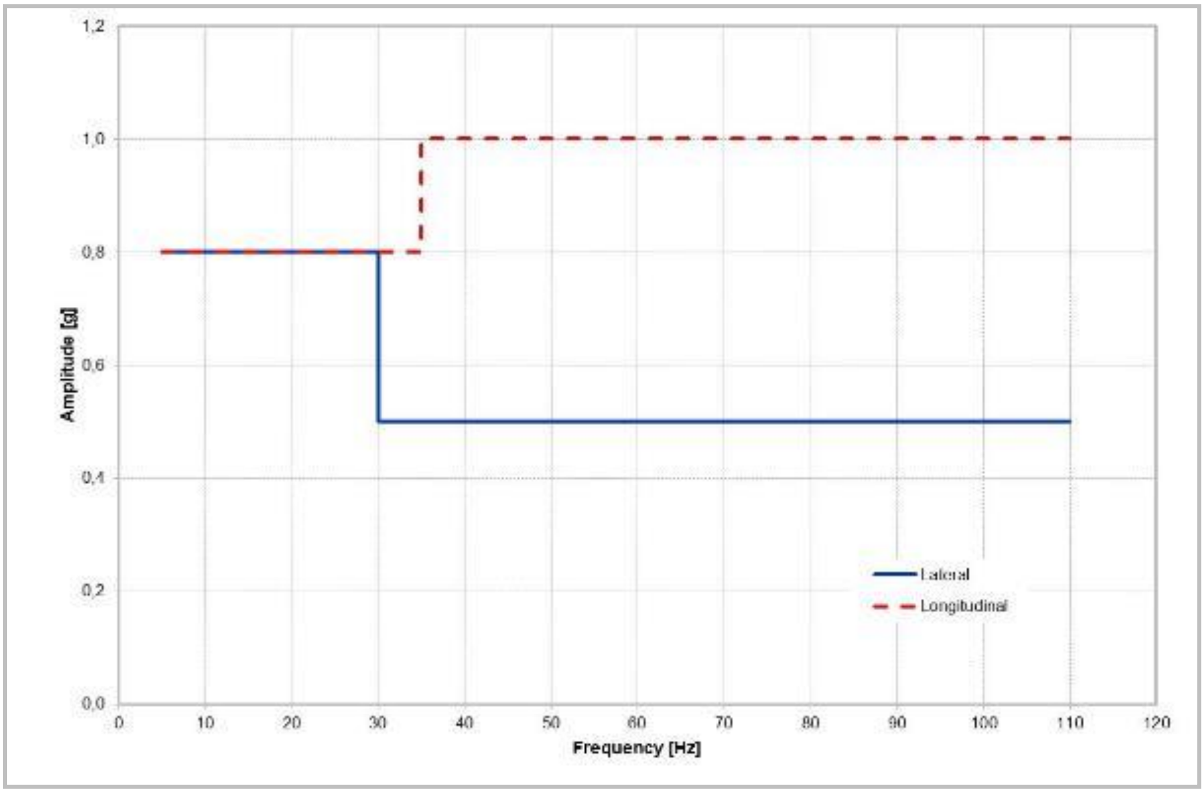


Figure 3.2.4.a – Sine-equivalent vibrations at spacecraft interface for spacecraft with mass above 500 kg – All configurations

3.2.5. Random vibrations

For a spacecraft with a mass above 500 kg:

- For frequencies under 100 Hz, the random environment is covered by the sine environment defined in § 3.2.4 above;
- For frequencies above 100 Hz, the excitations produced by random vibration at the spacecraft base are covered by the acoustic spectrum defined in § 3.2.6 below.

3.2.6. Acoustic vibrations

3.2.6.1. On ground

On ground, acoustic pressure fluctuations under the fairing are generated by the fairing ventilation system (refer to § 3.4.2). The noise level generated in the vicinity of the spacecraft does not exceed 94 dB.

3.2.6.2. In flight

During flight, acoustic pressure fluctuations under the fairing are generated by engine plume impingement on the pad during lift-off and by unsteady aerodynamic phenomena during atmospheric flight.

The acoustic environment during lift-off can be reduced with injection of water on the launch pad.

Apart from lift-off and transonic phase, acoustic levels are substantially lower than the values indicated hereafter.

The envelope spectrum of the noise induced inside the fairing is shown in the Tables 3.2.6.2.a & 3.2.6.2.b and Figures 3.2.6.2.a & 3.2.6.2.b below for the two cases without or with the Water Injection System.

It is assessed that the sound field under the fairing is diffuse.

Without Water Injection System		
Octave center frequency (Hz)	**Flight limit level (dB)** (reference: 0 dB = 2 x 10^{-5} Pa)	
	Lift-off ($H_0 \rightarrow H_0$+7s)	Atmospheric phase (H_0+14s $\rightarrow H_0$+75s)
31.5	124.7	116.0
63	126.8	120
125	134.2	122.4
250	136.6	127
500	136.6	130
1000	128.1	127
2000	124.6	118
OASPL[(1)] (20 – 2828 Hz)	**141.3**	**133.8**
Duration	7 seconds	61 seconds

[(1)] *OASPL: Overall Acoustic Sound Pressure Level*

Table 3.2.6.2.a – Acoustic noise spectrum under the fairing in flight (without Water Injection System)

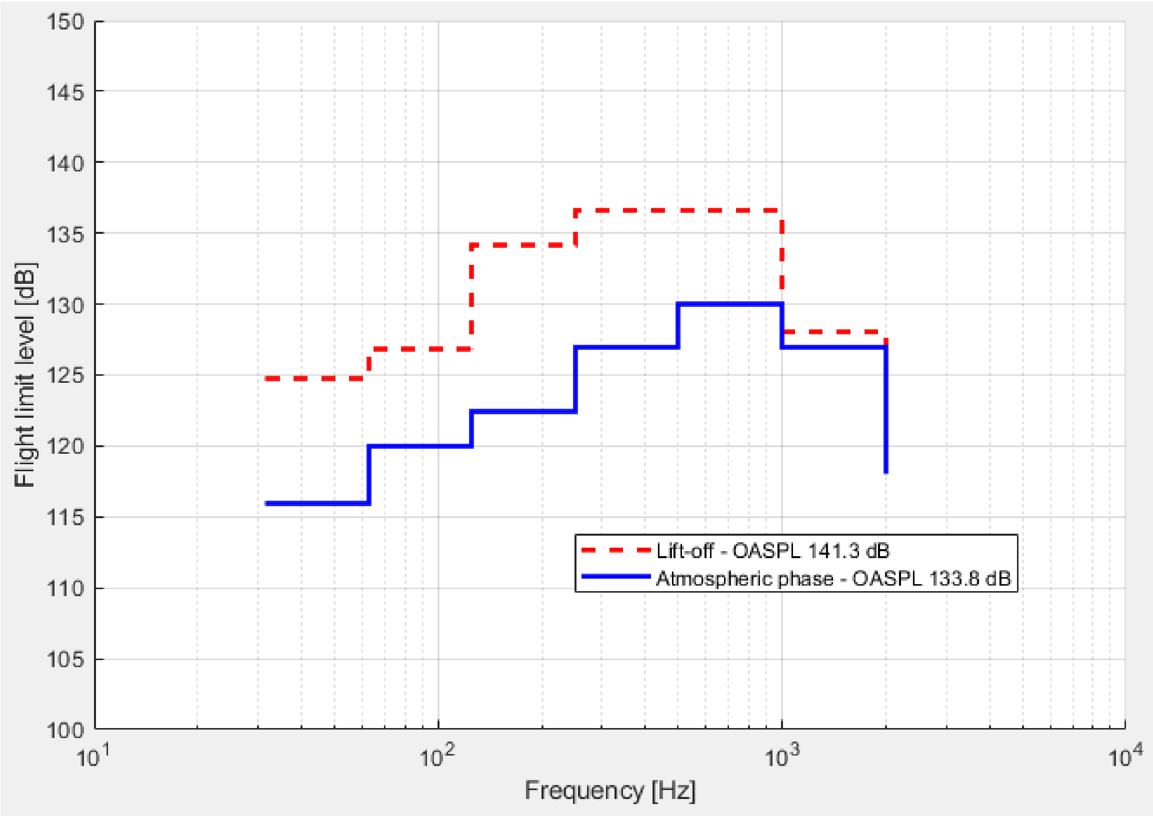


Figure 3.2.6.2.a – Acoustic noise spectrum under the fairing in flight (without Water Injection System)

With Water Injection System		
Octave center frequency (Hz)	**Flight limit level (dB)** (reference: 0 dB = 2 x 10^{-5} Pa)	
	Lift-off ($H_0 \rightarrow H_0$+7s)	Atmospheric phase (H_0+14s $\rightarrow H_0$+75s)
31.5	122.9	116.0
63	127.4	120
125	131.9	122.4
250	133.5	127
500	129.5	130
1000	120.8	127
2000	114.2	118
OASPL(1) (20 – 2828 Hz)	**137.5**	**133.8**
Duration	7 seconds	61 seconds

(1) OASPL: Overall Acoustic Sound Pressure Level

Table 3.2.6.2.b – Acoustic noise spectrum under the fairing in flight (with Water Injection System)

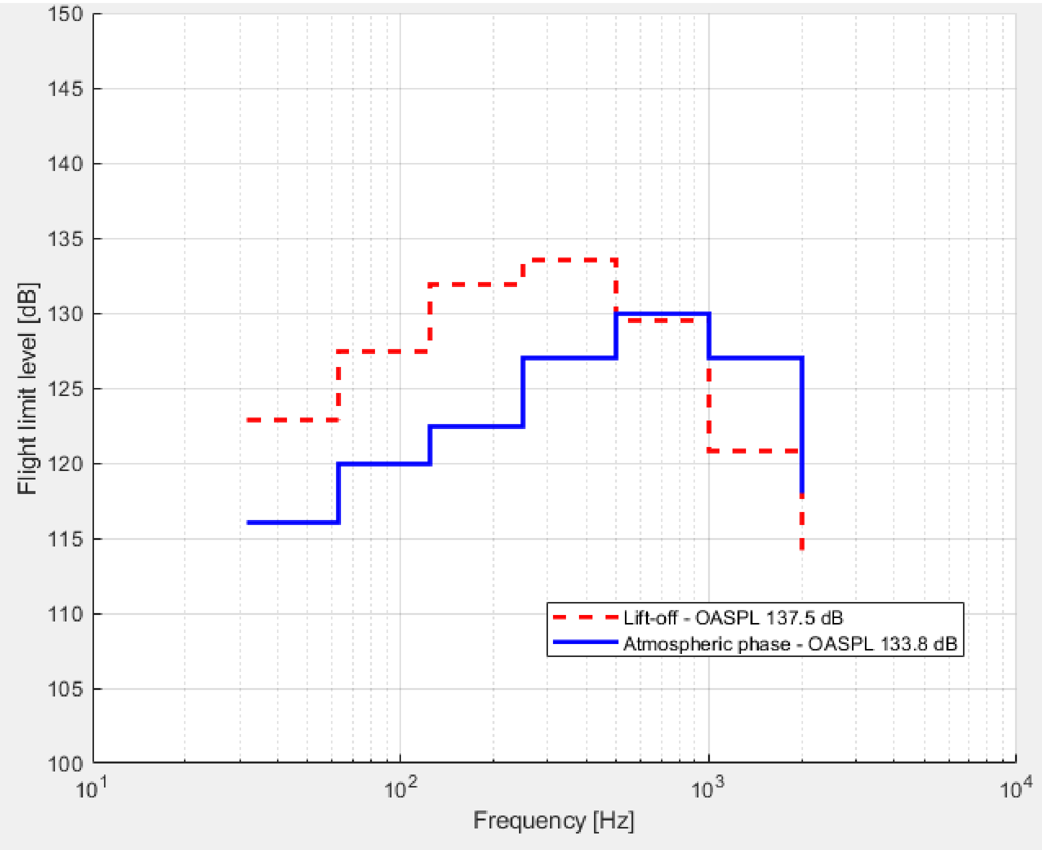


Figure 3.2.6.2.b – Acoustic noise spectrum under the fairing in flight (with Water Injection System)

3.2.7. Shocks

The spacecraft is subject to shock primarily during launcher events (Z9/AVUM+ stage separation) and at spacecraft separation.

The envelope acceleration Shock Response Spectrum (SRS) at the spacecraft/adapter interface (computed with a Q-factor of 10) is presented in Tables 3.2.7.a & 3.2.7.b and Figure 3.2.7.a below. These levels are applied simultaneously in axial and radial directions.

[NB: In case the adapter/separation system is provided by the Spacecraft Authority, the Customer is invited to contact Avio.]

Flight event	Frequency (Hz)	
	100 – 2 000	2 000 – 10 000
	SRS – Shock Response Spectrum (Q = 10) (g)	
Launcher events	30 – 1 500	1 500

Table 3.2.7.a – Shock Response Spectrum (SRS) during launcher events (Z9/AVUM+ separation)

Spacecraft adapter interface diameter	Frequency (Hz)	
	100 – 1 000	1 000 – 10 000
	SRS, Shock Response Spectrum (Q = 10) (g)	
Ø 1194	20 – 1 000	1 000

Table 3.2.7.b – Envelope Shock Response Spectrum (SRS) for clamp-band release

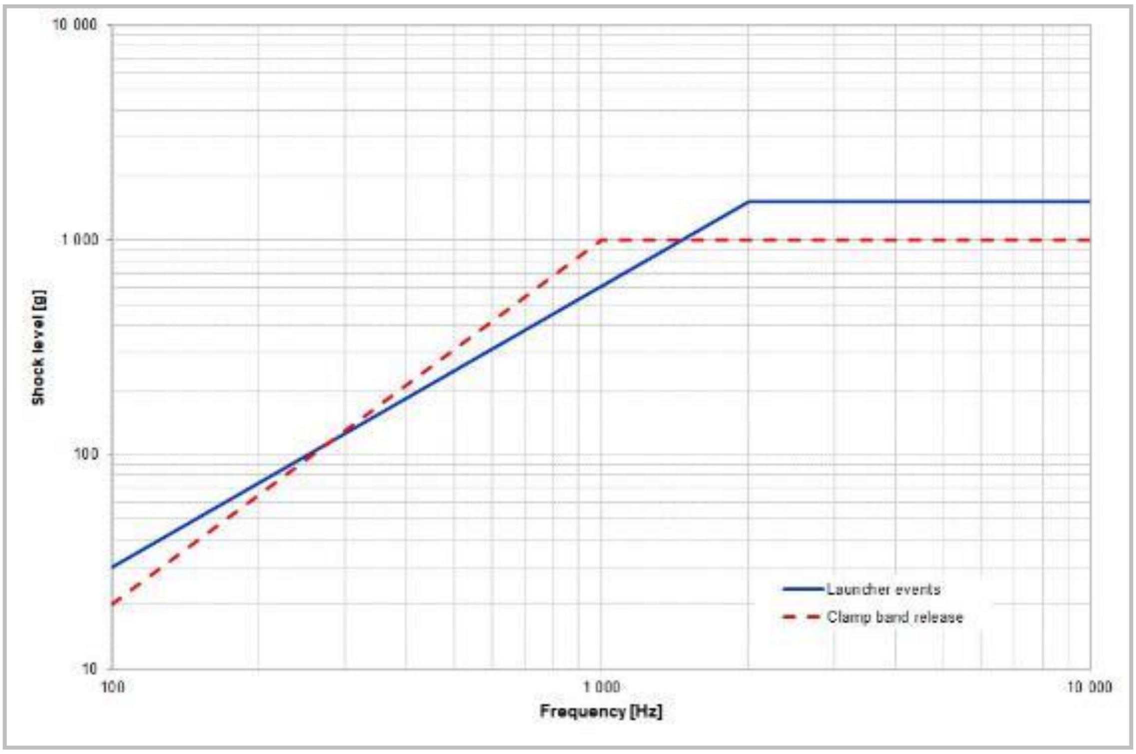


Figure 3.2.7.a – Envelope Shock Response Spectrum (SRS) for Z9/AVUM+ separation (launcher events) and spacecraft separation (clamp-band release) at the spacecraft/adapter interface (Q=10)

3.2.8. Static pressure under the fairing

3.2.8.1. On ground

After encapsulation, the air velocity around the spacecraft due to the ventilation system is lower than 4 m/s. Locally, depending on spacecraft geometry, in close vicinity of fairing air inlets and outlets, this air velocity may be exceeded until 9 m/s. In case of specific concern, please contact Avio.

During specific combined operations of the launch campaign (steps #04 and #06 in Table 3.4.2.2.a), an overpressure (50 mbar maximum) is maintained under the fairing in order to avoid any contamination.

3.2.8.2. In flight

The payload compartment is vented during the ascent phase through 20 one-way vent doors insuring a low depressurization rate of the fairing compartment.

In flight, the depressurization rate inside the fairing can reach a maximum value of 35 mbar/s for a duration of 5 seconds. For the rest of the flight, the depressurization rate is lower than 25 mbar/s.

3.3. LOCAL LOADS

The local loads which shall be considered for spacecraft sizing, on top of the global loads described in § 3.2, are the following:

- Payload adapter separation spring forces;
- Spacecraft umbilical connectors spring forces;
- Flatness effect at spacecraft-to-adapter interface;
- Pre-tension loads associated to the tightening of spacecraft-to-adapter separation subsystem (clamp-band);
- Thermo-elastic loads if applicable.

They will be specified in the Interface Control Document (DCI).

3.4. THERMAL ENVIRONMENT

3.4.1. Introduction

The thermal environment to be considered during spacecraft preparation and launch are:

- On ground, the thermal environment:
  - during the spacecraft preparation within the CSG facilities;
  - when the spacecraft is encapsulated inside the fairing.

- During flight, the thermal environment:
  - before fairing jettisoning;
  - after fairing jettisoning.

3.4.2. Ground operations

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

3.4.2.1. CSG facility environments

The typical thermal environment within the air-conditioned CSG facilities is kept around 23°C ± 2°C for temperature and 50% ± 10% for relative humidity.

3.4.2.2. Thermal conditions under the fairing

During the encapsulation phase and once mated on the launch vehicle, the spacecraft is protected by an air-conditioning system provided by the ventilation through pneumatic umbilical (see Figure 3.4.2.2.a).

Phase		Air conditioning system	Temperature [°C]	Relative humidity [%]	Air flow rate [Nm^3/h]	Duration
Launch preparation nominal sequence						
01	If any, transfer between EPCU building (using CCU)	-	< 26°C	< 60 %	-	-
02	Operation in EPCU (S/C standalone ops, PAC integration & fairing encapsulation)	EPCU air conditioning system	23 ±2°C	40% - 60%	-	As per contractual provisions.
03	Payload Assembly Composite (PAC) transfer from EPCU to SLV	PFRCS air conditioning system	16 ±1°C	≤ 60%	1 500 Nm^3/h ±10%	3h (D-5)
04	PAC hoisting to PFCU and positioning on AVUM+ spacers	Low flow rate to maintain a positive delta pressure under fairing	Ambient temperature	< 130 ppm	50 Nm^3/h ±10%	5h (D-5)
05	PAC stand-by on AVUM+ spacers and final mating on AVUM+	Launch pad air conditioning system	13 < T°< 22°C ±1°C (1)	DP < -10°C	500…2 000 Nm^3/h ±10%	(D-4)
06	PAC ventilation setup for launch	Low flow rate to maintain a positive delta pressure under fairing	Ambient temperature	DP < -10°C	50 Nm^3/h ±10%	4h (D-3)
07	Integrated launch vehicle stand-by and launch preparation	Launch pad air conditioning system	13 < T° < 22°C ±1°C (1)	DP < -10°C	500…2 000 Nm^3/h ±10% (2)	3 days (D-3 → H_0)
In case of launch postponement the day after						
08	Integrated launch vehicle stand-by	Launch pad air conditioning system	13 < T° < 22°C ±1°C (1)	DP < -10°C	500…2 000 Nm^3/h ±10%	1 day

Notes:

(1) The ventilation temperature setpoint will be agreed with Customer in order to fulfill the spacecraft limit temperatures taking into account Spacecraft heat dissipation.

(2) The ventilation flow rate is set at 500 Nm^3/h from 2 hours before the lift-off time (LO-2h), and up to 2 hours after the end of the launch window in case of launch postponement.

Table 3.4.2.2.a - Air conditioning under the fairing

The ventilation characteristics and settings will be such that no condensation shall occur inside the fairing cavity at any time during launch preparation.

The mobile gantry is withdrawn at ≈ LO-3h. In case of launch postponement, it is moved back ≈ LO+2h to protect the launch vehicle.

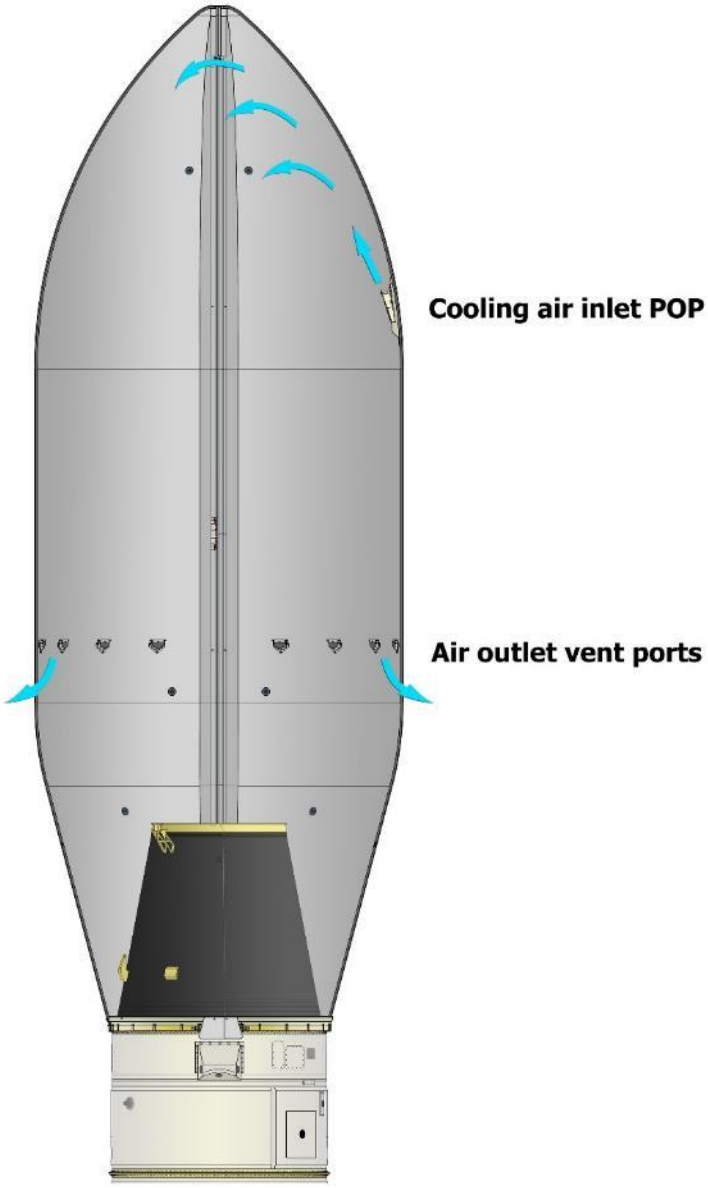


Figure 3.4.2.2.a – Configuration of the launch pad air-conditioning system

3.4.3. Thermal flight environment

3.4.3.1. Thermal conditions 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.

[NB: These figures do not take into account any effect induced by the spacecraft dissipated power.]

3.4.3.2. Aerothermal flux and time of fairing jettisoning

The main criteria for jettisoning the fairing is not to exceed a maximum instantaneous aerothermal flux of 1 135 W/m^2 at 99%. This flux is calculated as a free molecular flow acting on a plane surface perpendicular to the velocity direction ($\frac{1}{2} \rho V^3$).

Another criteria is that the earliest time for fairing jettisoning is 5 seconds after the Z9 ignition. As a result, for most missions, the mission profile is such that the obtained aerothermal flux at and after fairing jettisoning is much lower than 1 135 W/m^2.

3.4.3.3. Thermal conditions after fairing jettisoning

After fairing jettisoning, the spacecraft thermal conditions are the results of the remaining aerothermal fluxes, the solar radiation, albedo and terrestrial infrared radiation, and conductive/radiative exchanges with the launch vehicle.

- **Z9 plume effect**

After fairing jettisoning, the maximal thermal impingement on the payload external surface due to the 3rd stage (Z9) engine firing is:

- lower than 1 500 W/m^2 on the spacecraft plane "A" (see Figure 3.4.3.3.a) perpendicular to the launch vehicle longitudinal axis;
- lower than 600 W/m^2 on the spacecraft surfaces "B" parallel to the launch vehicle longitudinal axis and on the other spacecraft surfaces.

The maximum application time is 115 seconds.

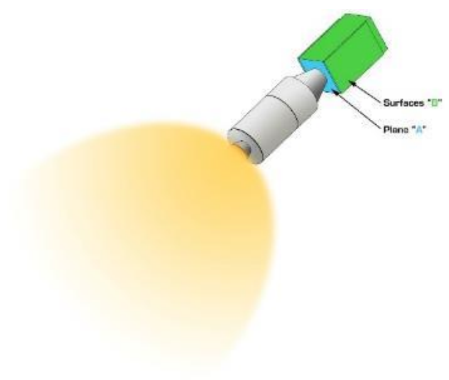


Figure 3.4.3.3.a – Spacecraft surfaces exposed to the 3rd stage (Z9) plume radiation

- **Coast phases**

During coast phases, in order to smooth the thermal environment, the launcher is set in a so-called barbecue mode, with low spin up to 2°/s with an accuracy of ± 1 °/sec, and with the launcher longitudinal axis perpendicular to the Sun's direction.

Temperature of spacecraft equipment will be assessed by the thermal coupled analysis (refer to § 7.4.2.3.5).

3.5. CLEANLINESS AND CONTAMINATION

3.5.1. Cleanliness

The following standard practices ensure that spacecraft cleanliness conditions are met:

- A clean environment is provided during production, test and delivery of all upper-composite components (fairing, adapter and carrying system, if any) to prevent contamination and accumulation of dust. The launch vehicle materials are selected not to generate significant organic deposit during all ground phases of the launch preparation.
- All spacecraft operations are carried out in controlled Class 100,000 (or ISO 8) clean rooms. If necessary for spacecraft transfer between buildings, the spacecraft is transported in payload containers (CCU) with the cleanliness Class 100,000 (or ISO 8). All handling equipment is clean room compatible, and it is cleaned and inspected before its entry into the facilities.
- Prior to the encapsulation of the spacecraft, the cleanliness of the fairing is verified based on the Visibly Clean Level 2 criteria, and cleaned if necessary.
- Once encapsulated, during transfer, hoisting or standby on the launch pad, the Payload Assembly Composite will be hermetically closed and air-conditioning of the fairing will be provided.
- On the launch pad, access can be provided to the payload. The mobile gantry not being air-conditioned, cleanliness level is ensured by the fairing overpressure.

The cleanliness conditions are summarized in Table 3.5.1.a, below.

Spacecraft location	**Transfer between EPCU buildings (if needed)**	**Spacecraft in EPCU**		**Transfer between EPCU and SLV (using PFRCS)**		**Spacecraft on Launch Vehicle**
	In CCU container	Not Encapsulated	Encapsulated (in EPCU)	Transfer on launch pad [(1)]	Hoisting [(1)]	Launch preparation [(1)]
Cleanliness class	ISO 8 (100,000)	ISO 8 (100,000)	ISO 8 (100,000)	ISO 7 (10,000)	ISO 7 (10,000)	ISO 7 (10,000)
Duration	~1 h 30	As per contractual provisions	~1 day	~3 h	~5 h	5 days

[(1)] *With the following filtration of air-conditioning system: standard HEPA H14 (DOP 0.3 µm).*

Table 3.5.1.a – Cleanliness conditions

3.5.2. Contamination

The organic and particle contaminations in facilities and under the fairing are controlled by contamination witness.

Plates are set up inside the buildings and inside the fairing from encapsulation until D-1. The launch vehicle systems are designed to preclude in-flight contamination of the spacecraft.

3.5.2.1. Particle contamination

- **Deposited particle contamination in the clean rooms**

In accordance with ECSS-Q-ST-70-01C, the ISO 8 cleanliness level is equivalent to a deposited particle contamination of 1 925 ppm/week.

- **Deposited particle contamination on launcher items**

Launcher equipment in the vicinity of a satellite will be cleaned in case the deposited particles contamination exceeds 4 000 ppm.

Prior to the encapsulation of the spacecraft, the cleanliness of the fairing is verified based on the Visibly Clean Level 2 criteria, and cleaned if necessary.

3.5.2.2. Organic contamination

- **Deposited organic contamination in the clean rooms**

The clean rooms and the surrounding environment of a satellite shall not generate deposited organic contamination exceeding 0.5 mg/m^2/week.

- **Deposited organic contamination on launcher items**

Launcher equipment in the vicinity of a satellite will be cleaned in case deposited organic contamination exceeds 2 mg/m^2.

- **Deposited organic contamination from encapsulation to spacecraft separation**

The maximum organic non-volatile deposit on satellite surfaces is lower than 4 mg/m^2 from encapsulation and until 4h00 after satellite separation, taking into account a maximum of 2 mg/m^2 due to out-gassing launcher materials and 2 mg/m^2 due to functioning of launch vehicle systems.

The non-volatile organic contamination generated during ground operations and in flight is cumulative.

3.5.3. Synthesis of thermal and cleanliness environment during ground phase

Table 3.5.3.a below provides a synthesis of the standard thermal and cleanliness environment during the operations.

[NB: The Combined Operations activities flow is described in § 7.5.5.4.]

Spacecraft location	Phase	Planning	Operations	Cleanliness class	Temperature	Hygrometry	Duration
Spacecraft in High Bay facilities (EPCU)	S/C Stand-alone activities			ISO 8 (100,000)	23 ± 2° C	40 – 60 %	According to contract. provisions
	Combined Operations	D-8	S/C mating on its adaptor				~1 day
		D-7	Fairing closure				~1 day
		D-6	Final PAC preparation and PAC transfer to the airlock				~1 day
Payload Assembly Composite (PAC) Transfer		D-5	PAC transfer on Launch Pad using PFRCS	ISO 7 (10,000)	16 ± 1° C	≤ 60 %	~5 h
			PAC hoisting inside Mobile Gantry	ISO 7 (10,000)	Ambient	< 130 ppm	~3 h
Payload Assembly Composite (PAC) on Launcher		D-4	PAC mating on Launcher	ISO 7 (10,000)	Selected by Customer 13 < T° < 22°C (± 1° C)	Dew Point < -10°C	1 day *
		From D-3 to D0	Launch preparation				4 days
			Final countdown (reduced flow rate)				Few minutes

Table 3.5.3.a Synthesis of thermal and cleanliness environment during ground phase

3.6. ELECTROMAGNETIC ENVIRONMENT

The launch vehicle and launch range RF systems and electronic equipment are generating electromagnetic fields that may interfere with satellite equipment and RF systems. The electromagnetic environment depends on the characteristics of the emitters and the configuration of their antennas.

3.6.1. Launch vehicle and launch range RF systems

3.6.1.1. Launcher

The launch vehicle is equipped with the following transmission and reception systems:

- A telemetry system in S-band comprising one transmitter, coupled with one left-handed antenna and one right-handed antenna having an omnidirectional radiation pattern. This transmitter is located in the AVUM+ avionic module with its antennas fitted in the external section of the AVUM+ upper stage. The transmission frequency is in the 2 200 – 2 290 MHz band.
- A navigation system in L-band comprising two antennas and a receiver with reception frequencies in the 1 164 – 1 300 MHz (GPS L2 band) and in the 1 555 – 1 595 MHz (GPS L1 and GALILEO E1 band).
- A telecommand-destruct reception system in UHF band, comprising two receivers operating in the 440 – 460 MHz band. Each receiver is coupled with a system of two antennas, located on the Z9/AVUM+ interstage, having an omnidirectional pattern and no special polarization.
- A radar transponder system in C-band, comprising two identical transponders with a reception frequency of 5 690 MHz and transmission frequencies in the 5 700 – 5 900 MHz band. Each transponder is coupled with a system of two antennas, located on the Z9/AVUM+ interstage, with an omnidirectional pattern and right-handed circular polarization.

3.6.1.2. Range

The ground radars, local communication network and other RF means generate an electromagnetic environment at the preparation facilities and launch pad. Together with the launch vehicle emission, they constitute an integrated electromagnetic environment applied to the spacecraft. The electromagnetic data are based on the periodical electromagnetic site survey conducted at CSG.

The launch base is equipped with the following systems:

- RADAR Transponder Transmitter (in C-Band) at 5 690 MHz
- Meteo RADAR Transmitters at 5 475 MHz and 5 600 MHz
- Telecommand Transmitter
- Primary RADAR Transmitters at 1-1.5 GHz and 2.9-3.4 GHz

3.6.2. The electromagnetic field

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 given in Figure 3.6.2.a. These levels are applicable for the complete cavity inside the fairing.

Spacecraft compatibility with these emissions will be assessed during the preliminary and final EMC analyses (refer to § 7.4.2.2.4 and 7.4.2.3.4).

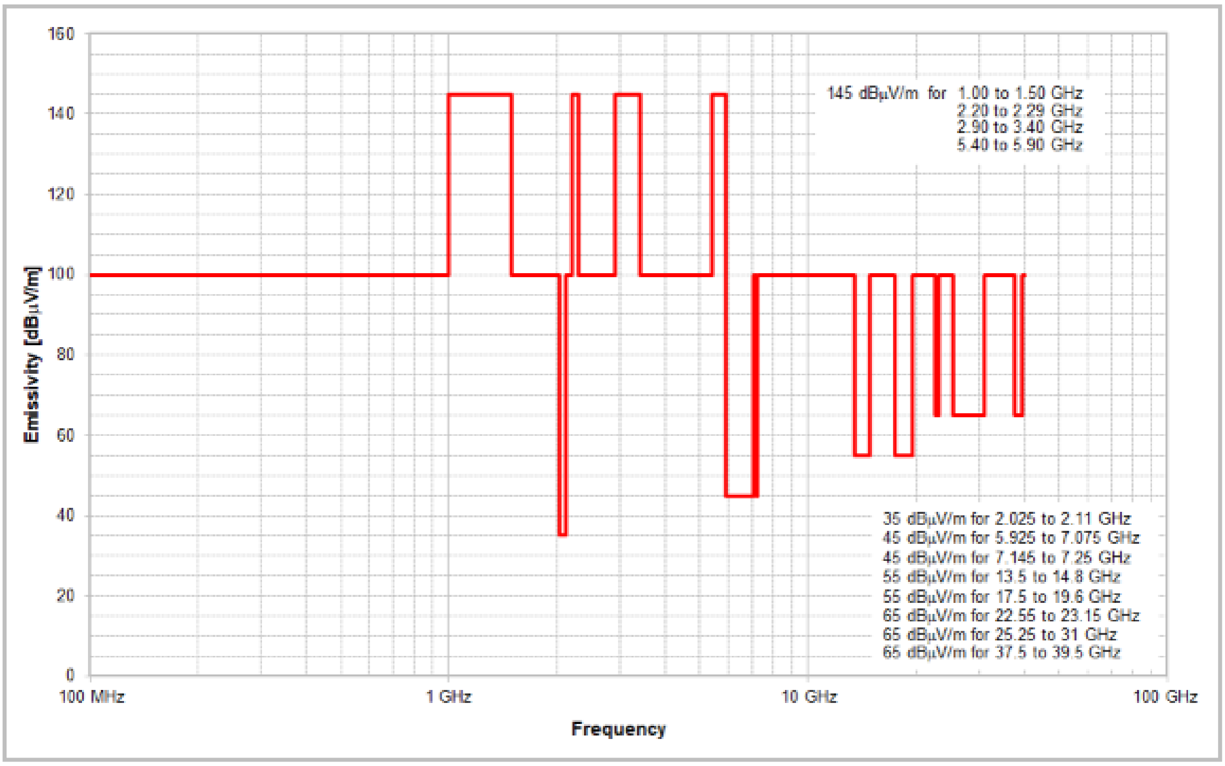


Figure 3.6.2.a – Spurious radiation and intentional emissions by launch vehicle and launch base – Narrow-band electrical field

VHF/UHF band is used by the range to communicate (Refer to § 6.3.1). If this frequency band interferes with satellites susceptibility, please contact Avio.

3.7. ENVIRONMENT VERIFICATION

The Vega C telemetry system captures low and high frequency data during the flight from the sensors installed on the fairing, upper stage and adapter and then relay these data to the telemetry ground stations. These measurements are recorded and processed during post-launch analysis to derive the actual environment to which the spacecraft was submitted to during the launch. A synthesis of the results is provided to the Customer.

SPACECRAFT DESIGN AND VERIFICATION REQUIREMENTS — Chapter 4

4.1. INTRODUCTION

The design and the verification requirements, that shall be taken into account by any Customer intending to launch a spacecraft compatible with the Vega C launch vehicle, are detailed in this chapter.

The requirements presented in the present chapter are applicable for spacecraft with a mass above 500 kg, using the adapter and/or carrying system described in chapter 5.

For satellites with a mass below 500 kg, the reader shall refer to the SSMS (Small Spacecraft Mission Service) Vega C User's Manual.

[NB: In case the adapter/separation system is provided by the Spacecraft Authority, the Customer is invited to contact Avio.]

4.2. DESIGN REQUIREMENTS

4.2.1. Safety requirements

To be compliant with the CNES/CSG safety rules applicable to the spacecraft operations at CSG, the Customer is required to design the spacecraft in conformity with the Payload Safety Handbook (CSG-NT-SBU-16687-CNES, Issue 2 Revision 1, August 2022) (PSH). The PSH compiles the principles and rules applicable to the design, qualification, production and implementation of spacecraft to be launched from CSG.

[NB: Refer to § 7.6.2 for a description of the spacecraft safety submission process.]

4.2.2. Selection of spacecraft materials

The spacecraft materials must satisfy the following outgassing criteria:

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

Those criteria are measured in accordance with the procedure ECSS-Q-ST-70-02C "Thermal vacuum outgassing test for the screening of space materials".

4.2.3. Spacecraft properties

4.2.3.1. Payload mass and Center of Gravity limits

The spacecraft mass and Center of Gravity (CoG) height shall comply with the limits described in the Table 4.2.3.1.a. below.

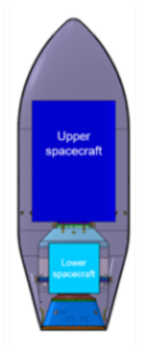
		Mass & CoG height limits
	Main passenger – VAMPIRE 1194 configuration	**2 500 kg @ 2 000 mm**
	Main passenger – IR1194/HEX-1 configuration	**1 500 kg @ 1 500 mm**
	Upper passenger – AR 1194/VESPA+R configuration	**1 700 kg @ 2 200 mm**

Table 4.2.3.1.a – Spacecraft and CoG height limits

For spacecraft with characteristics exceeding this domain, please contact Avio.

4.2.3.2. Static unbalance

- **Spacecraft separation in three-axis stabilized mode**

  The centre of gravity of the spacecraft must stay within a distance shorter than 30 mm from the longitudinal axis.

  A static unbalance above 15 mm may generate cinematic conditions after spacecraft separation greater than those described in § 2.9.2.1. If necessary, the separation system (number and location of the springs) can be tuned to counteract the spacecraft nominal static unbalance, at spacecraft separation.

- **Spacecraft separation in spin mode**

  The centre of gravity of the spacecraft must stay within a distance shorter than 15 mm from the launch vehicle longitudinal axis.

4.2.3.3. Dynamic unbalance

To ensure the spacecraft separation conditions in spin mode, described in the chapter 2, the maximum spacecraft dynamic unbalance shall be: $\varepsilon \leq 1$ degree for spin payloads and $\varepsilon \leq 6$ degrees for three-axes controlled payloads.

(ε corresponding to the angle between the spacecraft longitudinal geometrical axis and the spacecraft principal roll inertia axis.)

4.2.3.4. Frequency requirements

To prevent dynamic coupling with fundamental modes of the launch vehicle, the spacecraft should be designed with a structural stiffness which ensures that the following requirements are fulfilled. In that case, the design limit load factors in § 3.2.1 are applicable.

- **Lateral frequencies**

The fundamental (primary) frequency in the lateral axis of a spacecraft cantilevered at the interface must be as follows, with an off-the-shelf adapter:

$$> 12 \text{ Hz}$$

No local mode should be lower than the first fundamental frequencies, apart from sloshing modes which have to be analyzed on a case-by-case basis.

- **Longitudinal frequencies**

The fundamental (primary) frequency in the longitudinal axis of a spacecraft cantilevered at the interface must be as follows, with an off-the-shelf adapter:

$$> 20 \text{ Hz}$$

No local mode should be lower than the first fundamental frequencies, apart from sloshing modes which have to be analyzed on a case-by-case basis.

Nota:	Primary mode:	Mode associated with large effective masses (in practice, there are one or two primary modes in each direction).
	Secondary mode:	The mode which is not primary, i.e. with small effective mass.

4.2.3.5. Line loads peaking induced by spacecraft

The maximum value of the peaking line loads induced by the spacecraft, along its interface with the launcher, is allowed in local areas to be up to 10% over the maximum line loads induced by the dimensioning loads (deduced from QSL table in § 3.2.1.).

4.2.3.6. Spacecraft RF emissions

To prevent the impact of spacecraft RF emission on the proper functioning of the launch vehicle equipment and RF systems during ground operations and in flight:

- The spacecraft should be designed to respect the launch vehicle susceptibility levels given in Table 4.2.3.6.a and illustrated in Figure 4.2.3.6.a;
- The spacecraft must not overlap the frequency bands of the launch vehicle emitters/receivers.

The allocated frequencies to the ESA-developed launch vehicles operating from CSG, are:

- in the S-band, 2 206.5, 2 218, 2 227, 2 249, 2 254.5, 2 267.5 and 2 284 MHz with a bandwidth of 1 MHz and 2 805.5 MHz with a bandwidth of 4 MHz;
- in the C-band, 5 745 and 5 790 MHz with a bandwidth of 3 MHz.

The spacecraft RF emission (using spacecraft antennas) is allowed during some ground operations. However, no spacecraft RF emission and no change of the spacecraft configuration are allowed during countdown and ascent phase up to spacecraft separation + 20 s.

In addition, the Customer is not authorized to send any telecommand signal from ground to the spacecraft, nor to generate any command by a spacecraft onboard system (sequencer, computer, etc.), during the whole ascent phase from Lift-Off (LO) up to spacecraft separation + 20s.

For dual launch configuration, in case of compatibility issue between passengers, an emission time sharing plan may be set-up on Avio's request.

Spurious radiations acceptable to launch vehicle	
Frequency range	**Level**
From 14 kHz to 420 MHz	100 dBµVm
From 420 MHz to 480 MHz	35 dBµV/m
From 480 MHz to 1 000 MHz	100 dBµV/m
From 1 000 MHz to 1 164 MHz	145 dBµV/m
From 1 164 MHz to 1 300 MHz	40 dBµV/m
From 1 300 MHz to 1 555 MHz	145 dBµV/m
From 1 555 MHz to 1 595 MHz	40 dBµV/m
From 1 595 MHz to 5 640 MHz	145 dBµV/m
From 5 640 MHz to 5 825 MHz	70 dBµV/m
From 5 825 MHz to 40 GHz	145 dBµV/m

Table 4.2.3.6.a – Spurious radiations acceptable to launch vehicle
Narrow-band electrical field measured at the AVUM+ / carrying structure interface

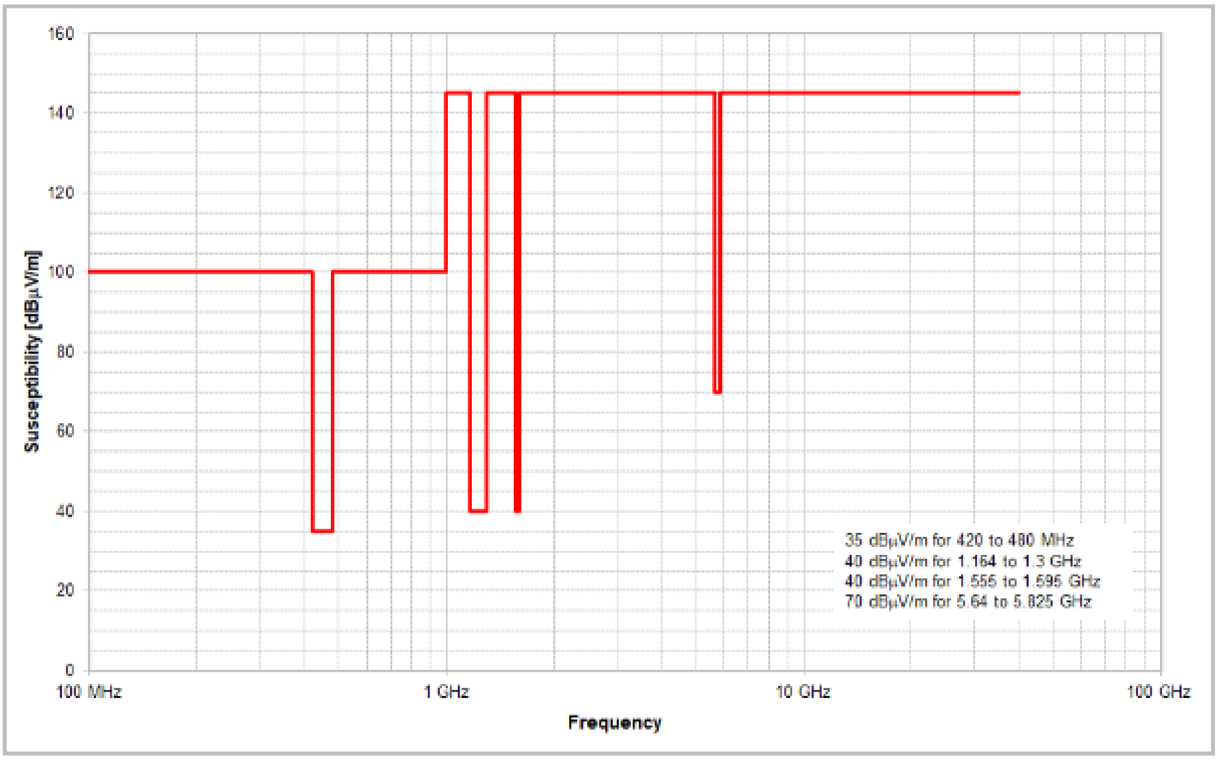


Figure 4.2.3.6.a – Spurious radiations acceptable to launch vehicle
Narrow-band electrical field measured at the AVUM+ / carrying structure interface

4.3. SPACECRAFT COMPATIBILITY VERIFICATION REQUIREMENTS

4.3.1. Verification logic

The spacecraft authority shall demonstrate that the spacecraft structure and equipment are capable of withstanding the maximum expected launch vehicle 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 4.3.1.a below.

Spacecraft development approach	Model	Static	Sine vibration	Random vibration	Acoustic	Shock [(5)]
With Structural Test Model (STM)	STM	Qual. test	Qual. test	Qual. test	Qual. test	Shock test characterization and analysis
	FM1	By heritage from STM [(1)]	Protoflight test [(2)]	Protoflight Test [(2)]	Protoflight test [(2)]	Shock test characterization and analysis or by heritage [(1)]
	Subsequent FM's [(3)]	By heritage from STM [(1)]	Acceptance test (optional) Or Based on manufacturing control, quality process and analysis	Acceptance test (optional)	Acceptance test	By heritage [(1)] and analysis
With ProtoFlight Model (PFM)	PFM = FM1	Qual. test or by heritage [(4)]	Protoflight test [(2)]	Protoflight Test [(2)]	Protoflight test [(2)]	Shock test characterization and analysis or by heritage [(4)]
	Subsequent FM's [(3)]	By heritage [(4)]	Acceptance test (optional) Or Based on manufacturing control, quality process and analysis	Acceptance test (optional)	Acceptance test	By heritage [(4)] and analysis

Table 4.3.1a – Spacecraft verification logic

Notes:

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

[(2)] Protoflight approach means qualification levels and acceptance duration/sweep rate.

[(3)] Subsequent FM: spacecraft identical to FM1 (same primary structure, major subsystems and appendages).

[(4)] If qualification is claimed by heritage, the representativeness of the previous model (which sustained the tests) with respect to the actual flight model must be demonstrated.

[(5)] Refer to § 4.3.3.4 for a detailed description of the possible approaches.

The mechanical environmental test plan, for spacecraft qualification and acceptance, shall comply with the requirements presented hereafter and shall be reviewed and approved by Avio 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 is 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 perform again some mechanical tests must be reassessed. If, despite 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 or any other passenger.

Also, it is suggested that the Customer will implement tests to verify the susceptibility of the spacecraft to the thermal and electromagnetic environment and will tune by this way the corresponding spacecraft models used for the mission analysis.

4.3.2. Safety factors

Spacecraft qualification and acceptance test levels are determined by increasing the design limit load factors presented in § 3.2 by the safety factors given in Table 4.3.2.a below. The spacecraft must have positive margins with these safety factors.

Spacecraft tests	**Qualification [3]**		**Protoflight**		**Acceptance**	
	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 [1]	1.25	4.0 oct./min [1]	1.0	4.0 oct./min [1]
Acoustics	+3 dB (or 2)	60 s	+3 dB (or 2)	30 s	1.0	30 s
Shock	+3 dB (or 1.41)	N/A [2]	+3 dB (or 1.41)	N/A [2]	N/A	

Table 4.3.2.a – Test factors, rate and duration

Notes:

[1] Refer to § 4.3.3.2.

[2] Number of tests to be defined in accordance with methodology for qualification (see § 4.3.3.5.).

[3] If qualification is not demonstrated by test, it is reminded that a safety factor of 2 (margin ≥ 100%) is requested with respect to the design limit.

4.3.3. Spacecraft compatibility tests

4.3.3.1. Static tests

Static load tests (in the case of a 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 (§ 3.2.1) and considering the additional line loads peaking (§ 3.2.2) and the local loads (§ 3.3).

The qualification factors (§ 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 qualification levels to be applied are derived from the flight limit amplitudes specified in § 3.2.4 and the safety factors defined in § 4.3.2. They are presented in Table 4.3.3.2.a here below.

Sine	Frequency range [Hz]	Qualification levels (0-peak) [g]	Protoflight levels (0-peak) [g]	Acceptance levels (0-peak) [g]
Longitudinal	1 – 5 [(1)]	10 mm	10 mm	8 mm
	5 – 35	1.0	1.0	0.8
	35 – 110	1.25	1.25	1.0
Lateral	1 – 5 [(1)]	10 mm	10 mm	8 mm
	5 – 30	1.0	1.0	0.8
	30 – 110	0.625	0.625	0.5

Table 4.3.3.2.a – Sinusoidal vibration tests levels

Notes:

[(1)]: Pending on the potential limitations of the satellite manufacturer's shaker, the achievement of the qualification levels in the [1-5Hz] frequency range can be subject to agreement in the frame of a Request for Waiver, pending that the spacecraft does not present internal modes in that range.

A notching procedure, to prevent excessive loading of the spacecraft structure or equipment, can be agreed in the frame of a Request for Waiver. The justification will be based on the latest Coupled Loads Analysis (CLA) available at the time of the tests. However, it must not jeopardize the tests' objective to demonstrate positive margins of safety with respect to the flight loads.

Sweep rates may be modified on a case-by-case basis depending on the actual damping of the spacecraft structure.

4.3.3.3. Acoustic vibration tests

Acoustic testing should be accomplished in a reverberant chamber. The volume of the chamber with respect to that of the spacecraft shall be sufficient so that the applied acoustic field is diffuse.

The test measurements shall be performed at an optimum distance all around the spacecraft, in order to avoid "wall effect".

The acoustic specification to be considered for spacecraft testing is defined considering:

- The acoustic limit levels described in Table 3.2.6.2.a;
- The margin policy defined in Table 4.3.2.a;
- The transient nature of the maximum acoustic levels recorded during the first seven seconds of the lift-off phase.

Without water injection system				
Octave center frequency [Hz]	**Qualification levels [dB]**	**Protoflight levels [dB]**	**Acceptance levels [dB]**	**Test tolerance [dB]**
31.5	127.7	127.7	124.7	-2 ; +4
63	129.8	129.8	126.8	-1 ; +3
125	137.2	134.2	134.2	-1 ; +3
250	139.6	136.6	136.6	-1 ; +3
500	139.6	139.6	136.6	-1 ; +3
1 000	131.1	131.1	128.1	-1 ; +3
2 000	127.6	127.6	124.6	-1 ; +3
OASPL[(1)] (20 – 2828 Hz)	144.3	142.9	141.3	-1 ; +3
Test duration	60 s	30 s	30 s	

[(1)] *OASPL: Overall Acoustic Sound Pressure Level*

Table 4.3.3.3.a – Acoustic vibration test levels (<u>without</u> water injection system)

With water injection system				
Octave center frequency [Hz]	**Qualification levels [dB]**	**Protoflight levels [dB]**	**Acceptance levels [dB]**	**Test tolerance [dB]**
31.5	125.9	125.9	122.9	-2 ; +4
63	130.4	130.4	127.4	-1 ; +3
125	134.9	131.9	131.9	-1 ; +3
250	136.5	133.5	133.5	-1 ; +3
500	132.5	132.5	129.5	-1 ; +3
1 000	123.8	123.8	120.8	-1 ; +3
2 000	117.2	117.2	114.2	-1 ; +3
OASPL[(1)] (20 – 2828 Hz)	140.5	138.7	137.5	-1 ; +3
Test duration	60 s	30 s	30 s	

(1) OASPL: Overall Acoustic Sound Pressure Level

Table 4.3.3.3.b – Acoustic vibration test levels (with water injection system)

Notes:

- The levels provided in Table 4.3.3.3.a and Table 4.3.3.3.b are applicable to the Average Sound Pressure Level per octave band.
- Test tolerances allow only to cover test calibration dispersion.
- 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.

4.3.3.4. Shock qualification

The ability of the spacecraft to withstand the shock environment generated by the stages' separation, the fairing jettisoning and the spacecraft separation shall follow a comprehensive process including tests and analysis.

✓ Launcher events (fairing/stages separation)

The approach recommended for demonstration of the spacecraft qualification to these shock events is based on **analysis** of internal spacecraft transfer functions.

The methodology "D" presented in the ECSS document ref. ECSS-E-HB-32-25A (Mechanical Shock Design and Verification Handbook) shall be applied for computations of the spacecraft internal attenuations, when submitted to launcher events shock spectrum as defined in Table 3.2.7.a.

As alternative approach, a **shock test** can be performed by the spacecraft manufacturer in order to characterize the shock transmission inside the spacecraft in clamped configuration and define the transfer functions between the spacecraft interface plane and the equipment base.

This test can be performed on the STM, PFM or on the first flight model, provided that the spacecraft configuration is representative of the flight model (structure, load paths, equipment presence and location…), with spacecraft cantilevered at its interface. This test can be performed once and the verification performed covers the spacecraft platform as far as no structural modification alters the validity of the analysis.

This qualification is obtained by comparing the component unit qualification levels to the equipment base levels experienced applying the interface shock spectrum specified in Table 3.2.7.a with the dedicated transfer function.

Regardless of the approach, a minimum +3 dB margin has to be highlighted to validate the qualification (see Table 4.3.2.a). Note that each unit qualification status can be obtained from environmental qualification tests other than shock tests by using equivalent rules (e.g. from sine or random vibration tests).

✓ Clamp-band release event

The demonstration of the spacecraft's ability to withstand the separation shock generated by the clamp-band release shall be based on one of the following methods:

Method number one: Release drop test, extrapolation to specification, comparison to spacecraft sub-systems qualification:

A clamp-band release drop test is conducted with the tension of the band set at the **nominal tension at installation**. During this test, interface levels and equipment base levels are measured. This test can be performed on the STM, on the PFM or on the first flight model provided that the spacecraft structure close to the interface as well as the equipment locations and associated supports are equivalent to those of the flight model.

The release shocks generated at the spacecraft's interface and measured during the above-mentioned test are compared to the applicable shock specification (see Table 3.2.7.b). The ratio derived from the above comparison is then considered to extrapolate the measured equipment levels to the specification.

These extrapolated shock levels are then increased by a safety factor of +3 dB and are compared to the qualification status of each spacecraft subsystem and/or equipment.

[NB: Each unit qualification status can be obtained from other environmental qualification tests (e.g. from sine or random vibration tests) by using equivalent rules.]

Method Number Two: Release drop test with maximal tension, direct comparison to spacecraft sub-systems qualification:

A clamp-band release drop test is conducted with the tension of the band set as close as possible to its **maximum value during flight**. During this test, interface levels and equipment base levels are measured. This test can be performed on the STM, on the PFM or on the first flight model provided that the spacecraft structure close to the interface as well as the equipment locations and associated supports are equivalent to those of the flight model.

The induced shocks generated on spacecraft equipment measured during the above-mentioned test are then increased by:

- A +3 dB uncertainty margin aiming at deriving flight limit environment from the single test performed in flight-like configuration;
  [NB: In case two clamp-band release drop tests are performed, this +3 dB uncertainty margin can be removed but the maximum recorded value between the two tests has to be considered for each equipment.]
- A +3 dB safety factor aiming at defining the required minimum qualification levels, to be compared to the qualification status of each spacecraft subsystem and/or equipment.

These obtained shock levels are then compared to the qualification status of each spacecraft subsystem and/or equipment.

[NB: Each unit qualification status can be obtained from other environmental qualification tests (e.g. from sine or random vibration tests) by using equivalent rules.]

General nota: In case of recurrent platform or spacecraft, the shock qualification can be based on heritage, pending that identical platform or spacecraft is already qualified to both launcher and clamp-band release events (for a tension identical or higher than the one targeted for the ongoing satellite).

SPACECRAFT INTERFACES Chapter 5

5.1. INTRODUCTION

This chapter covers the definition of the spacecraft interfaces with the payload adapter, the fairing, the carrying system, if any, and the on-board and ground electrical equipment.

This version of the Vega C User's Manual describes the interfaces with the current fairing and for spacecraft with 1194 mm interface diameter. A larger fairing is under development and other spacecraft interface diameters can be considered on Vega C. Please contact Avio for more information.

The spacecraft is mated to the launch vehicle through a dedicated structure, called an adapter, that provides mechanical interface, systems to ensure the spacecraft separation, and electrical harnesses routing.

The available adapters are described below and the corresponding detailed mechanical interface requirements are given in Appendix 3.

- For single launch configuration (one main passenger), the off-the-shelf adapter is the so-called "VAMPIRE 1194" with 1194 clamp band, from Beyond Gravity.
- For multiple launch configuration (main passenger with auxiliary passengers), the adapter is the so-called "Interface Ring 1194" from ADSM, which is bolted to the upper interface of "SSMS" Hexa carrying system, itself bolted to a VAMPIRE bolted flange conical structure. The SSMS Hexa can embark small spacecraft in cantilevered position.
- For dual launch configuration (two co-passengers or a main passenger with auxiliary passenger(s)), the adapter is the so-called "Active Ring 1194" also from ADSM, bolted to the upper interface of the VESPA+R carrying system, which can house either one small passenger or a cluster of small passengers.

The payload fairing protects the spacecraft from the external environment during the ground operations and flight. Fairing access doors and fairing RF windows can be arranged as option when necessary.

The electrical interface provides communication between the spacecraft and its ground support equipment on ground up to the lift-off. The launch vehicle can also provide various electrical services during the launch. In addition, numerous sensors on the launch vehicle allow to monitor the flight environment.

The adapter, fairing and carrying system elements could be adapted, as necessary, to meet Customer's requirements.

All the interfaces details are collected in the Interface Control Document (DCI) to ensure and control compatibility between the launch system and the spacecraft.

5.2. REFERENCE AXES

All definitions and requirements shall be expressed in the same reference axis system to facilitate the interface configuration control and verification.

Figure 5.2.a shows the Vega C launch vehicle coordinate system.

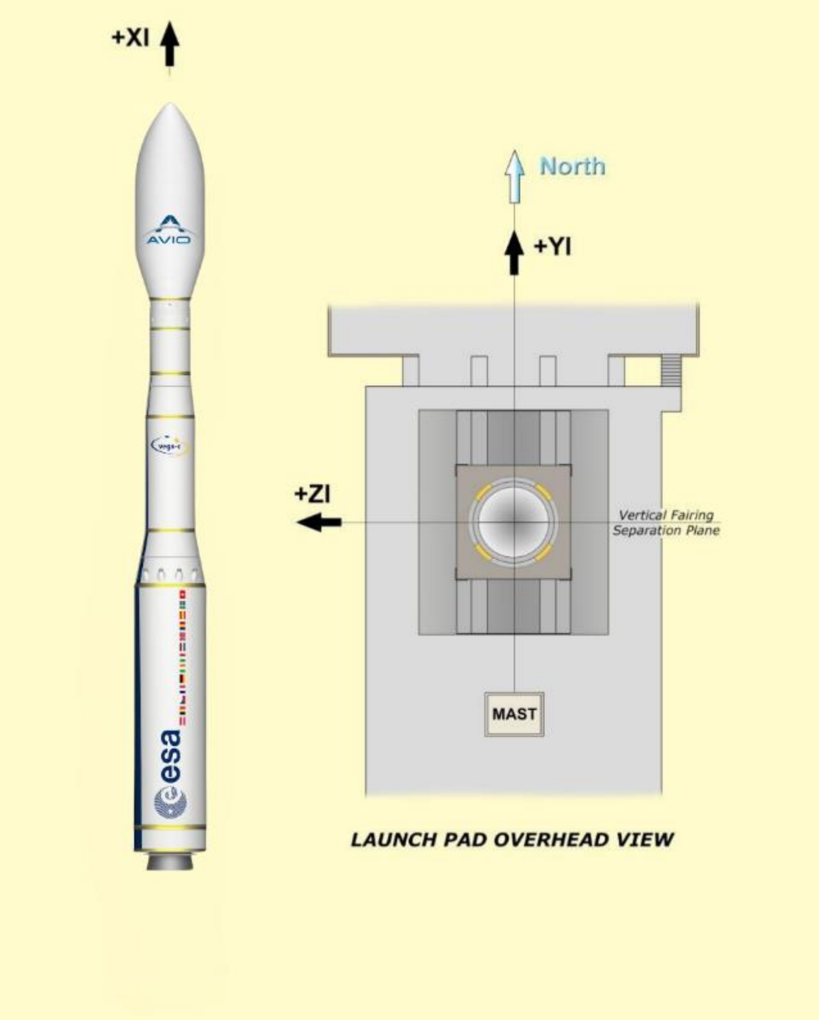


Figure 5.2.a – Vega C coordinate system

The clocking of the spacecraft with regard to the launch vehicle axes is defined in the Interface Control Document (DCI) taking into account the spacecraft characteristics and requirements (dimensions, any access doors or RF transparent windows, etc.).

5.3. ENCAPSULATED SPACECRAFT INTERFACES

5.3.1. Fairing description

The fairing protects the payloads from harmful natural environments such as humidity, rain, sunlight, and dust particles while the launch vehicle is on the launch pad; and from aero-thermal fluxes during atmospheric flight phase.

It consists of a two-half-shell Carbon-Fiber Reinforced Plastic (CFRP) sandwich with aluminum honeycomb structure. The total thickness is approximately 20 mm.

Separation of the nose fairing is achieved by means of two separation systems: a vertical one (VSS) which consists in a pyrotechnic cord, located at the level of the two half-fairings joining plan; and a horizontal one (HSS) consisting in a belt which connects the fairing to the AVUM+ upper stage.

5.3.2. Payload usable volume definition

The payload usable volume is the area under the fairing, or the dual launch carrying structure, available to the spacecraft. This volume constitutes the limits that the static dimensions of the spacecraft, including manufacturing tolerance, thermal protection installation, appendices, etc., shall not exceed. It takes into account the clamp-band stay out zone, which is equal to the volume required for clamp-band installation and release.

It has been established having regard to the potential displacement of the spacecraft complying with frequency requirements described in Chapter 4.

Allowance has been made for manufacturing and assembly tolerances of the upper part (adapter, fairing, carrying system, if any), for all displacements of these structures under ground and flight loads.

For the passenger in lower position of the VESPA+R dual system, the usable volume also takes into account the necessary clearance margin at separation of the VESPA+R upper part.

The definition of the usable volume available inside the fairing for the main spacecraft is presented hereunder:

- for single launch configuration (one main passenger) using the VAMPIRE 1194 adapter, see Figure 5.3.1.a;
- for multiple launch configuration (main passenger with auxiliary passengers) using the IR 1194 on top of a SSMS HEX-1 module and conical VAMPIRE, see Figure 5.3.1.b;
- for dual launch configuration (two co-passengers or one main passenger with auxiliary passenger(s)) using the AR 1194 on top of the VESPA+R system, see Figure 5.3.1.c.

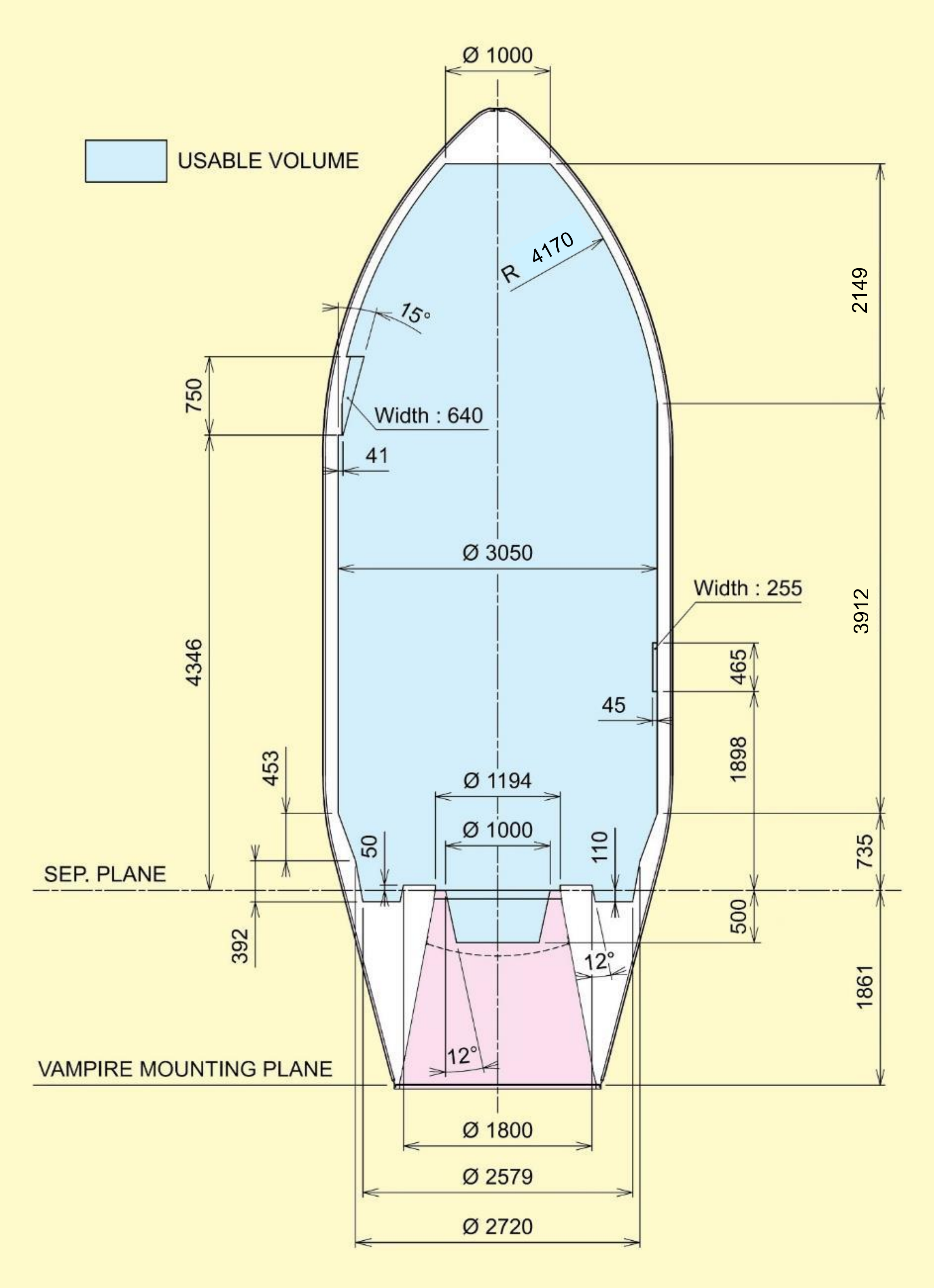
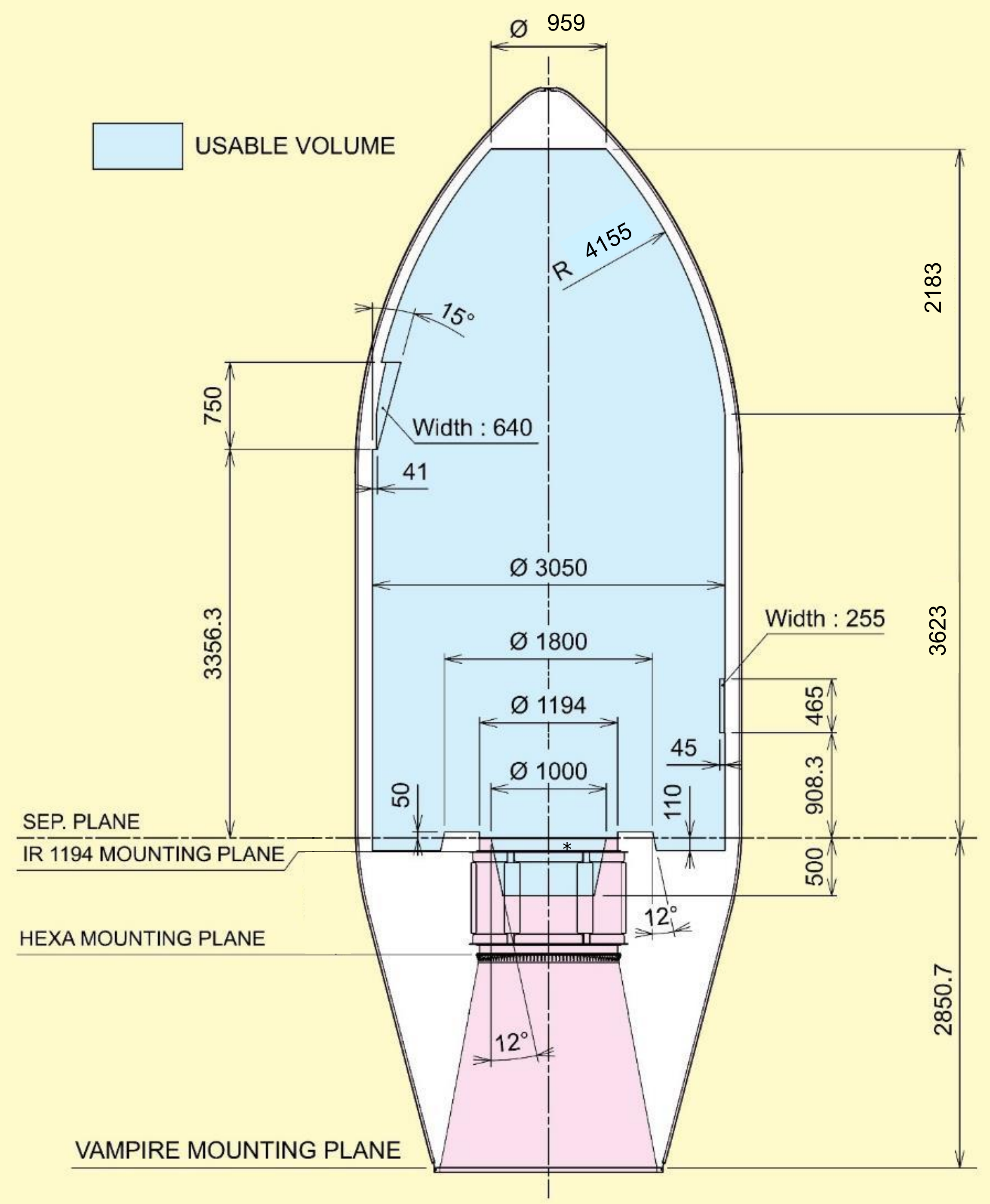


Figure 5.3.1.a – Single launch configuration using a VAMPIRE 1194 adapter – Usable volume inside Vega C fairing (taking into account clamp-band stay out zone)



* Occupancy of the Usable Volume below S/C separation plane inside IR 1194 shall be discussed and agreed with AVIO beforehand.

Figure 5.3.1.b – Multiple launch configuration using an IR 1194 and SSMS HEX-1 module – Usable volume inside Vega C fairing available for the main passenger (∅ 1194 interface) (taking into account clamp-band stay out zone)

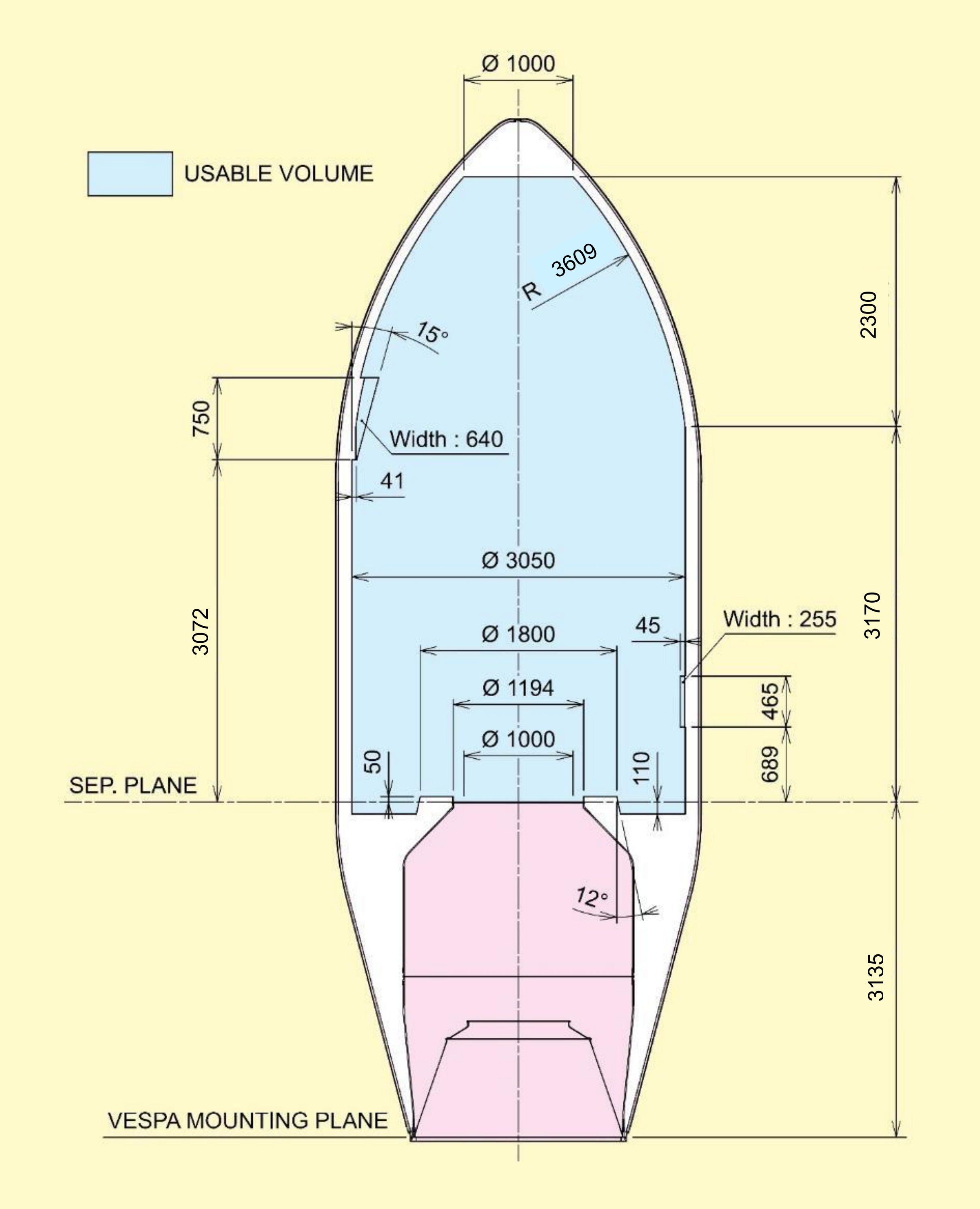


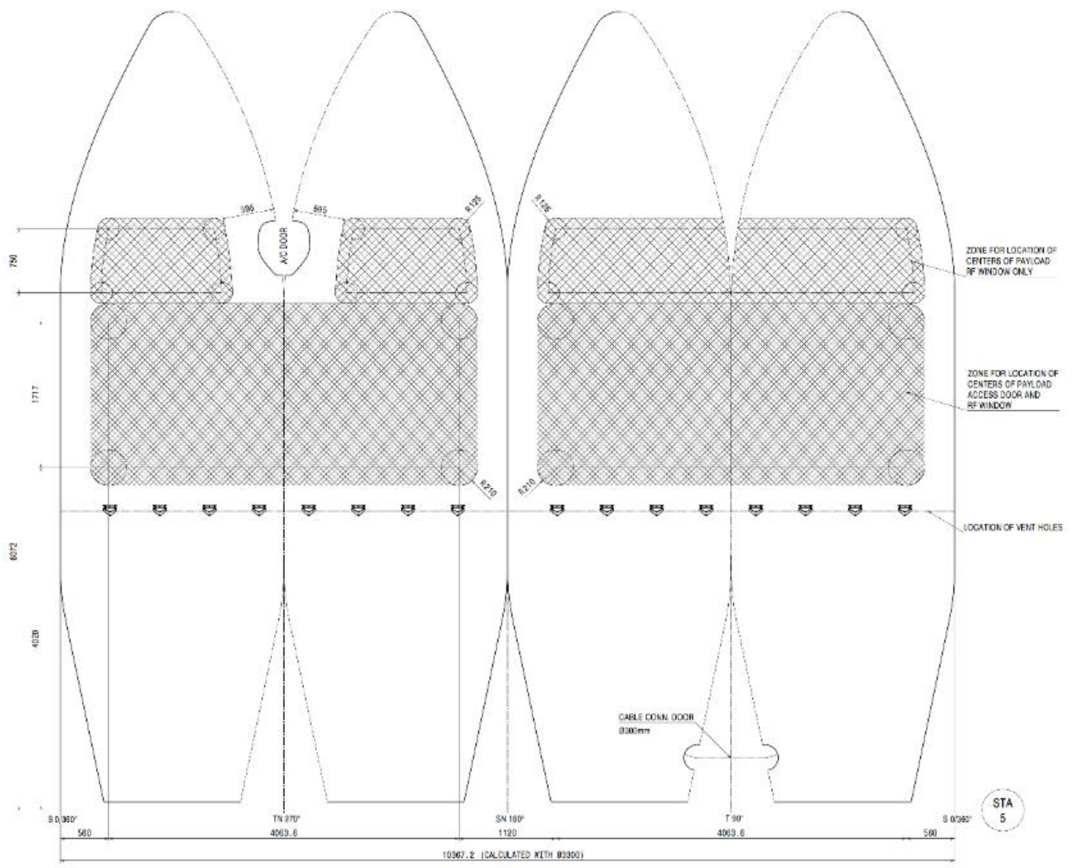
Figure 5.3.1.c – Dual launch configuration using an AR 1194 on VESPA+R system – Usable volume inside Vega C fairing available for the upper passenger (∅ 1194 interface) (taking into account clamp-band stay out zone)

5.3.3. Spacecraft accessibility

After encapsulation, if any access to specific areas of spacecraft is required, fairing access doors can be provided, in the authorized area, on a mission-specific basis.

Similarly, fairing radio-transparent windows can be provided to ensure RF link through the fairing between spacecraft antenna(s) and ground.

The locations authorized for access doors and RF windows are presented in Figure 5.3.3.a. below.



Access doors: *Ø 420 mm*
1 door for each half-fairing (2 doors max.)

RF window: *Ø 250 mm*
Min distance between access door / RF window centers = 800mm

Figure 5.3.3.a – Locations and dimensions of access doors and RF windows

During the operations through a fairing access window, cleanliness in the fairing is ensured thanks to the fairing overpressure maintained by the fairing ventilation.

5.3.4. Special on-fairing insignia

A special mission insignia based on Customers' supplied artwork can be placed by Avio on the cylindrical section of the fairing.

The dimensions, colors and location of each such insignia are subject to mutual agreement.

The artwork shall be supplied not later than six months before launch.

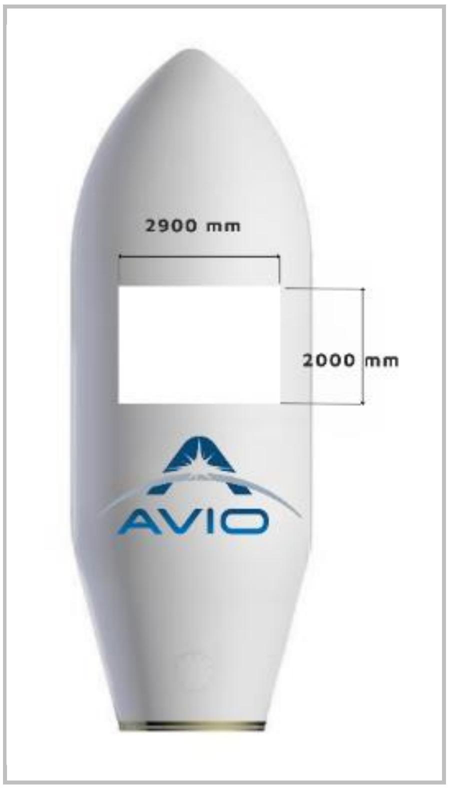


Figure 5.3.4.a – Dimension & location of Customers' logo

5.4. MECHANICAL INTERFACES

The spacecraft/launcher mechanical interface is ensured by the adapter.

The adapter is equipped with a spacecraft separation system, brackets for electrical connectors and sensors to detect spacecraft separation.

The payload separation system is a clamp-band system consisting of a clamp-band with a clamp-band opening device, catchers and separation springs.

The electrical connectors are mated on two brackets installed on the adapter and on the spacecraft's side. On the spacecraft's side, the umbilical connector's brackets must be stiff enough to prevent any deformation greater than 0.5 mm under the maximum force of the connector spring.

5.4.1. Standard Vega C adapter

5.4.1.1. ∅ 1194 mm interface

The general characteristics of the available off-the-shelf 1194 adapters are presented below. Refer to the Appendix 3 for a complete description of the mechanical interface requirements.

- **Single launch configuration**:

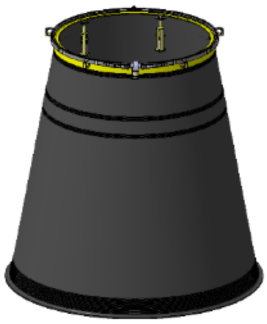
Adapter		Description	Separation system
VAMPIRE 1194 (manufactured by Beyond Gravity)		Height: 1 861 mm Max. mass: 100 kg	Clamp-band ∅ 1194 mm with low shock separation system (CBOD) (from Beyond Gravity)

Table 5.4.1.1.a – VAMPIRE 1194 adapter

- **Multiple launch configuration (using SSMS Hexa module)**:

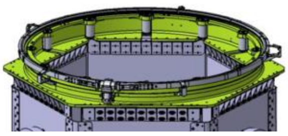
Adapter		Description	Separation system
Interface Ring 1194 (manufactured by S.A.B. Aerospace)		Height:119 mm Max. mass: 32 kg	Clamp-band ∅ 1194 mm with low shock separation system (CBOD) (from Beyond Gravity)

Table 5.4.1.1.b – IR 1194 adapter

- **Dual launch configuration (using VESPA+R dual launch carrying system):**

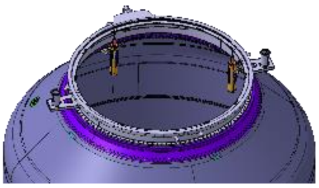
Adapter		Description	Separation system
Active Ring 1194 AR 1194-1226 (manufactured by ADSM)		Height: 122 mm Max. mass: 25 kg	LPSS Clamp-band ∅ 1194 mm with low shock separation system (from ADSM)

Table 5.4.1.1.c – AR 1194 adapter

5.4.1.2. ∅ 937 mm interface

Adapters for ∅ 937 mm interface are also available or under development for single, multiple or dual launch configurations. Please contact Avio for more information.

5.4.1.3. Other interface diameters

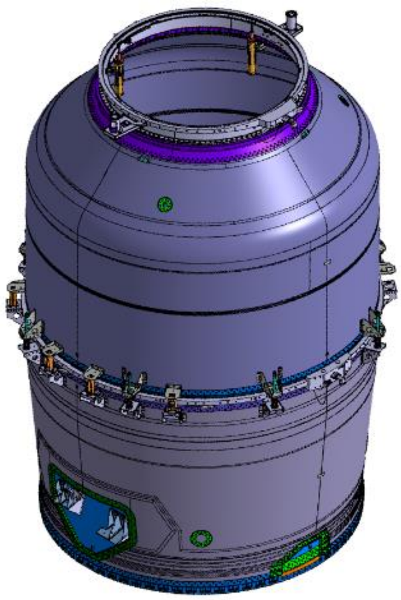
Other interface diameters can be considered using an additional conical adaptation. Please contact Avio for more information.

5.4.2. Vega C carrying system

5.4.2.1. Dual launch carrying system VESPA+R

The VESPA+R (Vega C Secondary Payload Adapter) is an upgraded version of the VESPA+ carrying system which flown several times on Vega. It is manufactured by ADSM. Compared to the previous VESPA+ version, the structure is reinforced to sustain a larger carrying domain (upper spacecraft up to 1 700 kg) and the upper interface is modified to offer more flexibility. The upper interface is a bolted interface ∅ 1226 mm allowing to accommodate either an AR 1194 or an AR 937 for large spacecraft (or even a SSMS system for a cluster of small spacecrafts).

The general characteristics of the VESPA+R are presented in Figure 5.4.2.1.a. below.



	VESPA+R
Total height (mm):	3 135 (with AR 1194)
Max diameter (mm):	2 342
Total max. mass (kg):	430 kg (with AR 1194)
Materials:	CFRP and aluminum alloy
Jettisoning of the upper part:	Clamp-band with low shock separation system + 4 springs (up to 12)

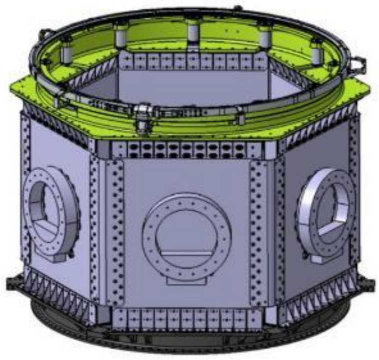
Figure 5.4.2.1.a – Dual launch system VESPA+R

5.4.2.2. SSMS base module – HEX-1

The SSMS (Small Satellite Mission System) carrying system is a modular system designed to address the small satellites market. It is manufactured by S.A.B. Aerospace.

Amongst the numerous possible configurations of the SSMS, the HEX-1 configuration can embark one main passenger in upper position, together with very small auxiliary passengers (mass < 70 kg) on the side of the six faces of the hexagonal base module.

The IR 1194 separation system for the upper passenger is manufactured by Beyond Gravity (same clamp band, CBOD and catchers as on VAMPIRE 1194).



SSMS base module HEX-1

Total height (mm):	986 (with IR 1194)
Max diameter (mm):	1 445
Total max. mass (kg):	210 kg (with IR 1194)
Materials:	CFRP and aluminum alloy

Figure 5.4.2.2.a – Multiple launch system SSMS – HEX-1 for one main passenger with auxiliary passenger(s)

5.4.2.3. Other carrying systems

Other carrying systems are also available or under development for dual launch and multiple launch configurations. Please contact Avio for more information.

5.5. ELECTRICAL AND RADIO-ELECTRICAL INTERFACES

5.5.1. General

On ground, the electrical links between the spacecraft and the EGSE located at the launch pad and preparation facilities insure all needs of communication with spacecraft during the launch preparation.

During flight, the launch vehicle supplies the required electrical services to payload to ensure a successful mission. The launch vehicle also sends the payload separation command and monitors the flight environment.

As an option, RF links can be also provided using fairing transparent window.

The electrical interface composition between the spacecraft and the launch vehicle is presented in Table 5.5.1.a below. The wiring diagram for the launch pad configuration is shown in Figure 5.5.2.2.a. The limitation on the number of lines available per spacecraft is presented in § 5.5.2.

All other data and communication network used for spacecraft preparation in the CSG facilities are described in chapter 6.

Service	Description	Lines definition	Provided as	I/F connectors [1]
Umbilical lines (on ground)	Spacecraft power, remote control and TC/TM lines	(see § 5.5.3)	Standard	2 × 37 pin DBAS 70 37 0 SN DBAS 70 37 0 SY 2 x 61 pin DBAS 70 61 0 SN DBAS 70 61 0 SY
LV to S/C services (during flight)	S/C separation detection (on S/C side)	(see § 5.5.3.1)	Standard	
	Dry loop commands	(see § 5.5.3.2)	Optional	
	Electrical commands	(see § 5.5.3.3)	Optional	
	Spacecraft TM retransmission	(see § 5.5.3.4)	Optional	
	Additional power supply during flight	(see § 5.5.3.5)	Optional	
	Pyrotechnic command	(see § 5.5.3.6)	Optional	2 × 12 pin DBAS 70 12 0 SN DBAS 70 12 0 SY
RF link (on ground)	Spacecraft TC/TM data transmission	RF passive repeater (see § 5.5.5)	Optional	N/A

(1) Avio will supply the Customer with the spacecraft's side interface connectors compatible with equipment of the off-the-shelf adapters.

Table 5.5.1.a – Launch-vehicle-to-spacecraft electrical and RF interfaces

<u>Flight constraints</u>

During the ascent phase from Lift-Off (LO) up to spacecraft separation + 20s, it is not authorized to send any telecommand signal from ground to the spacecraft, or to generate any command by a spacecraft's onboard system (sequencer, computer, etc.).

Orders can be sent by the launch vehicle to the spacecraft (as optional service), during ballistic phases (coast phase, if any, and ballistic phase before spacecraft separation).

Separation detection system or telecommand cannot be used earlier than 20s after spacecraft separation to command operations on the spacecraft, after its separation from the launch vehicle.

Initiation of operations on the spacecraft after separation from the launch vehicle, by a programmed spacecraft's onboard system, must be inhibited until spacecraft physical separation.

The typical flight constraints are summarized in the Table 5.5.1.b below.

LO – 1h30 mn ▼ 1st AVUM+ burn-out ▼ End of Coast Phase ▼ 2nd AVUM+ burn-out ▼ Separation ▼ Separation + 20 s ▼

Command	NO	NO	NO	NO	NO	YES
Spacecraft sequencer	NO	NO	NO	NO	YES	YES
LV orders	NO	YES	NO	YES	NO	NO

Table 5.5.1.b – Flight constraints for command signals to the spacecraft

5.5.2. Spacecraft-to-EGSE umbilical lines

5.5.2.1. Lines definition

The spacecraft-to-EGSE umbilical lines provide the following main functions on ground:

- Data transmission and spacecraft monitoring;
- Powering of the spacecraft and charge of the spacecraft battery.

The umbilical lines passing through the umbilical connector are disconnected at lift-off.

As a standard, 74 lines (2x37) are available at the spacecraft/payload adapter interface.

However, between the base of the payload adapter and the EGSE, a total of 100 pairs (i.e. 200 wires, one pair = 2 twisted wires) are available at launch system level, of which:

- 20 pairs (i.e. 40 wires) in 120 Ω impedance;
- 8 pairs (i.e. 16 wires) in 100 Ω impedance;
- 4 pairs (i.e. 8 wires) in 75 Ω impedance.

All other wires are in 50 Ω standard impedance.

These lines (200 wires) have to be shared between all Customers.

5.5.2.2. Lines description

The launch-vehicle-to-launch-pad harness layout is defined in Figure 5.5.2.2.a below.

The spacecraft EGSE(s) is (are) located in the so-called "COTE room 101" located in the launch pad basement. The wiring from the spacecraft to Customer's COTE comprises generic and customized sections.

The generic sections have the same configuration for each launch and consist of the lines between the connecting box (RCU) in the COTE room 101 and the connectors at the AVUM+/adapter interface. This segment is ~70 meters long.

The customized sections are configured for each mission. They consist of:

- The lines between the connecting box (RCU) in the COTE room 101 and the Customer's COTE. The Customer shall provide this segment (so-called cables "A"),
- The adapter wiring harness.

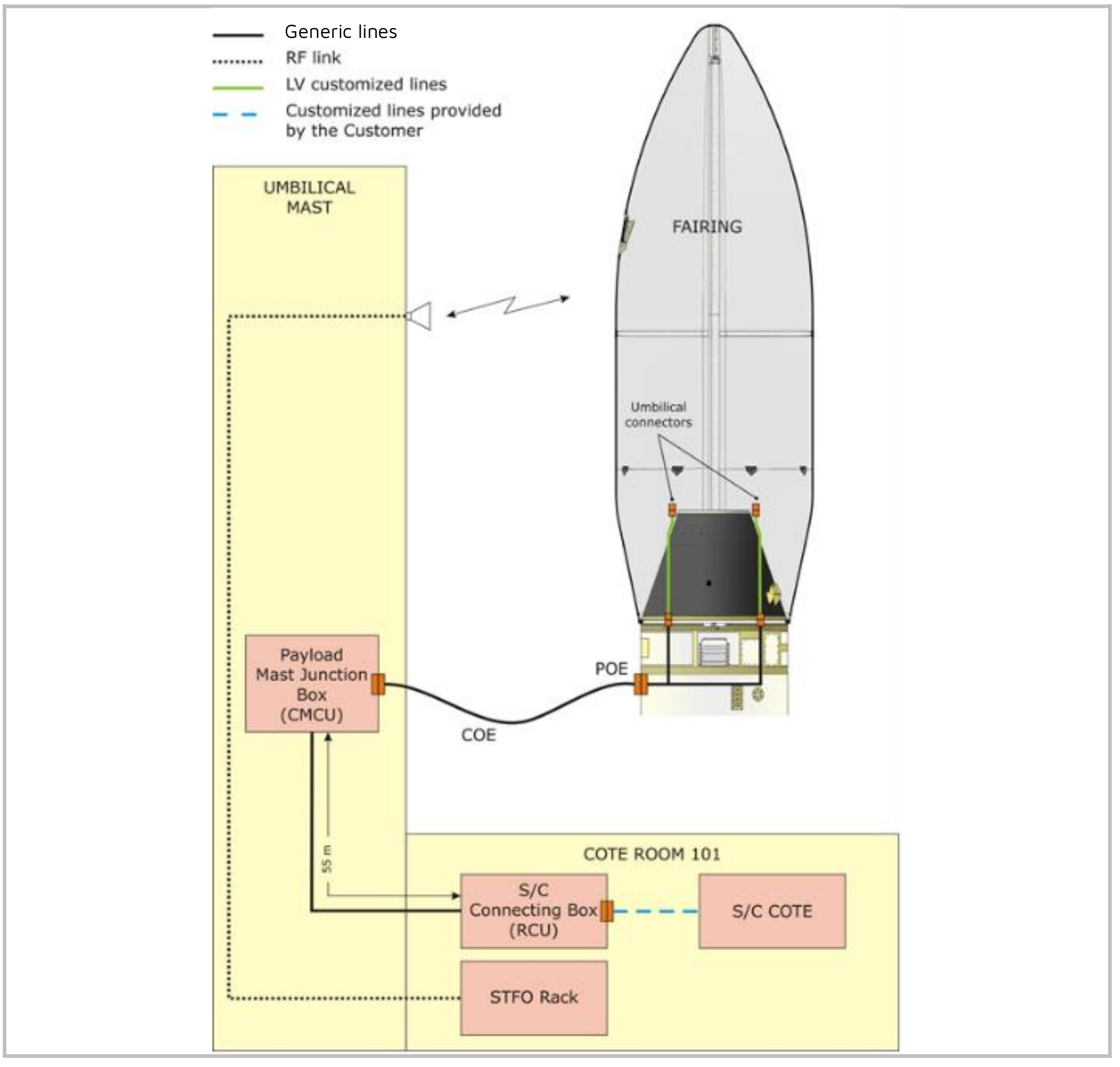


Figure 5.5.2.2.a – Umbilical links between spacecraft mated on the launcher and its Check-Out Terminal Equipment (COTE)

5.5.2.3. Lines composition and electrical characteristics

The characteristics of these umbilical links, between the connecting box in launch pad room (RCU) and the electrical umbilical plug POE, are:

- Resistance, for low impedance wire: < 1.2 Ω (one way);
  for high impedance wire: < 10 Ω (one way);
- Insulation > 5 MΩ under 500 Vdc (> 100 MΩ for onboard harness only).

The operating constraints are the following:

- Each wire shall not carry current in excess of 5 A;
- For all the lines, the voltage shall be less than 55 Vdc;
- No current shall circulate in the shielding.

The Customer shall design his spacecraft so that during the final preparation leading up to actual launch, the umbilical lines are carrying only low currents at the moment of lift-off, i.e. less than 100 mA – 50 V. Spacecraft power must be switched from external to internal, and ground power supply must be switched off before lift-off.

The total harness length from COTE to spacecraft connectors is ~95 m, through by 4 LV + 3 GS interface connections (plus 4 terminal strips in the mast junction and connecting boxes).

5.5.3. Launch-vehicle-to-spacecraft electrical functions

The launch vehicle can provide optional electrical functions used by the spacecraft during flight.

The execution of the different commands is monitored by the launch vehicle's telemetry system.

Due to the spacecraft-to-launch-vehicle interface, the Customer is required to protect the circuit against any overload or voltage overshoot induced by his circuits both at circuits switching and in the case of circuit degradation.

To protect spacecraft's equipment, a safety plug with a shunt on spacecraft's side and a resistance on the launch vehicle side shall be installed in all cases.

5.5.3.1. Spacecraft separation detection

The spacecraft separation detection, on spacecraft's side, can be provided by dry loop straps located on the adapter's side of umbilical connectors.

The main electrical characteristics of these straps are:

- Strap "closed": R ≤ 1 Ω;
- Strap "open": R ≥ 100 kΩ.

Note: As a standard, the spacecraft separation detection on the launch vehicle's side is provided by two redundant microswitches and transmitted by the launch vehicle's telemetry system to the launch vehicle's ground segment.

5.5.3.2. Dry loop commands (optional service)

This function can be used for spacecraft initiating sequence or status triggering. The information is sent through the opening or closing of a relay contact which is part of the AVUM+ electrical equipment (yes- or no-type information). Eight single commands (or four redundant commands) are available.

The main electrical characteristics are:

- Loop closed: R ≤ 10 Ω;
- Loop open: R ≥ 100 kΩ;
- Voltage: ≤ 32 V;
- Current: ≤ 0.5 A.

The insulation of the launch vehicle's onboard circuit is ≥ 1MΩ under 50 Vdc.

During flight, these dry loop commands are monitored by the launch vehicle's telemetry system.

Protection: The Customer is required to protect the circuit against any overload or voltage overshoot induced by his circuits both at circuits switching and in the case of circuit degradation.

The Customer has to intercept the launcher command units in order to protect the spacecraft equipment and to allow the integration check-out by using a safety plug equipped with an open circuit on the spacecraft's side and a short circuit on the launch vehicle's side.

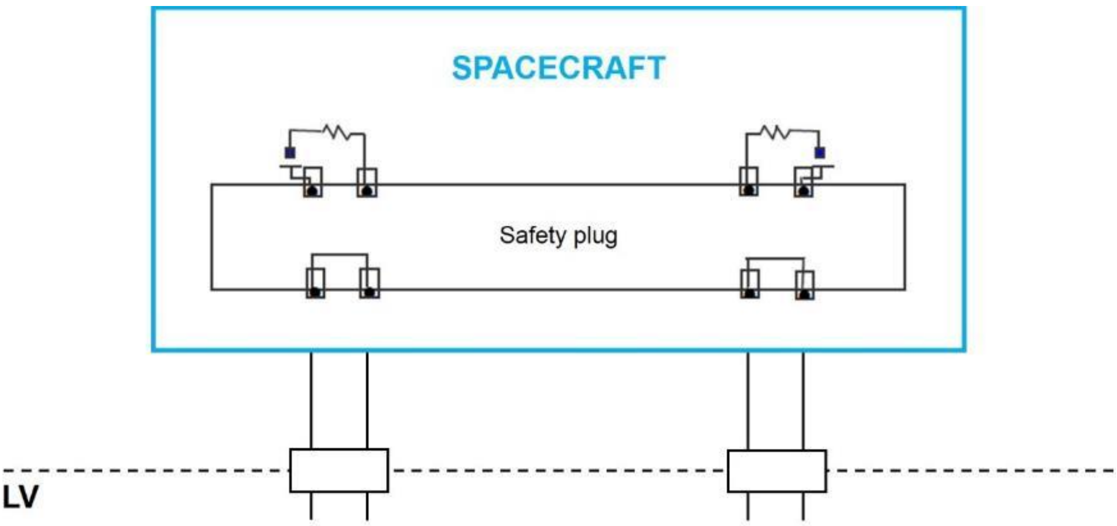


Figure 5.5.3.2.a – Typical principle of a dry loop commands diagram

5.5.3.3. Electrical commands (optional service)

The launcher can send up to four dedicated single commands with the following main electrical characteristics:

- Input voltage: 28 V ± 4 V;
- Input current: ≤ 0.5 A.

During the flight, the commands are monitored through the launch vehicle's telemetry system.

Protection: The Customer is required to protect the circuit against any overload or voltage overshoot induced by his circuits both at circuits switching and in the case of circuit degradation.

The Customer has to intercept the launch vehicle command units in order to protect the spacecraft equipment and to allow the integration check-out by using a safety plug equipped with an open circuit on the spacecraft's side and a protection resistance (100 Ω ± 5%) on the launch vehicle's side.

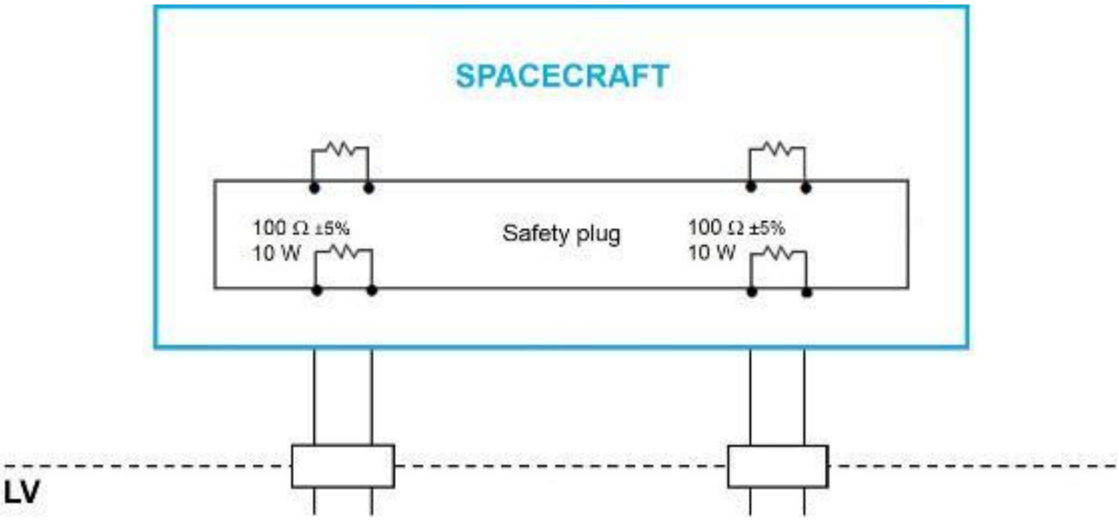


Figure 5.5.3.3.a – Typical principle of an electrical commands diagram

5.5.3.4. Spacecraft telemetry retransmission (optional service)

In flight, transmission of spacecraft measurements by the launch vehicle's telemetry system can be studied on a case-by-case basis. A Customer wishing to exercise such an option should contact Avio for interface characteristics. Signal data can only be provided after post-flight telemetry exploitation.

5.5.3.5. Power supply to spacecraft (optional service)

Additional power (three lines) can be supplied to the spacecraft as an optional service.

The main characteristics of these three lines are:

• 28 V power line:	Input voltage:	28 V ± 4 V;
	Maximal output power:	75 W;
• 12 V power line:	Input voltage:	12 V ± 5%;
	Maximal output power:	35 W;
• 5 V power line:	Input voltage:	5 V ± 5%;
	Maximal output power:	35 W.

The power output is equipped with protection device against overloads.

5.5.3.6. Pyrotechnic command (optional service)

The avionic system has the capability to issue all Nominal (N) and Redundant (R) orders (one pyrotechnic function initiates simultaneously two squibs) to initiate adapter or dispenser separation systems.

The avionic system is compatible with 1 Ω resistance squibs.

The squib should be able to sustain a low current of 25 mA (with a cumulative time of 10 seconds) for continuity test purpose.

In addition to the launch vehicle orders for spacecraft separation, other pyrotechnic commands could be generated to be used for spacecraft internal pyrotechnic system or in case where the spacecraft separation system is supplied by the Customer. The electrical diagram is presented in Figure 5.5.3.6.a.

The main electrical characteristics of a nominal pyro signal delivered by the launcher are:

• Minimal guaranteed current:	4.1 A;
• Maximal supplied current for one squib:	12 A;
• Typical current for standard cable and squib:	Between 5 and 7 A;
• Impulse duration:	20 msec ± 2.5 msec;
• Nominal battery voltage:	28 V ± 4 V;
• The redundant order:	The same – at the same time.

A maximum of two pyrotechnic functions (initiation of 2x2 (i.e. N+R) squibs) can be fired simultaneously.

The insulation between wires (open loop) and between wires and structure must be ≥ 1MΩ under 10 Vdc.

These orders are supplied from dedicated battery, and passing through dedicated connectors, segregated from the umbilical links and connectors.

The pyrotechnic order is compatible with an initiator with a resistance equal to 1.05 Ω ± 0.15 Ω. The resistance of the one-way circuit line between the AVUM+/adapter interface and the spacecraft initiator shall be adapted case-by-case. The Customer shall contact Avio to define the characteristics of this specific interface.

To ensure safety during ground operations, two electrical barriers are closed before lift-off. During flight, the pyrotechnic orders are monitored through the launch vehicle's telemetry system.

Protection: The Customer has to intercept the launch vehicle command circuits in order to protect the spacecraft equipment and to allow the integration check-out by using a safety plug equipment with a shunt on the spacecraft's side and a resistance of 2 kΩ ±1% (0.25W) on the launch vehicle's side.

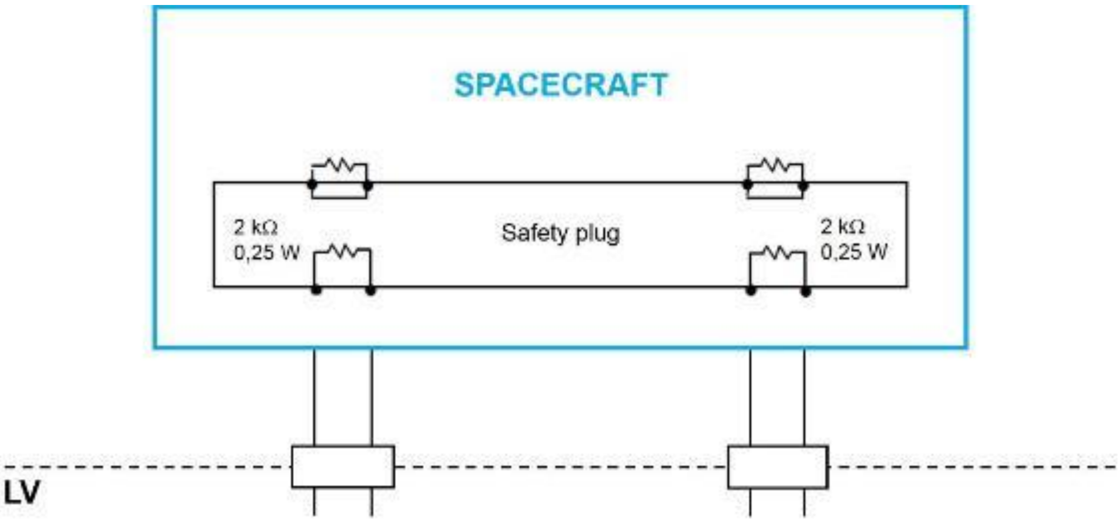


Figure 5.5.3.6.a – Typical principle of a pyrotechnic commands diagram

5.5.3.7. Non-explosive actuators (optional service)

The Vega C launcher is able to initiate Non-Explosive Actuators (NEA):

- Five with low voltage: 5 V ± 5% or 20 V ± 5%;
  Activation time ≤ 100 ms;
- Five with 28 V ± 4 V: Activation time ≤ 1 ms.

5.5.4. Electrical continuity interface

5.5.4.1. 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 launch vehicle (separation plane of the spacecraft's rear frame or mating surface of a Customer's adapter) 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's Earth reference point and that of the launch vehicle adapter.

5.5.4.2. Shielding

In the onboard and ground harness, the shield is linked to the metallic structure (launcher and ground).

The ground shield is linked to the onboard shield at COE/POE interface, through the mechanical housing of the POE connector.

5.5.5. RF communication link between spacecraft and EGSE (optional service)

A direct reception of RF emission from the spacecraft's antenna can be provided as an optional service requiring additional radio-transparent window(s) on the fairing and additional hardware installation on the launch pad and/or mobile gantry.

This option allows Customers to check the spacecraft RF transmission on the launch pad during countdown.

5.6. INTERFACE VERIFICATIONS

5.6.1. Prior to the launch campaign

Prior to the start of the launch campaign, the following interface checks shall be performed. Specific launch vehicle hardware for these tests is provided according to the contractual provision.

5.6.1.1. Mechanical fit-check

The objectives of this fit-check are to confirm that the satellite dimensional and mating parameters meet all relevant requirements as well as to verify operational accessibility to the interface and cable routing.

It can be followed by a release/drop test (in order to provide inputs for the spacecraft qualification to shock environment, refer to § 4.3.3.4).

This test is usually performed at the Customer's facilities, with the adapter equipped with its separation system and electrical connectors provided by Avio.

For a recurrent spacecraft or platform, the mechanical fit-check can be performed at the beginning of the launch campaign, in the payload preparation facilities.

5.6.1.2. Electrical fit-check

Electrical interfaces between the spacecraft and the adaptor shall be checked prior to the beginning of the launch campaign. The Customer shall provide the interface cable "A" to run a functional test using the adapter's harness and connectors.

5.6.2. Pre-launch validation of the electrical interfaces

5.6.2.1. Definition

The electrical interface between satellite 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 satellite with the launcher and help to pass the non-reversible operations. There are two major configurations:

- Spacecraft mated to the adapter;
- Spacecraft with adapter mated to the launcher.

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

5.6.2.2. Spacecraft EGSE

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

- OCOE, spacecraft test and monitoring equipment, permanently located in LBC and linked with the spacecraft during preparation phases and launch even at other preparation facilities and launch pad;
- COTE, front end Check-Out Terminal Equipment, providing spacecraft monitoring and control, ground power supply and any hazardous circuit's activation. The COTE follows the spacecraft during preparation activity in PPF and HPF. During launch pad operation, the COTE is installed in the COTE room 101 located in the launch pad's basement. The spacecraft COTE is linked to the OCOE by data lines to allow remote control;
- Set of ground cables for satellite electrical umbilical lines verification (so called cable "A" and "B").

The installation interfaces as well as environmental characteristics for the COTE are described in Chapter 6.

GUIANA SPACE CENTER Chapter 6

6.1. INTRODUCTION

6.1.1. French Guiana

The Guiana Space Center (CSG "Centre Spatial Guyanais") is located in French Guiana, a French Overseas Department (DOM "Département d'Outre-Mer"). It lies on the Atlantic coast of the Northern part of South America, close to the equator, between the latitudes of 2° and 6° North, and at the longitude of 50° West.

It is accessible by air and sea, served by international companies. There are direct flights every day from and to Paris. Regular flights with North America are also available via the French West Indies (Guadeloupe and Martinique).

The administrative regulation and formal procedures are equivalent to the ones applicable in France or European Union.

The climate is equatorial with a low daily temperature variation and a high relative humidity.

The local time is GMT-3h.

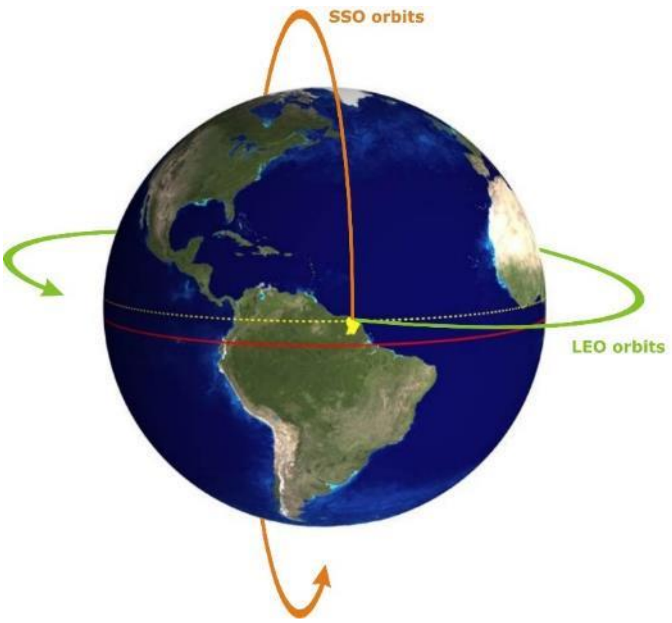


Figure 6.1.1.a – French Guiana on the world map

6.1.2. The European spaceport

The European spaceport is located between the two towns of Kourou and Sinnamary. It is operational since 1968.

The CSG is governed under an agreement between France and the European Space Agency (ESA) and the day-to-day life of the CSG is managed by the French National Space Agency (CNES "Centre National d'Études Spatiales") on behalf of the European Space Agency.

The CSG mainly comprises:

- the **CSG arrival area** through the sea and air ports (managed by local administration);
- the **Payload Preparation Complex** (EPCU "Ensemble de Préparation Charge Utile") where the spacecraft are processed, and where the Vega C Payload Assembly Composite (PAC) is constituted;
- the dedicated **Launch Sites**, each including Launch Pad, launch vehicle integration buildings, Launch Center (CDL "Centre De Lancement") and support buildings;
- the **Mission Control Centre** (MCC or CDC "Centre De Contrôle" Jupiter 2).

The Vega C Launch Site is located approximately 15 km to the North-West of the CSG Technical Centre and of Kourou city.

Figure 6.1.2.a – Entrance of CSG Technical Centre

6.2. CSG GENERAL PRESENTATION

6.2.1. Arrival areas

The spacecraft and Customer's ground support equipment can be delivered by aircraft, landing at the Cayenne Félix Eboué international airport, while the propellant can be delivered by "commercial" ship at the Cayenne Dégrad-des-Cannes international harbour.

The CSG provides all needed support for the equipment handling and transportation as well as formality procedures.

6.2.1.1. Cayenne Félix Eboué international airport

Félix Eboué international airport is located near Cayenne, with a 3 200 m runway adapted to aircraft of all classes and particularly to the jumbo-jets:

- Boeing 747;
- Airbus Beluga;
- Antonov 124.

A wide range of horizontal and vertical handling equipment is used to unload and transfer standard type pallets/containers.

Small freight can be shipped by the regular Air France passenger flight.

The airport is connected with the CSG by road, about 75 kilometers away.

6.2.1.2. Cayenne Dégrad-des-Cannes international harbour

Cayenne harbour is located south of the Cayenne peninsula in Dégrad-des-Cannes, on the shore of the Cayenne river. Facilities handle large vessels with less than six meters draught.

Harbour facilities allow container handling in Roll-On/Roll-Off (Ro-Ro) mode or in Load-On/Load-Off (Lo-Lo) mode. A safe open storable area is available at Dégrad-des-Cannes.

The port is linked to CSG by road, about 85 kilometers away.

6.2.1.3. Kourou Pariacabo docking area

The Pariacabo docking area is located on the Kourou river, close to Kourou city. This facility is dedicated to the transfer of the launcher stages and/or satellites by Avio ships and is under CSG responsibility.

The area facilities allow the container handling in Roll-On/Roll-Off (Ro-Ro) mode.

The docking area is linked to the CSG by road (~ 9 km).

6.2.2. Payload Preparation Complex (EPCU)

The Payload Preparation Complex is used for spacecraft autonomous preparation activities, including spacecraft fueling, up to transfer of the Payload Assembly Composite (PAC) to the Launch Pad for integration with the launch vehicle.

The EPCU provides wide and redundant capability to conduct several simultaneous spacecraft preparations. The facility is assigned to each spacecraft no later than one month prior to spacecraft arrival.

The Payload Preparation Complex consists of three major areas:

- **S1 area**, with Payload Processing Facility (PPF) located at the CSG Technical Centre;
- **S3 area**, with Payload Preparation Facility / Hazardous Processing Facility (PPF/HPF) located close to the Vega C launch pad;
- **S5 area**, with Payload Preparation Facility / Hazardous Processing Facility (PPF/HPF).

The complex is completed by auxiliary facilities: the Propellant Storage Area (ZSE "Zone de Stockage Ergols"), the Pyrotechnic Storage Area (ZSP "Zone de Stockage Pyrotechnique") and chemical analysis laboratories located near the different EPCU buildings.

All EPCU buildings are accessible by two-lane tarmac roads, with maneuvering areas for trailers and handling equipment.

6.2.2.1. S1 area: Payload Processing Facility

The S1 Payload Processing Facility consists of buildings intended for simultaneous preparation of several spacecraft. It is located north of the CSG Technical Centre close to Kourou city. The area location, far from the launch pads, ensures unrestricted all-year-round access.

The area is dedicated to the Customer's launch teams and is used for all non-hazardous operations.

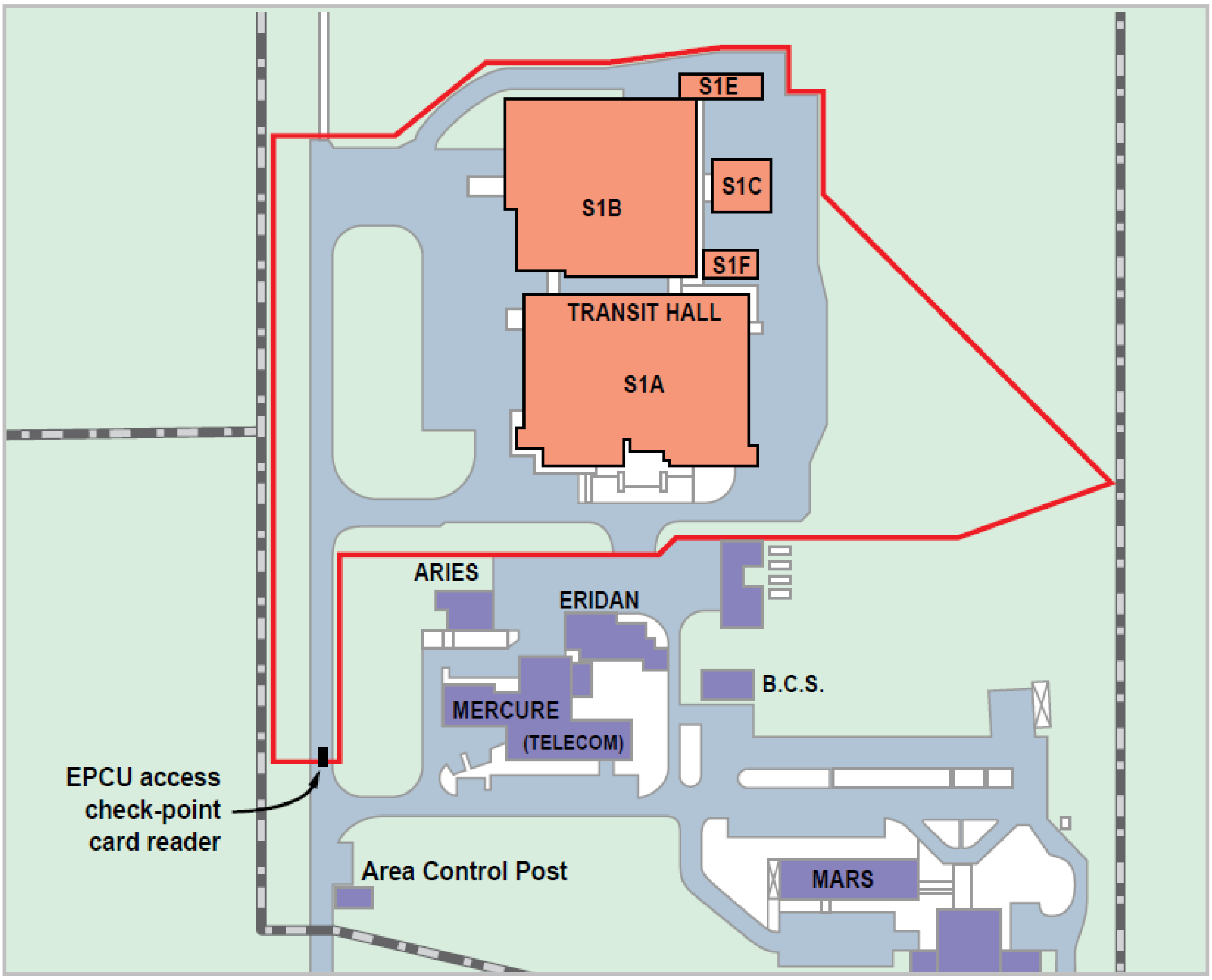


Figure 6.2.2.1.a – S1 area map

The facility is composed of two main buildings comprising one clean room each (S1A and S1B), a separated building for offices, and laboratory and storage areas. The path between buildings is covered by a canopy for sheltered access between the buildings. The storage area can be spread between buildings.

Figure 6.2.2.1.b – S1 area overview

The **S1A** building is composed of one clean high bay of 490 m^2, one control room (LBC), offices and storage areas.

The **S1B** building is composed of one clean high bay of 860 m^2 that could be split in two parts ("Northern" and "Southern" parts), four control rooms (LBC) and storage areas. Offices are available for spacecraft teams for around thirty people per spacecraft project.

The **S1C**, **S1E** and **S1F** buildings provide an extension of the S1B office space. The standard offices layout can accommodate around thirty people per building.

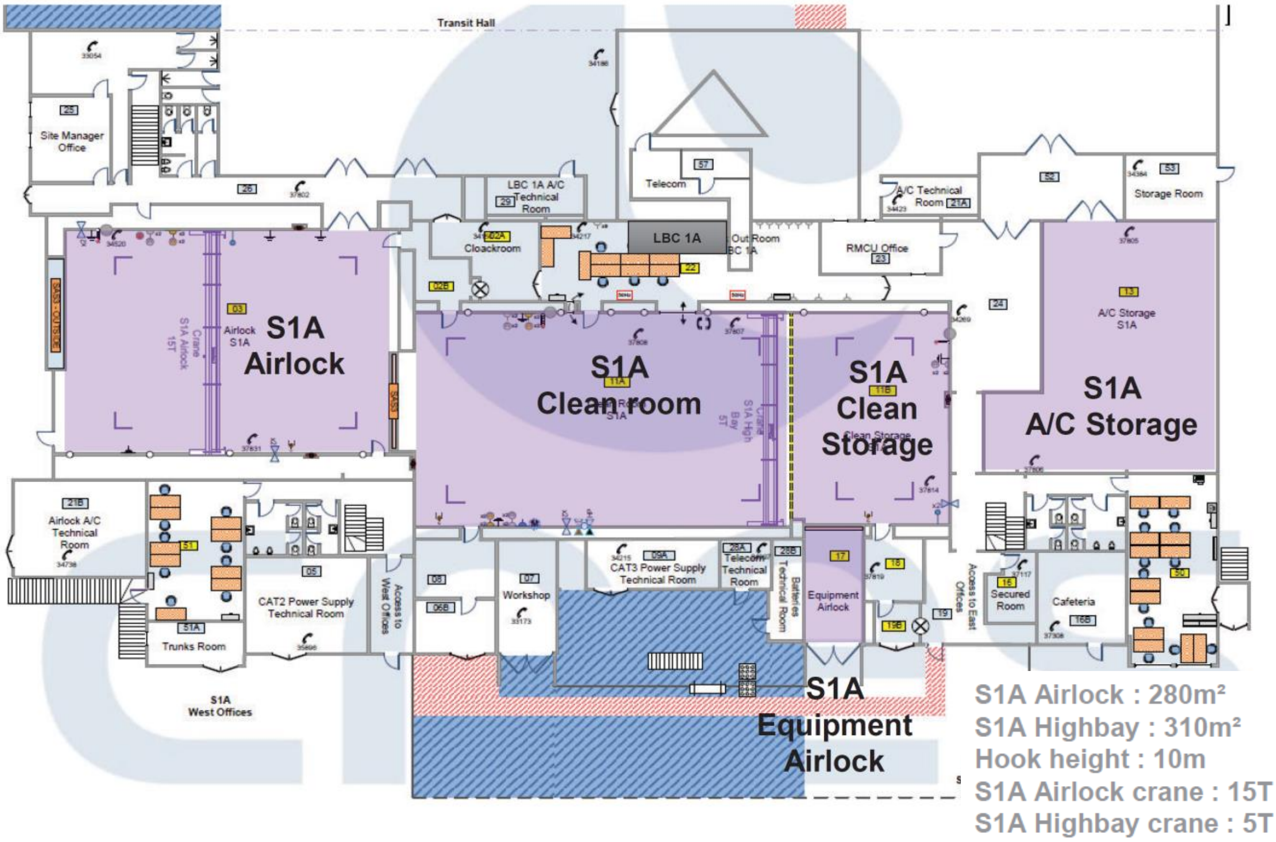


Figure 6.2.2.1.c – S1A building layout

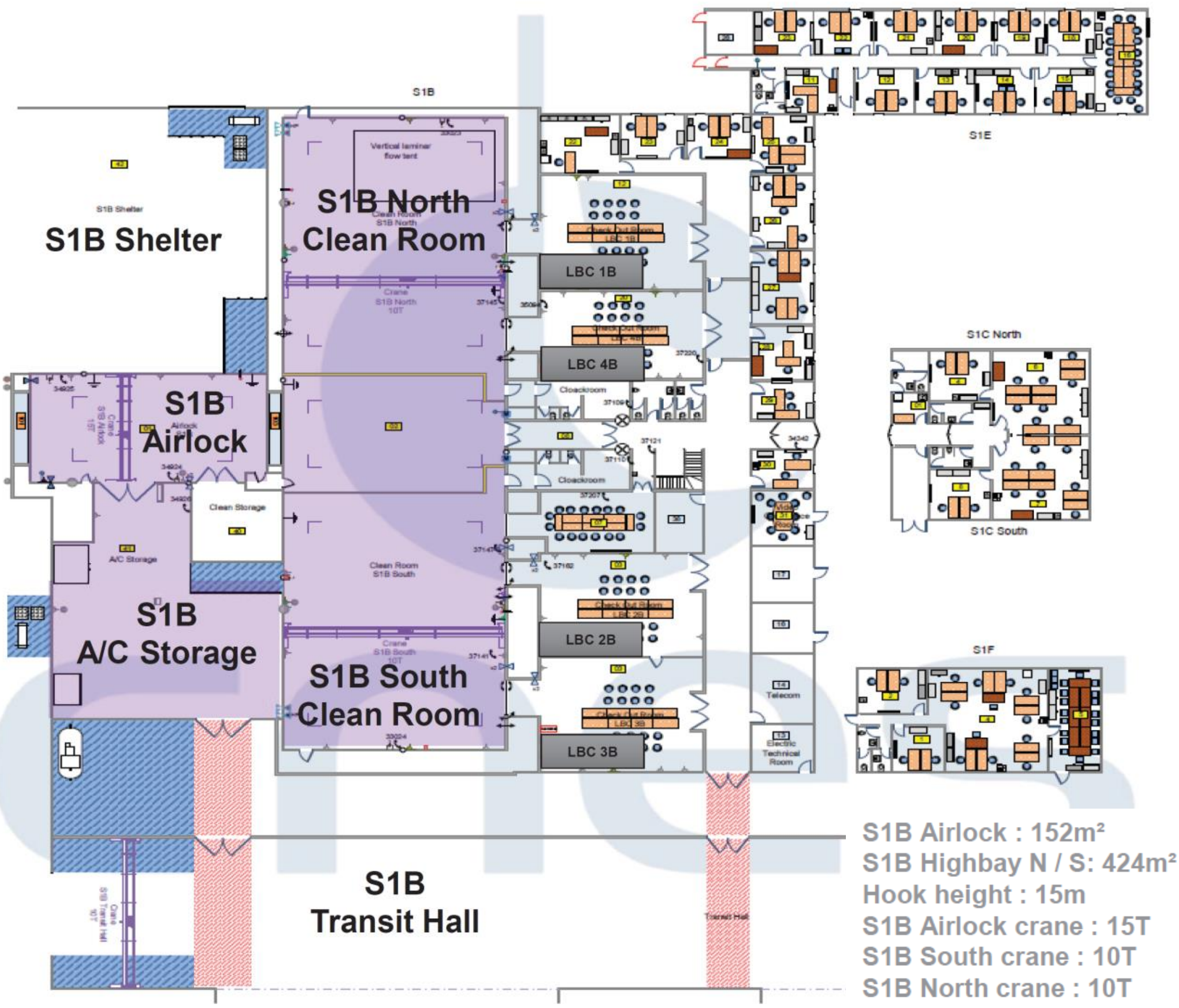


Figure 6.2.2.1.d – S1B building layout

6.2.2.2. S3 Payload Preparation Facility / Hazardous Processing Facility

The S3 Payload Preparation Facility / Hazardous Processing Facility consists of buildings used for payload preparation and hazardous operations. The area is located 15 km from the CSG Technical Centre. The area is close to the Vega C launch pad and imposes precise planning coordination of the activities conducted there.

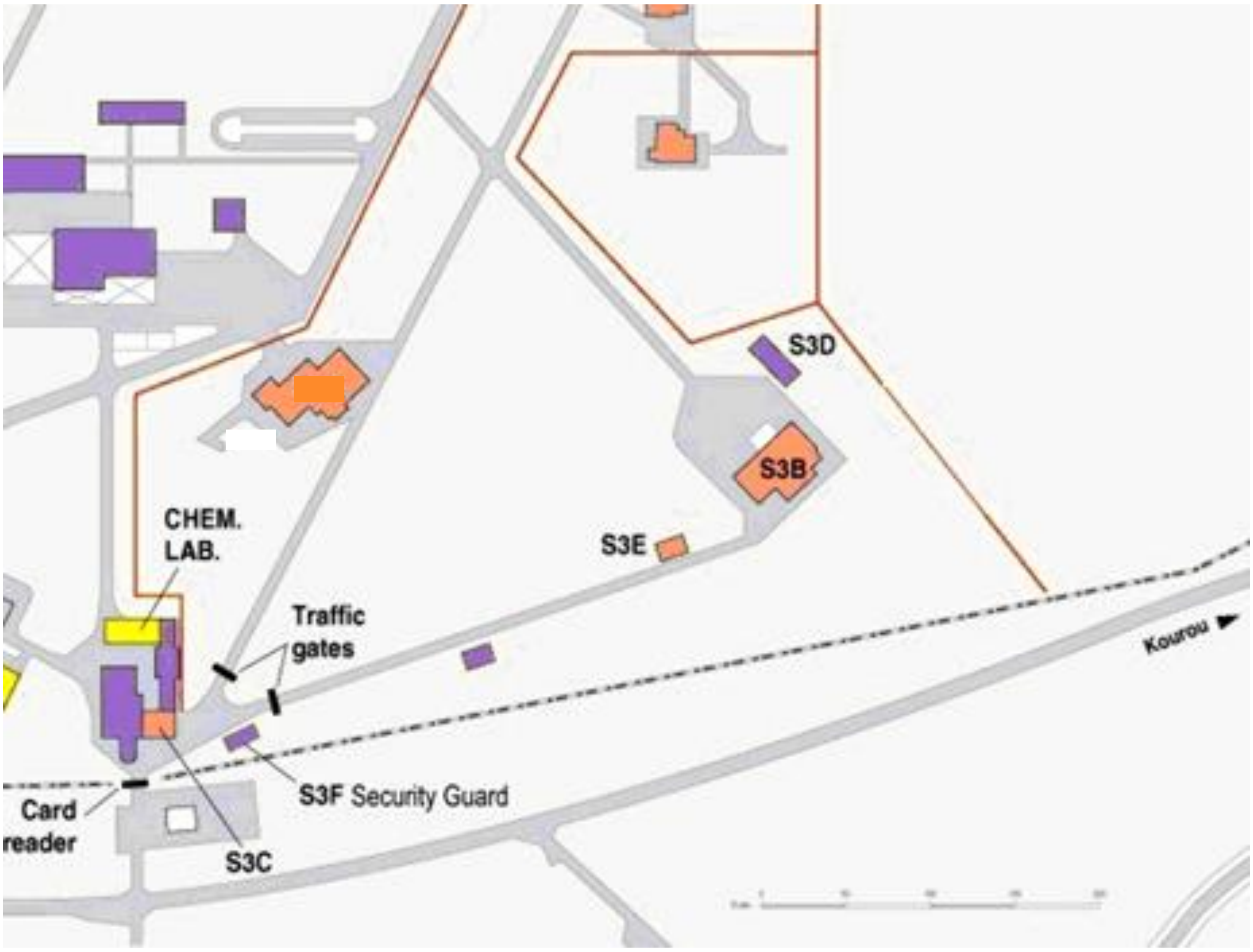


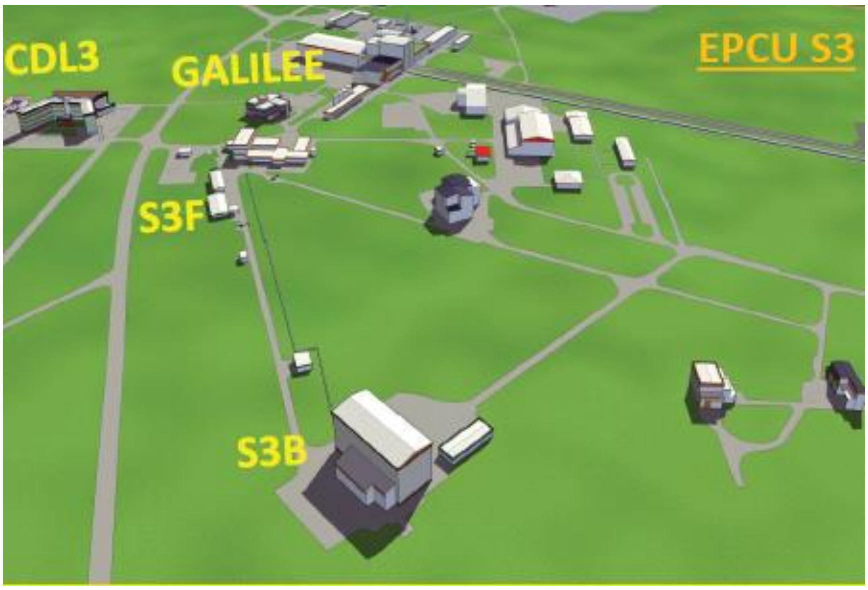
Figure 6.2.2.2.a – S3 area map

The Customer's facility includes two separated buildings S3B and S3C.

Figure 6.2.2.2.b – S3B and S3C buildings

The **S3B** building allows to conduct all spacecraft operations on a single site: spacecraft unpacking from its container, payload preparation and hazardous operations. The building is mainly composed of the airlock, one clean hall (S3B-HN) of 414 m^2 and one clean hall (S3B-HR) of 330 m^2 for hazardous operations (main tanks and attitude control system filling, weighing, pressurization and leakage tests…). Once the spacecraft is ready, the mating on its adapter and the fairing encapsulation is also done in the S3B-HR hall.

The **S3C** building is dedicated to the remote monitoring of hazardous operations such as spacecraft filling (safety control room).



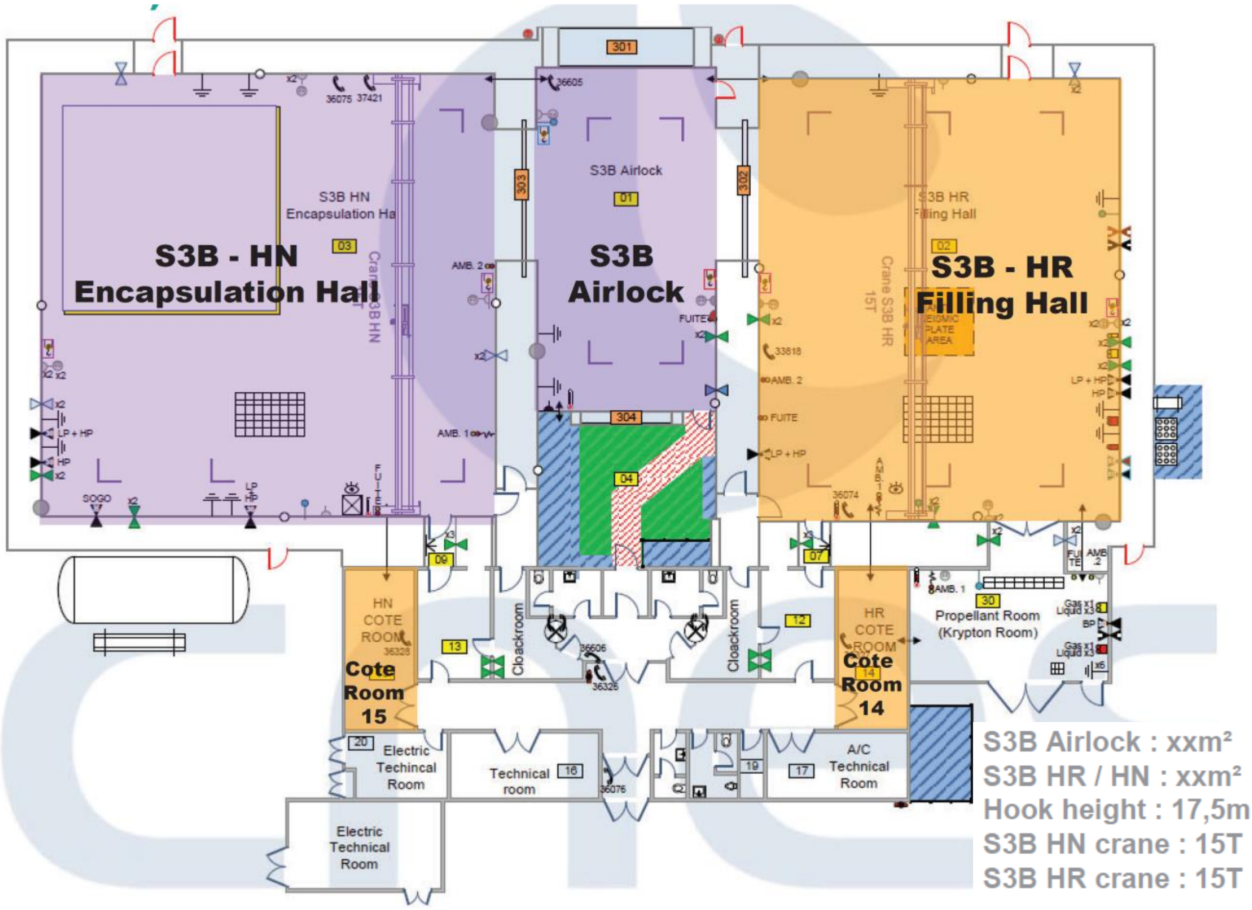


Figure 6.2.2.2.c – S3B building layout

6.2.2.3. S5 Payload Preparation Facility / Hazardous Processing Facility

The S5 Payload Preparation Facility / Hazardous Processing Facility consists of clean rooms, fueling rooms and offices connected by environmentally protected corridors. It is located on the south-west bank of the main CSG road, far from launch pads and other industrial sites providing all-year-round access.

EPCU S5 enables an entire autonomous spacecraft preparation on a single site, from satellite arrival to fueling. The building configuration allows for simultaneous preparation of up to four spacecraft at the same time: two spacecraft in PPF phase and two spacecraft in HPF phase. It provides easy and short transfers between halls.

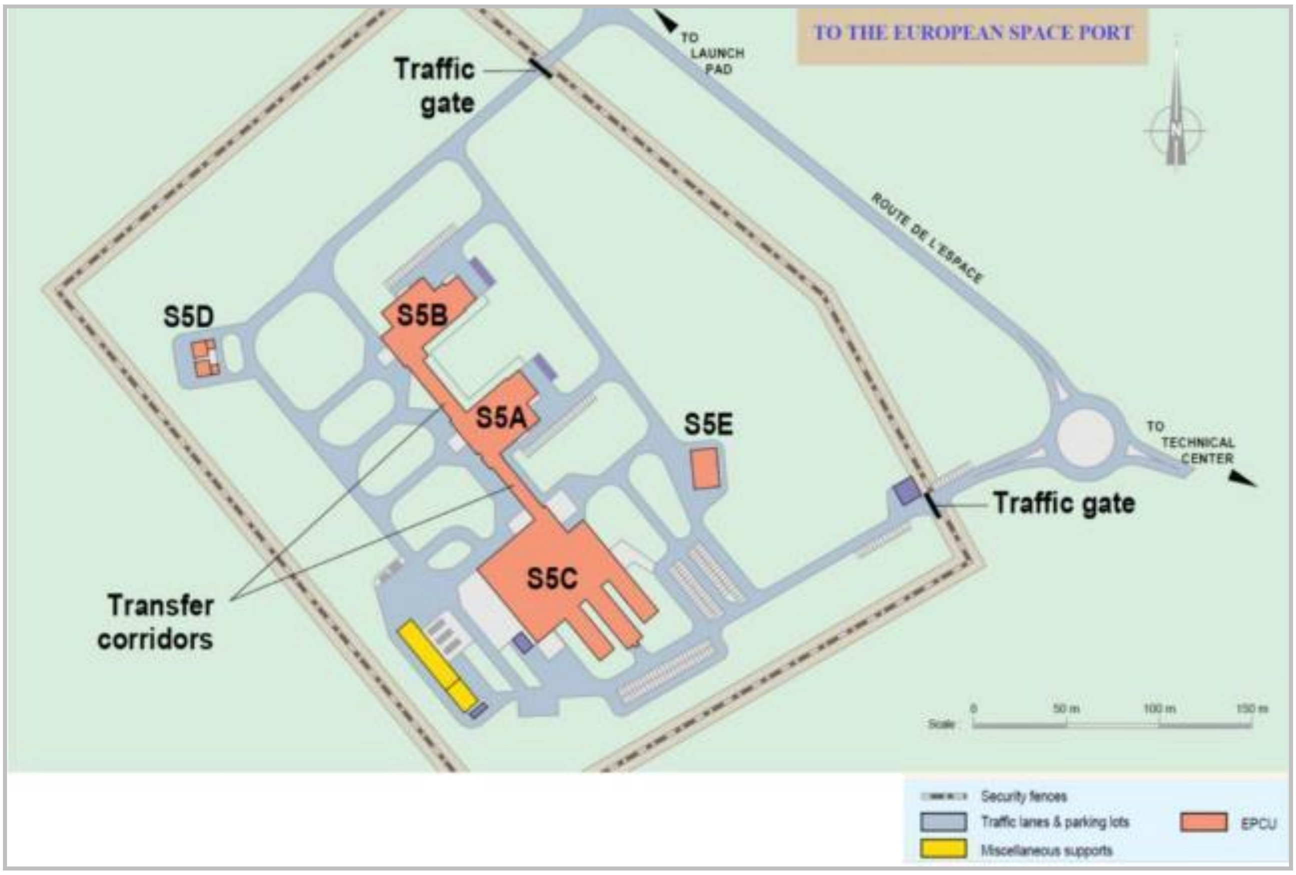


Figure 6.2.2.3.a – S5 area map

The main facility is composed of three areas equipped by airlocks and connected by two access corridors.

The satellite is transported from one hall to another, via the transfer corridors, on Customer's air cushions or trolleys.

The entrance to the area is secured at the main access gate.

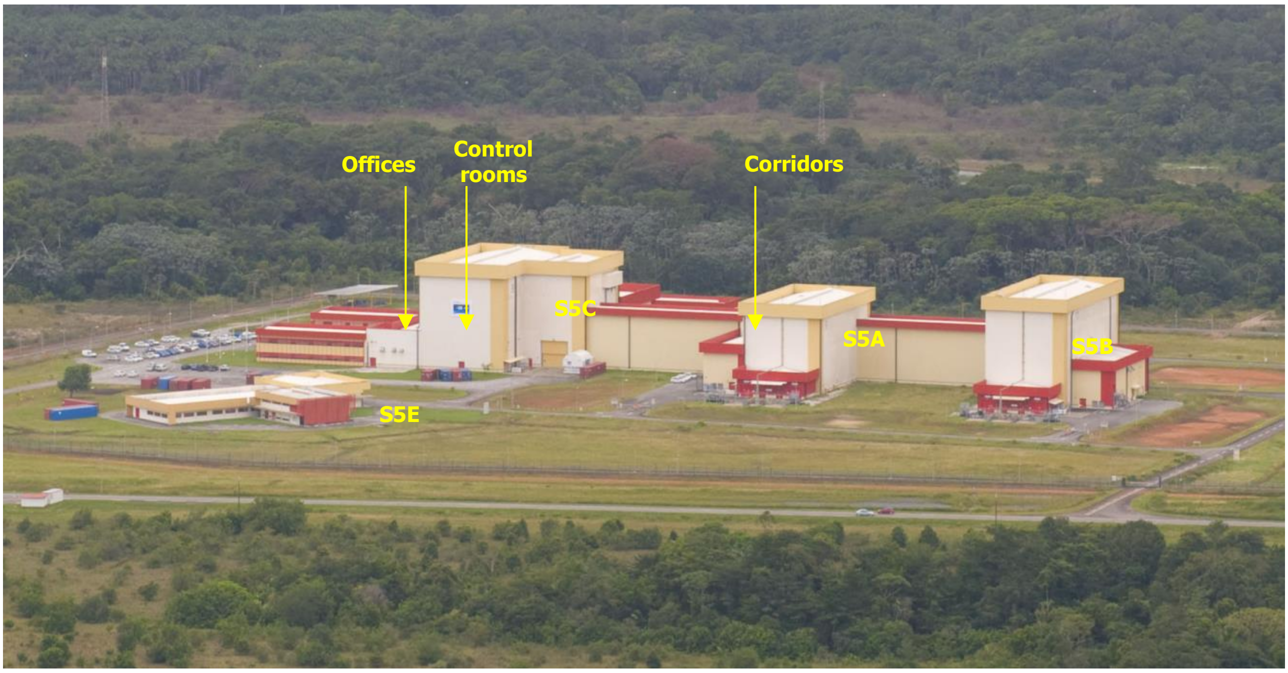


Figure 6.2.2.3.b – S5 area overview

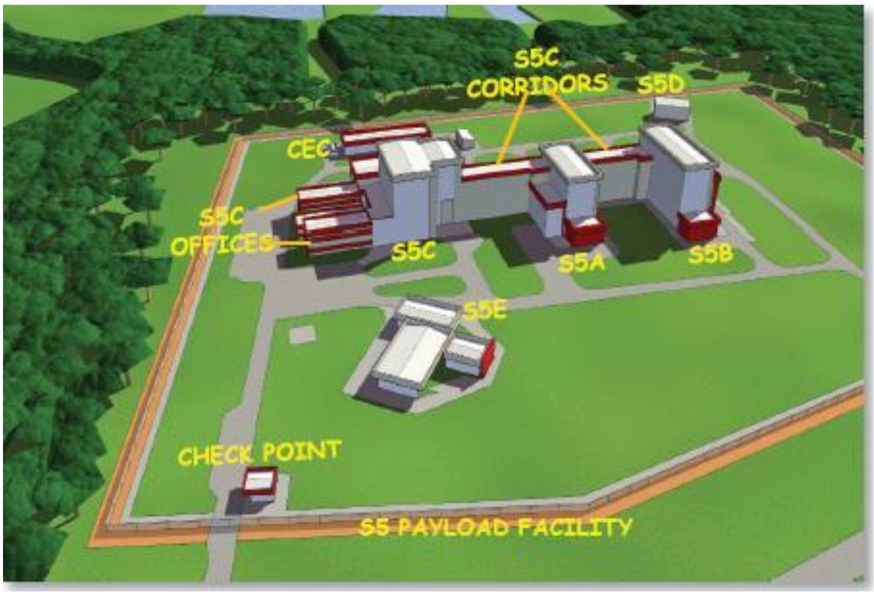
The **S5C** area, dedicated to the spacecraft non-hazardous processing and to house the spacecraft's team, is mainly composed of one large high bay of 700 m^2 that can be divided in two clean bays, four control rooms (LBC) and separated office areas.

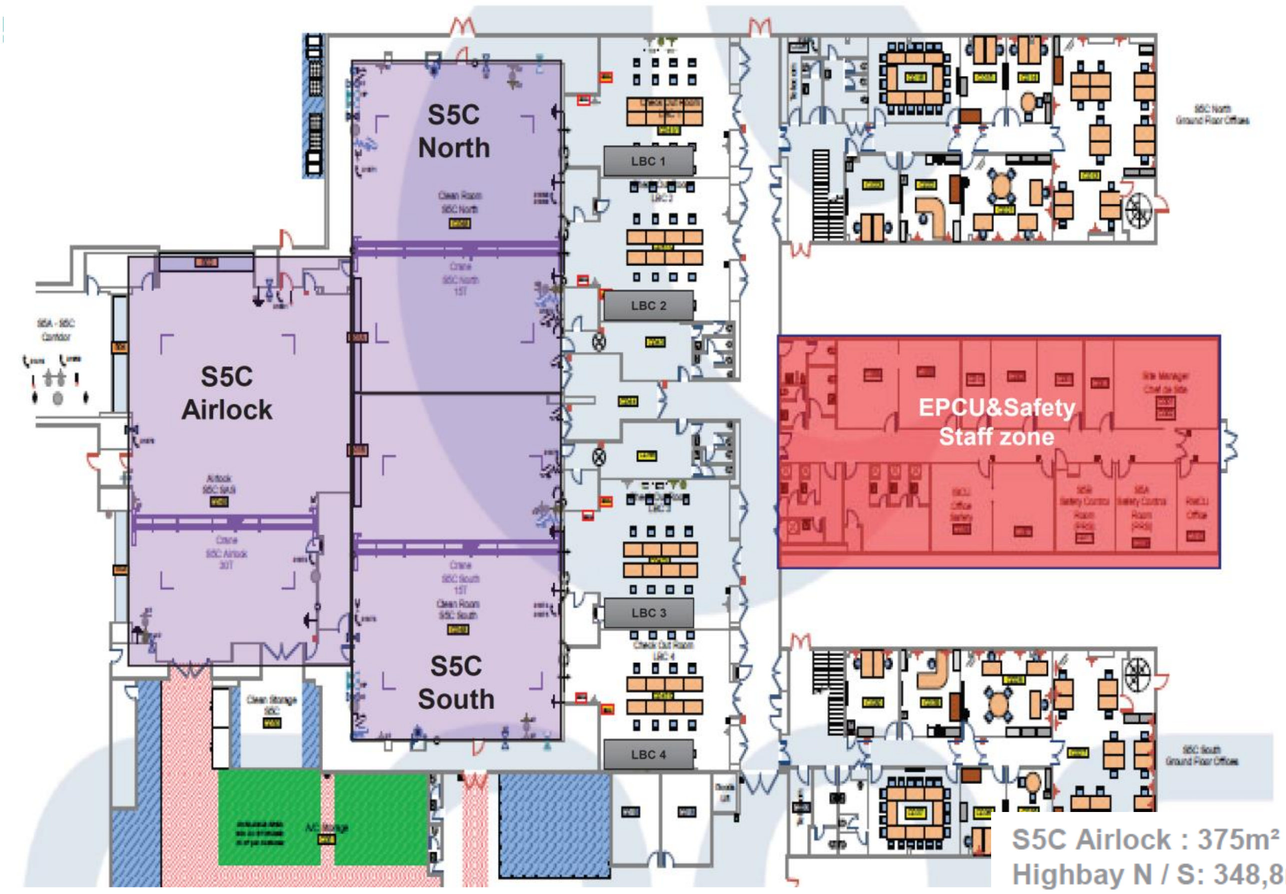
The **S5A** area, dedicated to hazardous processing, is mainly composed of one clean high bay of 300 m^2. Once the spacecraft is ready, the mating of the spacecraft on its adapter and the fairing encapsulation are also done in this hall.

The **S5B** area, also dedicated to hazardous processing, is mainly composed of one clean high bay of 410 m^2. Once the spacecraft is ready, the mating of the spacecraft on its adapter and the fairing encapsulation are also in this hall.

In addition to the main facility, the S5 area comprises the following buildings:

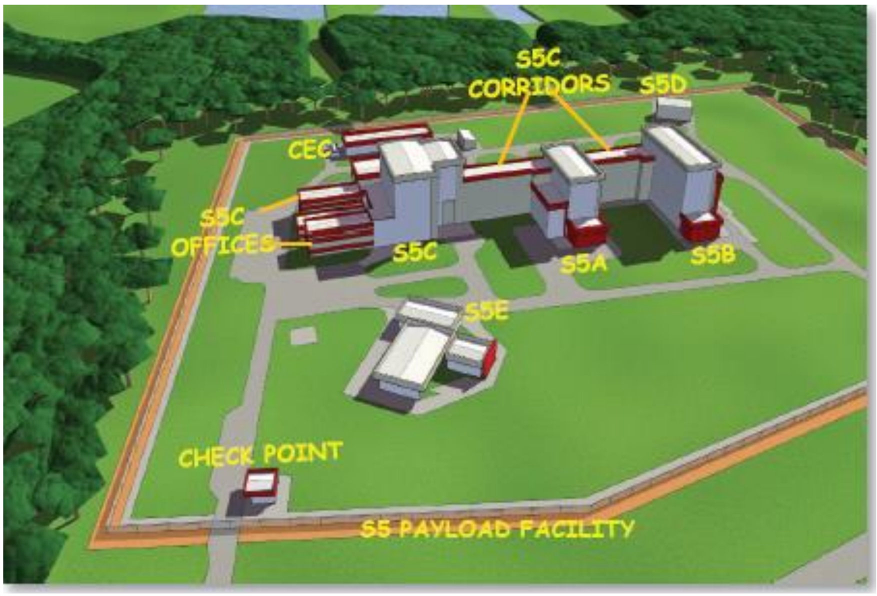
- **S5D** dedicated to final decontamination activities of satellite fueling equipment;
- **S5E** dedicated to the preparation of scape suits and training, dressing and cleaning of propulsion teams.

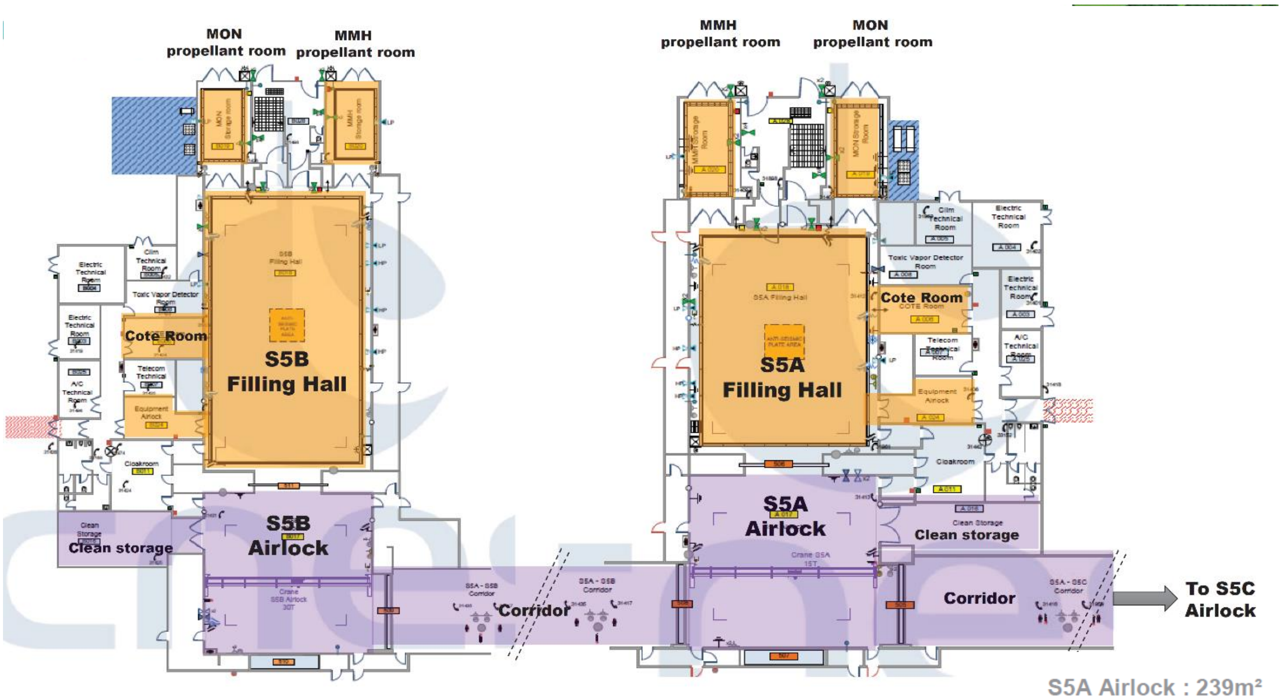




S5C Airlock : 375m²
Highbay N / S: 348,8m²
Hook height : 20m
Airlock crane : 30T
S5C south crane : 15T
S5C South crane : 15T

Figure 6.2.2.3.c – S5 building layout – Part 1





S5A Airlock : 239m^2
S5BAHighbay : 300m^2
Hook height : 15m
S5A crane : 15T

S5B Airlock : 412m^2
S5B Highbay : 235m^2
Hook height : 20m
S5B crane : 30T

Figure 6.2.2.3.d – S5 building layout – Part 2

6.2.3. Facilities for combined and launch operations

6.2.3.1. Hazardous Processing Facilities (S5A, S5B and S3B-HR)

The Vega C fairing encapsulation is performed in the HPF clean hall. When the spacecraft is ready, after spacecraft fueling and final verification, it is integrated on its adapter, and then on the carrying structure (if any, depending on the PAC configuration). Finally, it is encapsulated under the fairing. All operations are performed with spacecraft in vertical position.

The overall Payload Assembly Composite (PAC) is then transferred by road to the Vega C Launch Site (SLV "Site de Lancement Vega C") for integration onto the launch vehicle.

6.2.3.2. Vega C Launch Site (SLV « Site de Lancement Vega C »)

The Vega C launch site is a dedicated area designed for launch vehicle assembly and final preparation, the PAC integration with launch vehicle, and final launch chronology activities. It includes the launch pad (ZL "Zone de Lancement"), the mobile gantry, exhaust duct, water injection system, lighting protection masts and some support buildings.

Figure 6.2.3.2.a – Vega C launcher within mobile gantry on the launch site

Figure 6.2.3.2.b – Vega C launch site

Figure 6.2.3.2.c – Vega C launch site

6.2.3.2.1 Launch pad and mobile gantry

The mobile gantry is used for assembly, integration and tests of the launch vehicle (P120C, Z40, Z9, AVUM+), and the integration of the Payload Assembly Composite (PAC) on the launch vehicle.

It is equipped with a ceiling traveling crane for hoisting and mating of the different launch vehicle stages.

It protects from the external environment (rain, wind, sunlight).

The steps of the launcher preparation are illustrated hereunder.

a) Transfer of the P120C first stage to the Vega C launch site

Figure 6.2.3.2.1.a – Transfer of P120C first stage atop its pallet from the Booster Integration Facility by mean of a low-slung transporter vehicle up to the mobile gantry / launch pad

b) Integration of the 1/2 interstage

Figure 6.2.3.2.1.b – Hoisting and integration of the 1/2 interstage

c) <u>Integration of the Z40 second stage</u>

Figure 6.2.3.2.1.c – Transfer of the Z40 second stage from storage up to the mobile gantry / launch pad

Figure 6.2.3.2.1.d – Hoisting of the Z40 second stage and integration on the 1/2 interstage

d) <u>Integration of the Z9 third stage</u>

Figure 6.2.3.2.1.e – Transfer of the Z9 third stage with the 2/3 interstage up to the mobile gantry / launch pad

Figure 6.2.3.2.1.f – Integration on the Z9 third stage

e) <u>Integration of the AVUM+ upper stage</u>

Figure 6.2.3.2.1.g – Transfer of the AVUM+ upper stage in its container and hoisting to the mobile gantry upper platform

Figure 6.2.3.2.1.h – Integration of the AVUM+ upper stage

f) <u>Integration of the Payload Assembly Composite</u>

After integration of all launch vehicle stages (P120C, Z40, Z9, AVUM+) and completion of all the tests, the launcher is ready for the integration of the Payload Assembly Composite (PAC) and for entering the final phase of the launch preparation.

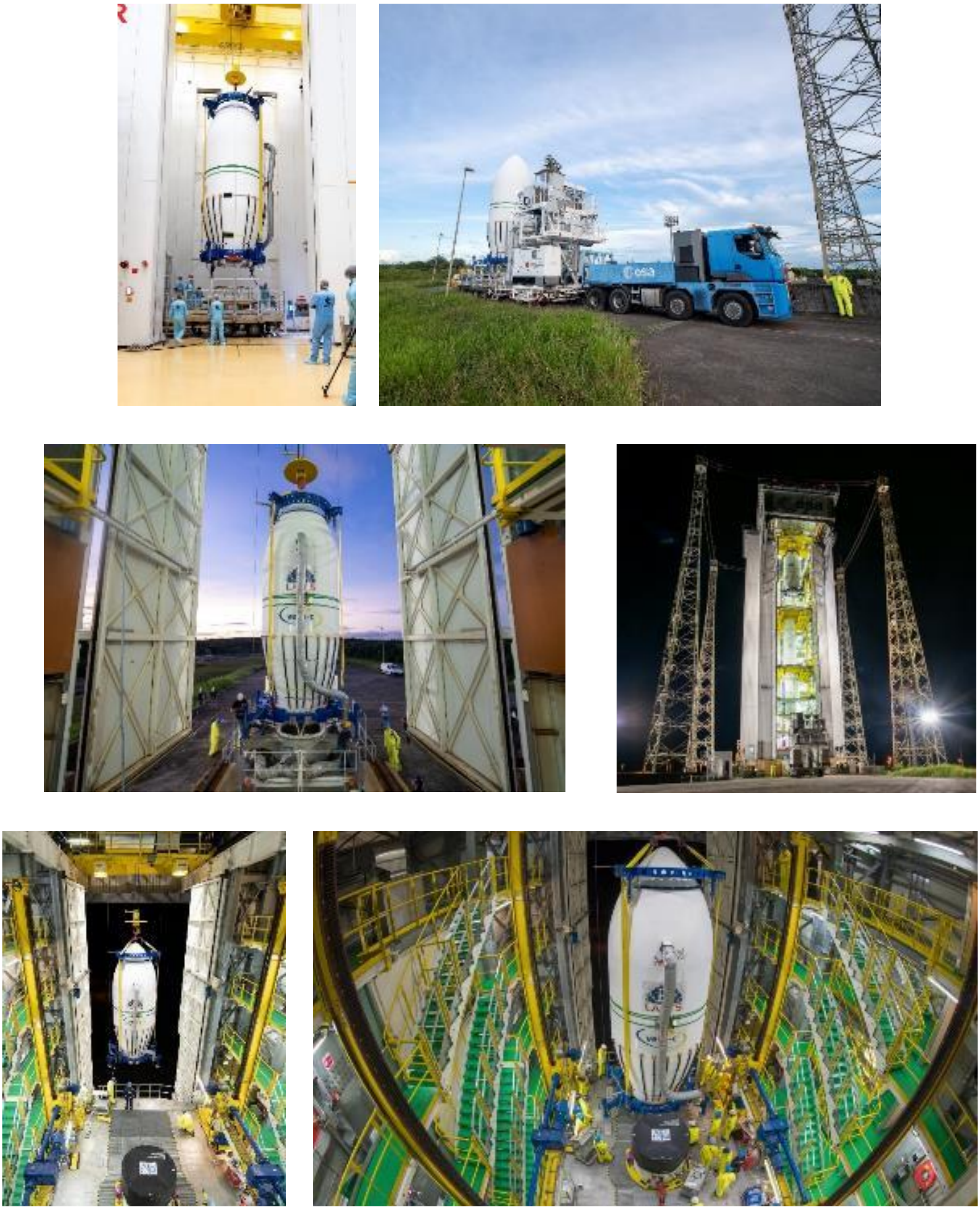


Figure 6.2.3.2.1.i – Transfer and hoisting of the PAC

The launch tower is equipped with an air-conditioning system providing clean air under the fairing, via a ventilation boa between the mast and the fairing.

Similarly, the spacecraft umbilical lines transit through the electrical umbilical cable (COE "Cable Ombilical Électrique") between the mast and the AVUM+ interstage section.

Figure 6.2.3.2.1.j – Launch vehicle completed and ready for final chronology

g) Final launch preparation for chronology

For the final chronology and launch, the mobile gantry is removed.

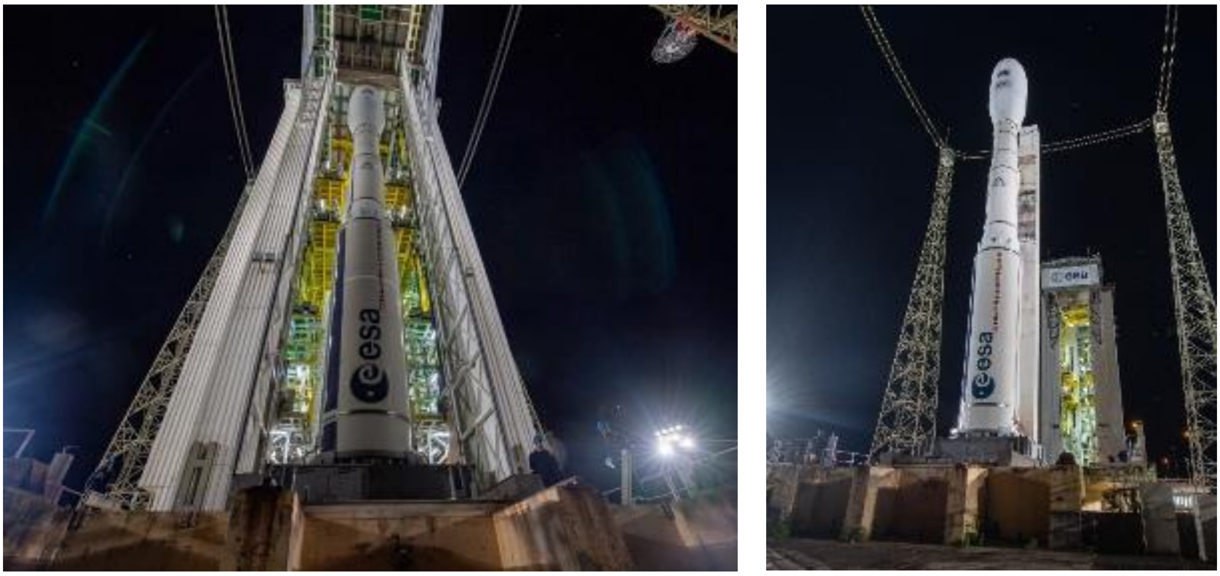


Figure 6.2.3.2.1.k – Mobile gantry roll-back

h) COTE room 101

The launch pad COTE room 101 is the location of the spacecraft front-end electrical equipment for spacecraft monitoring.

It is located underneath the launch pad.

The equipment installed in the COTE room 101 shall be qualified either acoustic or random with respect to the following levels:

- Acoustic

Octave band center [Hz]	31.5	63	125	250	500	1000	2000	Overall
Qualification level [dB]	133	132	128	126	123	122	118	137

Time duration: 1 minute

- Random

Bandwidth [Hz]	Overall level [g eff]	PSD [g^2/Hz]	Time duration
20 – 2000	12	0.0727	1 minute on 3 axes

The room 101 & spacecraft COTE are not accessible during the very final phase of the launch chronology.

6.2.3.2.2 Vega C launch control centre (Pandora)

The Vega C launch control centre is located at the CSG Technical Centre. It is used for managing the final launch preparation and monitoring the good health of the launch vehicle and the launch pad during the final chronology and it houses the launch vehicle operational team.

The launch control centre is integrated into the CSG operational communication network providing capabilities to act as one of the entities affecting countdown automatic sequence.

Figure 6.2.3.2.2a – Vega C launch control centre (Pandora)

6.2.3.3 Mission Control Centre – Jupiter 2 (CSG Technical Centre)

The CSG Technical Centre houses the Mission Control Centre located in the Jupiter 2 building. The Mission Control Centre is used for:

- Management and coordination of final pre-launch preparation and countdown,
- Processing of the data from the launcher ground telemetry network,
- Processing of the readiness of the launch base (weather forecast, safety, etc.),
- Providing data exchange and decisional process,
- Flight monitoring.

The spacecraft launch manager, or his representatives, stay in the Mission Control Centre during pre-launch and launch activities and, if necessary, can call a hold which may stop the countdown.

The Customer will have up to three operator's seats in the operational area, and two other seats for other Customer's representatives in the area called "fishbowl".

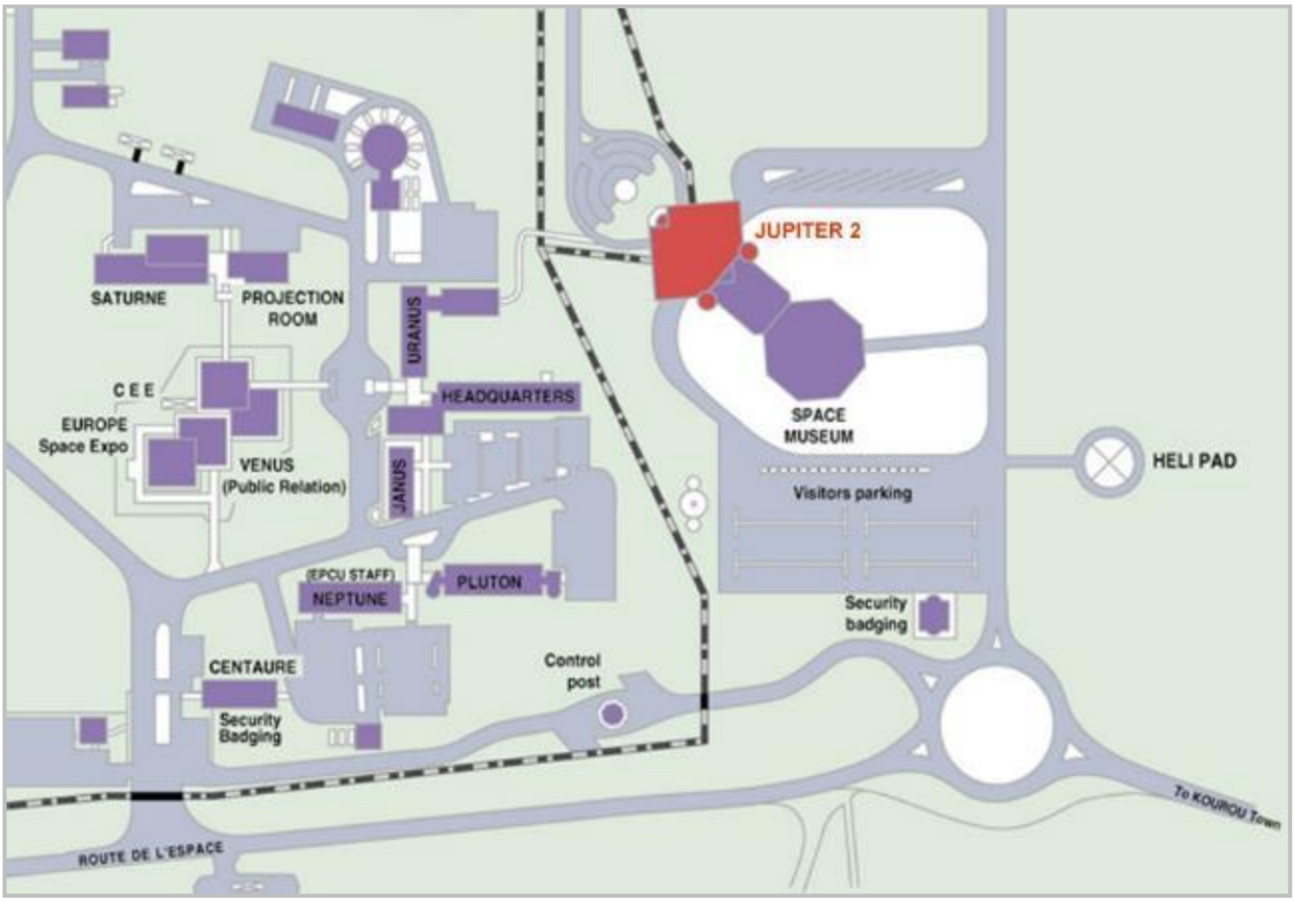


Figure 6.2.3.3.a – Location of Mission Control Centre in CSG Technical Centre

Figure 6.2.3.3.b – Typical Mission Control Centre (Jupiter 2) layout

6.3. CSG GENERAL CHARACTERISTICS

6.3.1. Environmental conditions

6.3.1.1 Climatic conditions

The outside climatic conditions at the Guiana Space Centre are defined as follows:

- the ambient air temperature varies between 18°C ≤ T ≤ 35°C;
- the relative humidity varies between 60% ≤ HR ≤ 100%.

6.3.1.2 Temperature, humidity and cleanliness in the facilities

Data related to the environment and cleanliness of the various working areas are given in Table 3.4.2.2.a for spacecraft environment on ground.

6.3.1.3 Mechanical environment

No specific mechanical requirements are applicable during the activity at the CSG except during transportation and handling.

During transport mainly by trucks and handling of the non-flight hardware and support equipment as well as spacecraft in its container, the following dimensioning loads at the interface with platform shall be taken into account:

- Longitudinal QSL (direction of motion): ± 1g;
- Vertical QSL (with respect to the Earth): 1g ± 1g;
- Transverse QSL: ± 1g.

Details on the mechanical environment of the spacecraft when it is removed from its container are given in Chapter 3.

6.3.2. Power supply

Category I is the public power network.

Category II is the CSG generators power network. It is an automatic back-up in case of Category I failure. In case of switch from Category I to Category II, the interruption lasts less than one minute.

Category III is the uninterruptible power supply network available in LBC and COTE rooms. Category III is used for critical equipment like spacecraft EGSE, communication, safety circuits, etc.

CSG equipment can supply current of European standard (230 V / 400 V - 50 Hz) or US standard (120 V / 208 V - 60 Hz).

6.3.3. Communication networks

6.3.3.1 Operational data network

Data links are provided between the Customer's support equipment located in the different facilities and the spacecraft during preparation and countdown. The Customer EGSE located in the Control room (LBC) is connected with the satellite through the COTE in the HPF COTE room and in launch pad COTE room 101.

Customer data transfer is managed through links based on optical fiber links. Three main dedicated subsystems and associated protected networks are available.

- **STFO ("Système de Transmission par Fibres Optiques")**

Transmission of TM/TC between Customer's EGSE located in LBC and satellite or COTE can be performed as follows:

  - RF signals in S, C, Ku and Ka (optional) frequency bands.

- **CAIMAN (CArrier IP Metropolitan Area Network)**

CAIMAN provides Customer with dedicated Ethernet VPLS network (10/100 Mbps). This network is set-up and managed by CSG: it can be accommodated according to Customer's request for operational data transfer between EGSE and satellite and/or for inter-offices connections between personal computers. It is a fully redundant network between LBC and launch pad.

- **Bare Fibers**

Dedicated stripped ends optical fibers are also available in LBC for EGSE connectors at one side, in HPF and in the launch pad's Customer's room for COTE connection at the other end.

6.3.3.2 Range communication network

The multifunctional range communication network provides Customer with different ways to communicate internally at CSG and externally, by voice and data, and delivers information in support of satellite preparation and launch.

The following services are proposed in their standard configuration or adapted to the Customer's needs:

- **CSG Telephone PABX System (CTS)**

CSG provides telephone sets, fax equipment for voice and data transmission through the CSG local phone network with PABX Commutation Unit.

- **Public external network**

The CSG Telephone System (CTS) is commutated with external public network including long-distance calls.

The GSM system cellular phones are operational at CSG through public operator providing roaming with major international operators.

- **Intercommunication system (Intercom)**
  - <u>Operational intersite Intercom system (IO)</u>

    The operational communication during satellite preparation, countdown and launch is provided by independent Intercom system with a host at each EPCU facility LBC. This system allows full-duplex conversations between fixed stations in various facilities, conference and listening mode. All communications on this network are recorded during countdown.

  - <u>Dedicated Intercom for hazardous operations (IE)</u>

    This restricted independent full-duplex radio system is available between operator's scape suits and control rooms for specific hazardous operations such as fueling. Upon request, this system could be connected to Operational Intercom (IO).

- **VHF communication system**

The CSG facilities are equipped with a VHF network that allows individual handsets to be used for point-to-point mobile connections by voice.

- **Paging system**

CSG facilities are equipped with a paging system. Beepers are provided to the Customers during their campaign. When on duty, Customer's representative must be joined by beeper 7/24.

- **Videoconference communication system**

Access to the CSG videoconference studio, located in the EPCU area, is available upon Customer's specific request.

6.3.3.3 Range information systems

- **Time distribution network**

The Universal Time (UT) and the Countdown Time signals are distributed to the CSG facilities from two redundant rubidium master clocks to enable the synchronization of the checkout operations. The time coding is IRIG B standard accessed through BNC connectors.

- **Operational reporting network (CRE)**

The Reporting System is used to handle all green/red status generated during final countdown.

- **Closed-circuit television network (CAMDEC)**

The PPF and HPF are equipped with internal Closed-Circuit TV network for monitoring and safety activities. It is distributed to safety control rooms. The safety video images are also distributed in Customer's offices. Hazardous operations such as fueling are recorded.

- **Public one-way announcement system**

The public one-way announcement system ensures emergency announcements, alarms or messages to dedicated CSG locations.

This system is activated through the console of a site manager and safety control rooms.

6.3.4. Transportation and handling

6.3.4.1 Transportation

For all intersite transportation including transportation from the port of entry of spacecraft and support equipment, CSG provides a wide range of road trailers, trolleys and trucks. These means are adapted to the various freight categories: standard, hazardous, fragile, oversized loads, low speed drive, etc.

The spacecraft is transported either:

- Inside its container on the open road trailer;
- In a payload container (CCU "Conteneur Charge Utile") mainly between PPF and HPF buildings whenever necessary;
- After spacecraft encapsulation inside the fairing, by the PFRCS (Plate-Forme Routière Composite Supérieur) from HPF to launch pad.

The payload containers CCU ensure transportation of spacecraft between the facilities, with low mechanical loads and maintain environments equivalent to those of clean rooms. Two containers are available, CCU2 and CCU3. [NB: CCU2 will be replaced with a larger CCU4 in the near future.]

Figure 6.3.4.1.a – The CCU2 and CCU3 payload containers
(for spacecraft transportation between facilities whenever necessary)

Figure 6.3.4.1.b – The PFRCS (for Payload Assembly Composite transportation to the launch pad)

6.3.4.2 Handling

Handling equipment including traveling cranes and trolleys are available for the transfer of spacecraft and support equipment inside the buildings.

Spacecraft lifting devices should be provided by the Customer.

6.3.5. Fluids and gases

Avio provides the following standard fluids and gases to support the Customer's launch campaign operations:

- Industrial quality gases:
  - Compressed air supplied through distribution network;
  - N50 grade nitrogen (GN_2), supplied through distribution network (from tanks) or in 50 l bottles;
  - N30-grade nitrogen (GN_2), supplied through distribution network only in S3 area;
  - N55-grade helium (GHe), supplied through distribution network from tanks (limited capacity) or in 50 l bottles;
- Industrial quality liquids:
  - N30 grade nitrogen (LN_2), supplied in 35 l or 60 l Dewar flasks;
  - IsoPropyl Alcohol (IPA);
  - De-mineralized water.

Additionally, breathable-air and distilled-water networks are available in the HPF for hazardous operations.

Any gases and liquids different from the standard fluid delivery (different fluid specification or specific use: GN2-N60, de-ionized water…) can also be procured. This service can be requested as an option.

The CSG is equipped with laboratories for chemical analysis of fluids and gases. This service can be requested by the Customer as an option.

Avio does not supply propellants. However, propellant sampling analyses can be performed on request as an option.

Disposal of chemical products and propellants are not authorized at the CSG and wastes must be brought back by the Customer.

6.4. CSG OPERATIONS POLICY

6.4.1 CSG guidelines

Normal working hours at the CSG are based on two shifts of eight hours per day, between 6:00 am and 10:00 pm from Monday to Saturday. CSG support is available as a standard between 8:00 am and 05:00 pm, and with advanced notice between 6:00 am and 08:00 am and between 05:00 pm and 10:00 pm.

Work shifts outside of normal working hours, Sunday or public holiday can be arranged on a case-by-case basis with advance notice and is subject to negotiations and agreement of CSG authorities. No hazardous activities should be scheduled on Sunday and public holidays. In all cases, access to the facility is possible 24 hours a day, 7 days a week, with the following restrictions, mainly due to safety reasons:

- Advanced notice;
- No hazardous operation or external hazardous constraints;
- No changes to the facilities configuration;
- No use of cranes and other handling equipment;
- No requirement for range support.

After spacecraft preparation and transfer to another facility, the spacecraft equipment shall be evacuated from the PPF clean room 24 hours after spacecraft departure.

The CSG is equipped with different storage facilities that can be used for temporary equipment storage during the campaign, and, optionally, outside the campaign.

6.4.2 Security

The French Government, CSG authorities and Avio maintain strict security measures. They are applicable to all launch systems on the base and allow strictly limited access to the spacecraft.

The security management is also compliant with the requirements for the export of U.S. manufactured satellites or parts.

The security measures include:

- Restricted access to the CSG at the road entrance with each area guarded by the Security service;
- Escort for the transportation of sensitive spacecraft, to and within the CSG;
- Full control of the access to the spacecraft: access to the facilities used for spacecraft preparation is limited to authorized personnel only through a dedicated electronic card system; the clean rooms are monitored 24 hours a day and 7 days a week by a security dedicated CCTV system with recording capability.

Security procedures can be adapted according to any specific Customer's requirements, as an option.

6.4.3 Safety

The CSG safety division is responsible for the application of the CSG safety rules during the campaign: this includes authorization to use equipment, operator certification and permanent operation monitoring.

All CSG facilities are equipped with safety equipment and first aid kits. Standard equipment for various operations like safety belts, gloves, shoes, gas masks, oxygen detection devices, propellant leak detectors, etc. are provided by CSG. Upon Customer's request, the CSG can provide specific items of protection for members of the spacecraft's team.

During hazardous operations, a specific safety organization is activated (officers, equipment, fire brigade, etc.).

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

The spacecraft design and spacecraft operations compatibility with CSG safety rules is verified according with mission procedure described in Chapter 7.

6.4.4 Training course

In order to use the CSG facilities in a safe way, the CSG will provide general training courses for the Customer's team. In addition, training courses for program-specific needs (e.g., safety, propellant team, crane and handling equipment operations and communication means) will be given to appointed operators.

6.4.5 Customer assistance

6.4.5.1 Visas and access authorization

For entry to French Guiana, the Customer will be required to obtain entry permits according to the French regulations.

Avio may provide support to address special requests to the French administration as needed.

Access badges to the CSG facility will be provided by the CSG following to Customer's request.

6.4.5.2 Customs clearance

The satellites and associated equipment are imported into French Guiana on a temporary basis, with exemption of duties. By addressing the equipment to CSG with attention to Avio, the Customer benefits from the adapted transit procedure (fast customs clearance) and does not have to pay a deposit, in accordance with the terms agreed by the customs authorities.

However, if after a campaign, part of the equipment remains definitively in French Guiana, it will be subject to payment of applicable local taxes.

The CSG will support the Customer in obtaining customs clearances at all ports of entry and exit as required.

Moreover, the CSG will ensure all required controls to certify that equipment leaving French Guiana at the end of the campaign is explosive-free, in order to prepare verifications at departure by airport authorities ("registered charger").

6.4.5.3 Personnel transportation

Customers have access to public rental companies located at Félix Eboué international airport.

6.4.5.4 Medical care

The CSG is fully equipped to give first medical support on the spot with first aid kits, infirmary and ambulance. Moreover, public hospitals with very complete and up-to-date equipment are available in Kourou and Cayenne.

The Customer's team shall take some medical precautions before the launch campaign: the yellow fever vaccination is mandatory for any stay in French Guiana.

6.4.5.5 VIP accommodation

Avio may propose some places for Customer's VIP in the Mission Control Centre (Jupiter 2) for witnessing of the final chronology and launch. The details of this VIP accommodation shall be agreed with advance notice.

MISSION INTEGRATION AND MANAGEMENT

Chapter 7

7.1. INTRODUCTION

This chapter describes the activities flow and organization for the overall launch service: management, mission integration process, hardware supply, etc.

The organization aims to provide the Customer with smooth launch preparation and on-time reliable launch. A customer-oriented mission integration and management process is implemented.

The mission integration and management process covers:

- **Mission management** and mission integration schedule,
- **Launch vehicle manufacturing** and hardware/software adaptation as needed,
- **Systems engineering support**,
- **Launch campaign management**,
- **Safety assurance**,
- **Quality assurance.**

The mission integration and management processes are consolidated through the mission documentation and verified during formal meetings and reviews.

7.2. MISSION MANAGEMENT

7.2.1. 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)** comprising the **Technical Specification**.

Based on the Customer Interface Requirement Document (IRD) or on the Application to Use Vega C launch vehicle filled out by the Customer (refer to template in Appendix 1), the Statement Of Work and its Technical Specification identifies the task and deliveries of the parties and the technical interfaces and requirements.

At the LSA signature, an Avio Mission Director (MD) is appointed to be the single point of contact with the Customer in charge of all aspects of the mission including technical and financial matters.

The Mission Director, through the Avio organization handles the company's schedule obligation, establishes the project priority and implements the high-level decisions. At the same time, he has full access to the company's technical staff and industrial suppliers. He is in charge of the information and data exchange, preparation and approval of the documents, organization of the reviews and meetings.

During the launch campaign, the Mission Director (MD) is supported by the Mission Operations Manager (MOM) for all activities conducted at the CSG (support during spacecraft's standalone activities, Combined Operations and launcher preparation).

Besides the meetings and reviews described hereafter, Avio will meet the Customer whenever required to discuss technical, schedule or contractual items. The following main principles are applied for these meetings:

- the agenda, dates and location are proposed in advance by the Mission Director and defined by mutual agreement;
- the host is responsible for the meeting organization and access clearance;
- the participation is open for both side subcontractors or any third parties by mutual preliminary agreement.

7.2.2. Mission integration schedule

The Mission Integration Schedule is established in compliance with the milestones and Launch Term or Period specified in the Launch Service Agreement and its Statement Of Work.

The Mission Integration Schedule provides the planning of all the tasks necessary to the mission preparation and takes into account the spacecraft's key milestones schedule (spacecraft Critical Design Review, spacecraft environment tests…).

A typical schedule is based on a 24-month timeline as shown in Figure 7.2.2.a. This planning can be adapted to each mission.

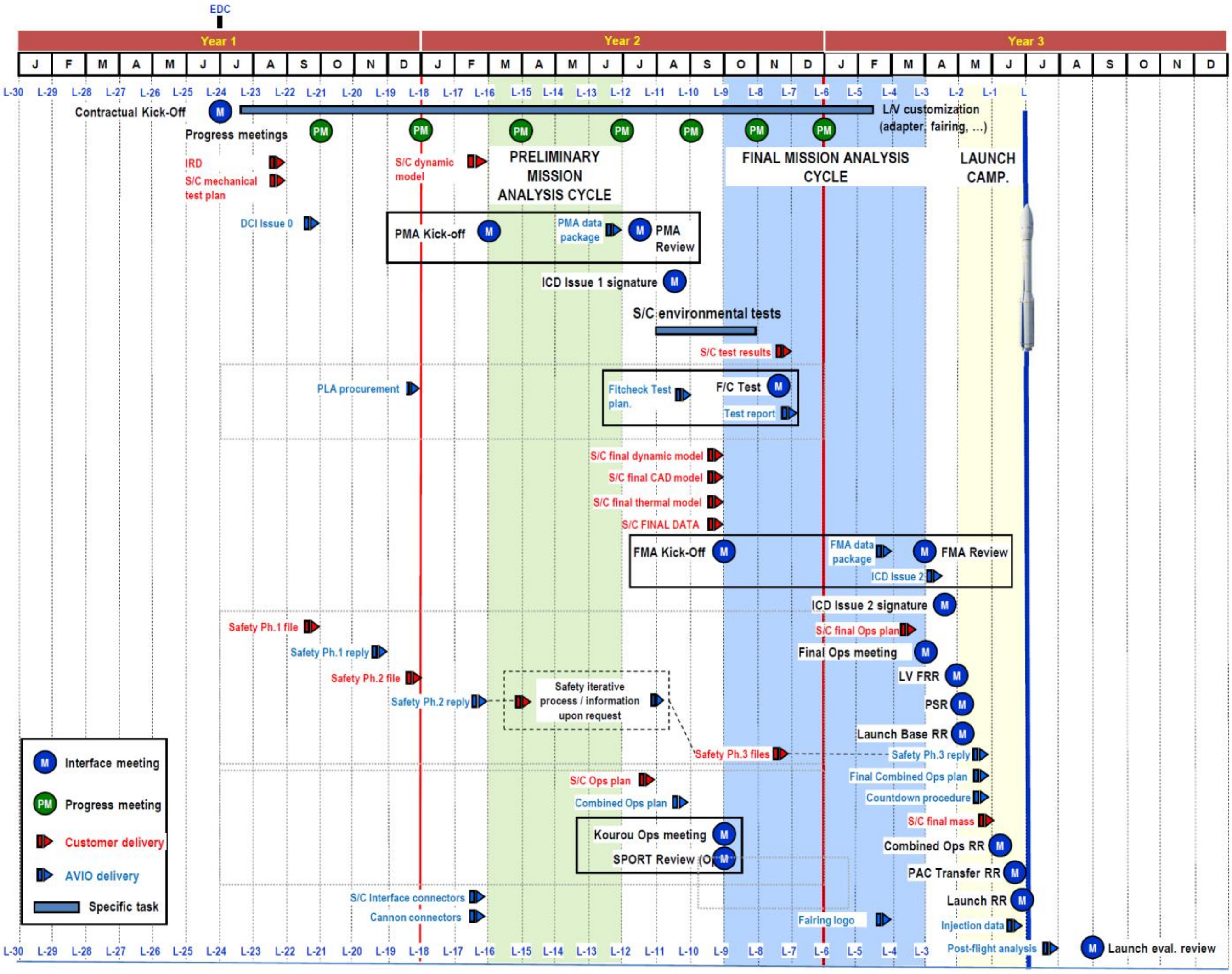


Figure 7.2.2.a - Typical Mission Integration Schedule

7.3. LAUNCH VEHICLE MANUFACTURING AND ADAPTATION

7.3.1. Manufacturing/adaptation process

Avio ensures the manufacturing/procurement of launch vehicle hardware according to the industrial organization described in § 1.5.4. The following flight items are available for the Customer launch:

- One equipped launch vehicle and its propellants;
- One dedicated flight program;
- One standard Fairing with optional access doors and optional RF transparent window;
- One adapter with its separation system, umbilical harnesses, and instrumentation;
- Mission dedicated interface items (electrical connectors…);
- Mission logo on the fairing based on artwork supplied by Customer.

7.3.2. Launch vehicle Flight Readiness Review (FRR)

The review verifies that the launch vehicle is technically capable to execute its mission.

During this review, all changes, non-conformities and waivers encountered during launch vehicle production, acceptance tests and storage are presented and justified. The launch vehicle/spacecraft interfaces are also examined with reference to the DCI, as well as the Launch System compatibility with the mission. Finally, the status of the launch operational documentation and CSG facilities readiness are reviewed.

Before the launch vehicle Flight Readiness Review, the Customer shall have demonstrated spacecraft compatibility to mission environment and launcher interfaces (mechanical and electrical).

The review is conducted by Avio and the Customer is invited to attend.

The review concludes on the authorization to start the launch campaign.

7.4. SYSTEM ENGINEERING SUPPORT

The Avio's launch service includes the engineering tasks conducted to ensure system compatibility between the spacecraft, its mission and the launch system, as well as the consistency of their respective interfaces. The final target of this activity is to demonstrate the correct dimensioning of the spacecraft, the ability of the launch vehicle to perform the mission, to perform the hardware and software customization for the launch and to confirm after the launch the predicted conditions. In this regard, the following activities are included:

- Interface management;
- Mission analysis;
- Spacecraft compatibility verification;
- Post-launch analysis.

7.4.1. Interface management & control

The technical interface management is based on the Interface Control Document (DCI) which is prepared by Avio based on the Technical Specification of the Launch Service Agreement and on the Customer Interface Requirement Document (IRD) or on the Application to Use Vega C launch vehicle filled out by the Customer (refer to template in Annex 1).

The DCI collects all spacecraft characteristics and mission parameters, defines all the interfaces between the launch system and spacecraft, and illustrates their compatibility.

Nominally, three successive versions of the DCI are provided in the course of the mission preparation:

- An initial version after the Contractual Kick-Off (Issue 0);
- An update after the Preliminary Mission Analysis Review (Issue 1);
- An update after the Final Mission Analysis Review (Issue 2).

All modifications of the DCI are approved by Avio and the Customer before being implemented.

This document is maintained under configuration control until launch. In the event of a contradiction, the document takes precedence over all other technical documents.

7.4.2. Mission Analysis

7.4.2.1. Introduction

Avio conducts several mission analyses in order to design the mission, ensure that the mission objectives can be achieved and that the spacecraft and the launch system are mutually compatible.

Mission analyses comprise two loops which are:

- The Preliminary Mission Analysis (PMA),
- The Final Mission Analysis (FMA).

The schedule of the PMA can be adapted to spacecraft development milestones and to the availability of spacecraft input data.

Typically, the following analyses are conducted:

	Preliminary	Final
Trajectory, performance and injection accuracy analysis	✓	✓
Spacecraft separation and collision avoidance analysis	✓	✓
Dynamic Coupled Loads Analysis (CLA)	✓	✓
Electromagnetic and RF compatibility analysis	✓	✓
Thermal coupled analysis	Option	✓

Note: The Customer can require additional analysis as optional services.

Each mission analysis loop begins with a kick-off meeting. At the completion of each loop, a Review is held under the joint responsibility of Avio and the Customer with support of the appropriate documentation package (Preliminary Mission Analysis Review (PMAR) and Final Mission Analysis Review (FMAR)).

7.4.2.2. Preliminary Mission Analysis

The purposes of the Preliminary Mission Analysis are as follows:

- To verify the compliance between the launch vehicle and the spacecraft;
- To evaluate the environment seen by the spacecraft to enable the Customer to verify the validity of spacecraft dimensioning;
- To review the spacecraft test plan (see Chapter 4);
- To identify all open points in terms of mission definition that shall be closed during the Final Mission Analysis;
- To identify any deviation with regard to this User's Manual (Request for Waiver).

The outputs of the Preliminary Mission Analysis are used to define the adaptation of the mission, flight and ground hardware or to adjust the spacecraft design or test program as needed. Based on the results of the PMA, the DCI is updated, issued as Issue 1 and signed by both parties.

7.4.2.2.1. Preliminary trajectory, performance and injection accuracy analysis

The preliminary trajectory, performance and injection accuracy analysis comprises:

- Definition of the preliminary reference trajectory and verification of the short- and long-range safety aspects;
- Definition of flight sequence including spacecraft separation and controlled reentry of the upper stage;
- Definition of the spacecraft injection orbital parameters;
- Evaluation of nominal performance and the associated margins with regard to spacecraft mass and upper stage propellant reserves;
- Evaluation of injection orbit accuracy;
- Verification of compliance with attitude requirements during flight;
- Definition of the tracking and telemetry ground stations visibility plan.

7.4.2.2.2. Preliminary spacecraft separation and collision avoidance analysis

The preliminary spacecraft separation and collision avoidance analysis comprises:

- Verification of the feasibility of the required orientation at spacecraft separation;
- Definition of the separation system (location and energy of the pushers) and evaluation of the relative velocity between the spacecraft and the launch vehicle;
- Evaluation of the spacecraft kinematic conditions after its separation;
- Verification of the clearance during spacecraft separation;
- Evaluation of the short- and long-term distances between the bodies.

7.4.2.2.3. Preliminary dynamic Coupled Loads Analysis (CLA)

The preliminary CLA uses a preliminary spacecraft Finite Element Model (FEM) provided by the Customer according to Avio's specification.

The preliminary dynamic Coupled Load Analysis:

- Performs the modal analysis of the launch vehicle and the spacecraft;
- Provides the dynamic responses of the spacecraft for the most severe load cases induced by the launch vehicle;
- Gives, at nodes selected by the Customer, the min-max tables and the time history of forces, accelerations, and deflections as well as launch vehicle/spacecraft interface acceleration and force time histories;
- Provides inputs to analyze, with Avio, requests for notching during the spacecraft qualification sine tests.

The results of the CLA allow the Customer to verify the validity of spacecraft dimensioning and to adjust its qualification test plan, if necessary, after discussion with Avio.

7.4.2.2.4. Preliminary electromagnetic and RF compatibility analysis

This study allows to check the compatibility between the frequencies used by the launch vehicle, the range and the spacecraft during launch preparation and flight. The analysis is intended to verify that:

- the spacecraft susceptibility level is compatible with the electromagnetic field generated by the range and the launcher, and
- the spacecraft-generated electromagnetic field is compatible with the launch vehicle susceptibility level, and vice versa,

as defined in Chapters 3 & 4 of this document.

The spacecraft antennas characteristics and transmission plan, provided by the Customer in accordance with the Avio specification, is used as input for this analysis.

The results of the analysis allow the Customer to verify the validity of the spacecraft dimensioning and to adjust its test plan or the emission sequence if necessary.

7.4.2.2.5. Preliminary thermal analysis

A preliminary thermal analysis is performed as an option.

This analysis allows to predict the spacecraft nodes temperatures during ground operations and flight, to identify potential areas of concern and, if necessary, needed adaptations to the mission.

A spacecraft thermal model provided by the Customer in accordance with Avio's specifications is used as input for this analysis.

7.4.2.3. Final Mission Analysis

The purposes of the Final Mission Analysis are:

- To define the actual flight plan and define the data necessary for the flight program production;
- To confirm mission compliance with all spacecraft's requirements;
- To review spacecraft's environment tests results and confirm spacecraft qualification;
- To confirm acceptability of any Request for Waiver (with regard to this User's Manual).

Based on the results of the FMA, the DCI is updated, issued as Issue 2 and signed by both parties.

Once results and DCI issue 2 have been accepted and signed by the Customer, the mission is considered frozen.

7.4.2.3.1. Final trajectory, performance and injection accuracy analysis

The final trajectory analysis comprises:

- Evaluation of the final launch vehicle performance, taking into account actual launch vehicle (mass breakdown, propulsion parameters, etc.) and spacecraft final mass;
- Definition of the nominal trajectory and flight sequence, and final verification of the flight safety aspects (short- and long-range);
- Definition of the final spacecraft injection orbital parameters obtained after spacecraft separation;
- Evaluation of the final injection orbit accuracy;
- Definition of the attitude profile during flight (propelled and ballistic phases);
- Definition of the final tracking and telemetry ground stations visibility plan.

The final analysis data allows the production and test of the onboard flight program (loaded in AVUM+ onboard computer).

7.4.2.3.2. Final spacecraft separation and collision avoidance analysis

The final spacecraft separation and collision avoidance analysis confirms the preliminary analysis with the latest configuration data and actual spacecraft parameters.

7.4.2.3.3. Final dynamic Coupled Loads Analysis

The final CLA updates the preliminary analysis, taking into account the actual flight configuration and the latest FEM of the spacecraft, validated by tests. It provides:

- For the most severe launch vehicle load cases:
  - The final estimate of the forces and accelerations at the interfaces between the adapter and the spacecraft;
  - The final estimate of forces, accelerations and deflections at selected spacecraft nodes;
- The verification that the spacecraft acceptance test plan and associated notching procedure comply with these final data.

7.4.2.3.4. Final electromagnetic and RF compatibility analysis

The final electromagnetic and RF compatibility analysis updates the preliminary study, taking into account the actual launch configuration and final operational sequences of RF equipment with particular attention on electromagnetic compatibility between spacecrafts in case of a multiple launch configuration.

7.4.2.3.5. Thermal analysis

The thermal analysis provides a time history of the temperature at nodes selected by the Customer.

On ground, the analysis takes into account the fairing air ventilation set point (air temperature and flow rate) and the spacecraft dissipation plan.

During flight, it takes into account the attitudes of the launch vehicle during the entire launch phase, the depressurization, the flux radiated by the fairing before fairing jettisoning, and after fairing jettisoning, the aerothermal flux, the flux coming from the Sun and the flux generated by the Z9 engine plume.

The study allows Avio to confirm the fairing ventilation parameters, needed to meet specified spacecraft temperature limits.

7.4.3. Spacecraft design compatibility verification

In close relationship with mission analysis, Avio supports the Customer in demonstrating that the spacecraft design is able to withstand the launch vehicle's environment.

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

- **A spacecraft environment test plan.**

  The Customer shall describe its approach for 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 are performed to demonstrate the adequacy of the spacecraft for ground and flight loads (e.g. static loads, vibration, acoustics and shock).

  The test plan shall be in line with the requirements described in Chapter 4 of this User's Manual. It shall include test objectives and success criteria, test specimen configuration, general test methods and a schedule. It shall not include detailed test procedures.

- **A spacecraft environment test file/data pack.**

  It shall comprise theoretical analysis and test results of the system-level structural load and dynamic environment testing.

  It shall summarize the testing performed according to Avio specification.

  For structural systems not verified by test, a structural loads analysis report, documenting performed analyses and resulting margins of safety, shall be provided.

The synthesis of the compatibility status of the spacecraft, including the mechanical and electrical interface verification tests (fit-check) are presented at the FRR.

Avio requests to attend environmental tests for real-time discussion of notching profiles and tests correlations.

7.4.4. Post-launch analysis

7.4.4.1. Injection parameters

During flight, confirmation and time of the spacecraft separation are provided in real-time to the Customer (by voice loop).

Orbit diagnosis with the injection orbit characteristics and attitude obtained just before spacecraft separation is given within one hour after spacecraft separation (by information sheets).

The first flight results based on real-time flight assessment are presented during the Post-Flight Debriefing, one day after launch.

For subsequent verification of launch vehicle performance, Avio requires the Customer to provide spacecraft's estimated orbit (tracking data on its initial orbit), and, if available, estimated spacecraft's angular rates just after separation.

7.4.4.2. Flight synthesis report

Avio provides the Customer with a flight synthesis report within two months after launch. This report covers all launch vehicle/payload interface aspects, flight events sequence, launch vehicle's performance, injection orbit and accuracy, separation attitude and rates, records of ground and flight environment, and onboard system status during flight.

These analyses, performed by experts, compare all recorded in-flight parameters to the predictions. The subsequent actions and their planning are then established by a steering committee.

7.5. LAUNCH CAMPAIGN

7.5.1. Introduction

The spacecraft launch campaign formally begins with the arrival in French Guiana of the spacecraft and its associated GSE. It concludes, after launch, with GSE shipment back.

Prior to the launch campaign, the preparation phase takes place during which all operational documentation is issued and the facilities' compliance with Customers' needs is verified.

The launch campaign is divided into three major phases:

- **Spacecraft autonomous preparation**

  It includes operations from the spacecraft arrival to the CSG and up to spacecraft readiness for integration on the launch vehicle. It is performed in two steps.

  Step 1: spacecraft preparation and check;

  Step 2: spacecraft hazardous operations.

  Spacecraft's autonomous operations are managed by the Customer, with the support and coordination of Avio and CNES/CSG for what concerns the facilities, supplying items and services.

  Spacecraft's preparation and check are carried out in the Payload Preparation Facility (PPF).

  Spacecraft's hazardous operations are carried out in the Hazardous Payload Facilities (HPF).

- **Combined Operations**

  It includes the spacecraft mating on the launch vehicle adapter, the encapsulation in the fairing, the transfer of the Payload Assembly Composite (PAC) to the launch pad under the mobile gantry, the integration on the launch vehicle and the verification procedures.

  The Combined Operations are managed by Avio with direct Customer's support.

  The first Combined Operations (spacecraft mating on its adapter, fairing closure) are carried out in the HPF.

- **Launch countdown**

  It covers the last launch preparation sequences up to the launch. Operations are carried out at the launch pad using dedicated Avio/Customer organization.

The following paragraphs provide the description of the preparation phase, launch campaign organization and associated reviews and meetings, as well as a typical launch campaign flow chart.

7.5.2. Spacecraft launch campaign preparation phase

During the launch campaign preparation phase, to ensure activity coordination and compatibility with CSG facility, Avio issues the following operational documentation based on the Spacecraft Operations Plan (POS):

- The synthesis of Customer requirements with regard to facilities (former "SPORT");
- The overall launch campaign planning ("POI" Interleaved Operations Plan);
- The Combined Operations Plan (former "NT-190");
- The electrical link verification plan (former "NT-41");
- The set of detailed procedures for Combined Operations;
- The Countdown manual.

For the Customer's benefit, prior to the launch campaign, Avio can organize a visit of the CSG facilities, coupled with operations preparation meeting. It comprises the visit of the CSG facilities, preparation of the SPORT, presentation of the POI, NT-190 and NT-41 and discussions on specific topics (safety, logistics, telecom…).

The operational documentation and related items are discussed at dedicated operations preparation meetings and status is presented at FRR.

7.5.2.1. Operational documentation

7.5.2.1.1. Customer's requirements for the Launch Campaign

The Customer Interface Requirement Document (IRD) or the Application to Use Vega C launch vehicle can provide a first level of requirements for the spacecraft launch campaign.

7.5.2.1.2. Spacecraft Operations Plan (POS)

The Customer has to prepare a Spacecraft Operations Plan (POS "Plan d'Opérations Satellite") defining the operations to be executed on the spacecraft starting from arrival in French Guiana, including during transport, spacecraft verification and test, any complementary integration, propellant loading, etc.

The POS shall define the timeline of these operations and specifies the corresponding requirements for their execution.

7.5.2.1.3. Requirement with regard to CSG facilities (former "SPORT")

Based on the IRD and POS, Avio issues a document detailing in a standard way all the spacecraft and GSE characteristics and all the spacecraft project needs for the spacecraft's launch campaign.

This document is prepared by Avio and is filled with the Customer during the operations preparation meetings. It is submitted to the Customer's approval.

7.5.2.1.4. Interleaved Operations Plan (POI)

Based on the IRD, POS and SPORT, Avio issues the Interleaved Operations Plan (POI "Plan d'Opérations Imbriquées") which provides the overall planning for spacecraft preparation from the time of arrival of spacecraft and GSE in French Guiana until launch.

In case of a multiple launch configuration, in order to facilitate the coordination, one POI is issued, applicable to all passengers of a given mission.

It is submitted to the Customer's approval.

7.5.2.1.5. Combined Operations Plan (former "NT-190")

Based on the POS and on the interface definition presented in the DCI, Avio issues the Combined Operations Plan (POC "Plan d'Opérations Combinées") which defines all the activities involving simultaneously the spacecraft and the launch vehicle or elements of the launch vehicle, in particular:

- Spacecraft mating on the launch vehicle adapter;
- Encapsulation inside the fairing;
- Transfer of the Payload Assembly Composite (PAC) to the launch pad under the mobile gantry;
- Hoisting the PAC in the mobile gantry and PAC integration on the launch vehicle;
- Dress rehearsal;
- Final countdown.

It identifies:

- All non-reversible and non-interruptible spacecraft and launch vehicle activities;
- All hazardous operations;
- Any operational requirements and constraints;
- The reference to the relevant detailed procedure and associated responsibilities.

If necessary, this document can be updated during the campaign to reflect the true status of the work or to consider real-time coordination.

The Combined Operations Plan is prepared by Avio and submitted to the Customer's approval.

As for the POI, in case of a multiple launch configuration, in order to facilitate the coordination, one NT-190 is issued, applicable to all passengers of a given mission.

7.5.2.1.6. Electrical links Checkout (former "NT-41")

Based on the POS, SPORT and POC, Avio issues the Electrical links Checkout Plan which defines the activities necessary to check the umbilical links between the spacecraft and the EGSE during the various phases of the launch campaign, especially:

- During adapter umbilical harness verification;
- After spacecraft mating on its adapter in HPF with COTE located in LBC;

- After PAC integration on the launch vehicle with OCOE installed in the COTE room located in the launch pad basement.

7.5.2.1.7. Detailed procedures for Combined Operations

The procedures include the description of the activities to be performed, the corresponding sequence, the identification of the responsibilities, the required support and the applicable constraints.

7.5.2.1.8. Countdown Manual

Avio establishes a Countdown Manual that gathers all information relevant to the countdown processing on launch day, including:

- A detailed countdown sequence flow, including all communication exchanges (instruction, readiness status, progress status, parameters, etc.) performed on launch day;
- Go/No-Go criteria;
- Communications network configuration;
- List of all authorities who interface with the Customer, including launch team members' names and functions.

7.5.3. Launch campaign organization

7.5.3.1. Spacecraft launch campaign management

During the operations at CSG, the Customer interfaces with the Mission Operations Manager for daily operation activities. The Mission Director remains Avio point of contact responsible for all the non-operational activities.

The Range Operations Manager (DDO "Directeur des Opérations") interfaces with the Mission Operations Manager. He is in charge of the coordination of all the range activities dedicated to Customer's support:

- Support in the payload preparation complex (transport, telecommunications, etc.);
- Weather forecast for hazardous operations;
- Ground safety of operations and assets;
- Security and protection on the range;
- Launcher down range stations set-up for flight.

The launch campaign organization is presented in Figure 7.5.3.1.a.

Positions and responsibilities are briefly described in Table 7.5.3.1.a.

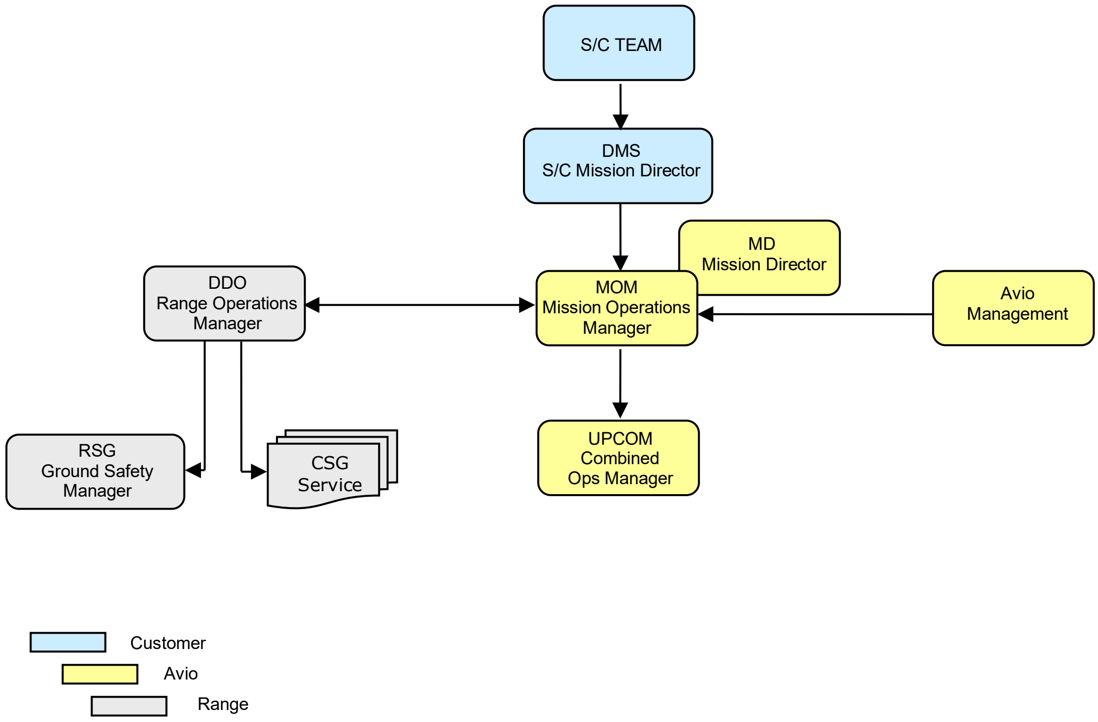


Figure 7.5.3.1.a – Launch campaign organization

Customer's Representative			
DMS Spacecraft Mission Director - *"**D**irecteur de la **M**ission **S**atellite"*	Responsible for spacecraft preparation to launch and Spacecraft launch campaign. DMS reports spacecraft and spacecraft ground network readiness during final countdown and provides confirmation of the spacecraft acquisition after separation.		
Spacecraft Manufacturer's Representatives			
CPS Spacecraft Project Manager – *"**C**hef de **P**rojet **S**atellite"*	CPS manages the spacecraft preparation team. Usually he is representative of the spacecraft manufacturer.		
RPS Spacecraft Preparation Manager – *"**R**esponsable de la **P**réparation **S**atellite"*	Responsible for the preparation, activation, and checkout of the spacecraft. Provides final spacecraft status to DMS during countdown.	**ARS** Spacecraft Ground Stations Network Assistant – *"**A**djoint **R**éseau **S**tations sol satellite"*	Responsible of spacecraft Orbital Operations Centre. Provides the final spacecraft Network readiness to DMS during countdown.
Avio's representatives			
CEO **C**hief **E**xecutive **O**fficer *supported by* **CTO**	Ensures the Avio's commitments fulfillment - Flight Director during final countdown.	**CTO** **C**hief **T**echnical **O**fficer	Chairman of Launch Vehicle Flight Readiness Review (FRR) and Launch Readiness Review (LRR). Responsible of launch authorization.
MD Mission Director	Responsible for the contractual aspects of the mission.	**CPO** Chief Product Officer	Launch vehicle authority: coordinates all technical activities allowing to state the launch vehicle flight readiness.
MOM Mission Operations Manager	Responsible for preparation and execution of the spacecraft launch campaign activities: spacecraft preparation, combined operations and final countdown.	**LCOM** Launch Complex Operations Manager	Responsible of all operations (Launcher preparation, launch site operations, combined operations with spacecraft).
UPCOM Upper Part Combined Operations Manager	MOM's deputy to interface the Customer and prepare documentation, in charge to coordinate the combined operations.		
Guiana Space Center (CSG) representatives			
CG/D Range Director	Ensures the CSG's commitments fulfillment.		
DDO Range Operations Manager - *"**D**irecteur **D**es **O**pérations"*	Responsible for the preparation, activation and use of the CSG facilities and down-range stations and their readiness during launch campaign and countdown.	**RMCU** Payload facilities Manager - *"**R**esponsable des **M**oyens **C**harge **U**tile"*	Responsible for EPCU maintenance and technical support for operations in the EPCU facilities.
RSP Security Officer - *"**R**esponsable **S**urete **P**rotection"*	Responsible of spacecraft security.	**RSV** *Flight Safety Officer – "**R**esponsable **S**auvegarde **V**ol"*	Responsible for the applications of the CSG safety rules during flight.
ISCU Payload Safety Officer - *"**I**ngénieur **S**auvegarde **C**harge **U**tile"*	Responsible for the monitoring of the payload hazardous operations.		

Table 7.5.3.1.a – Positions and responsibilities

7.5.3.2. Launch countdown organization

A typical operational countdown organization is presented on Figure 7.5.3.2.a reflecting the Go/ No-Go decision path and responsibility tree.

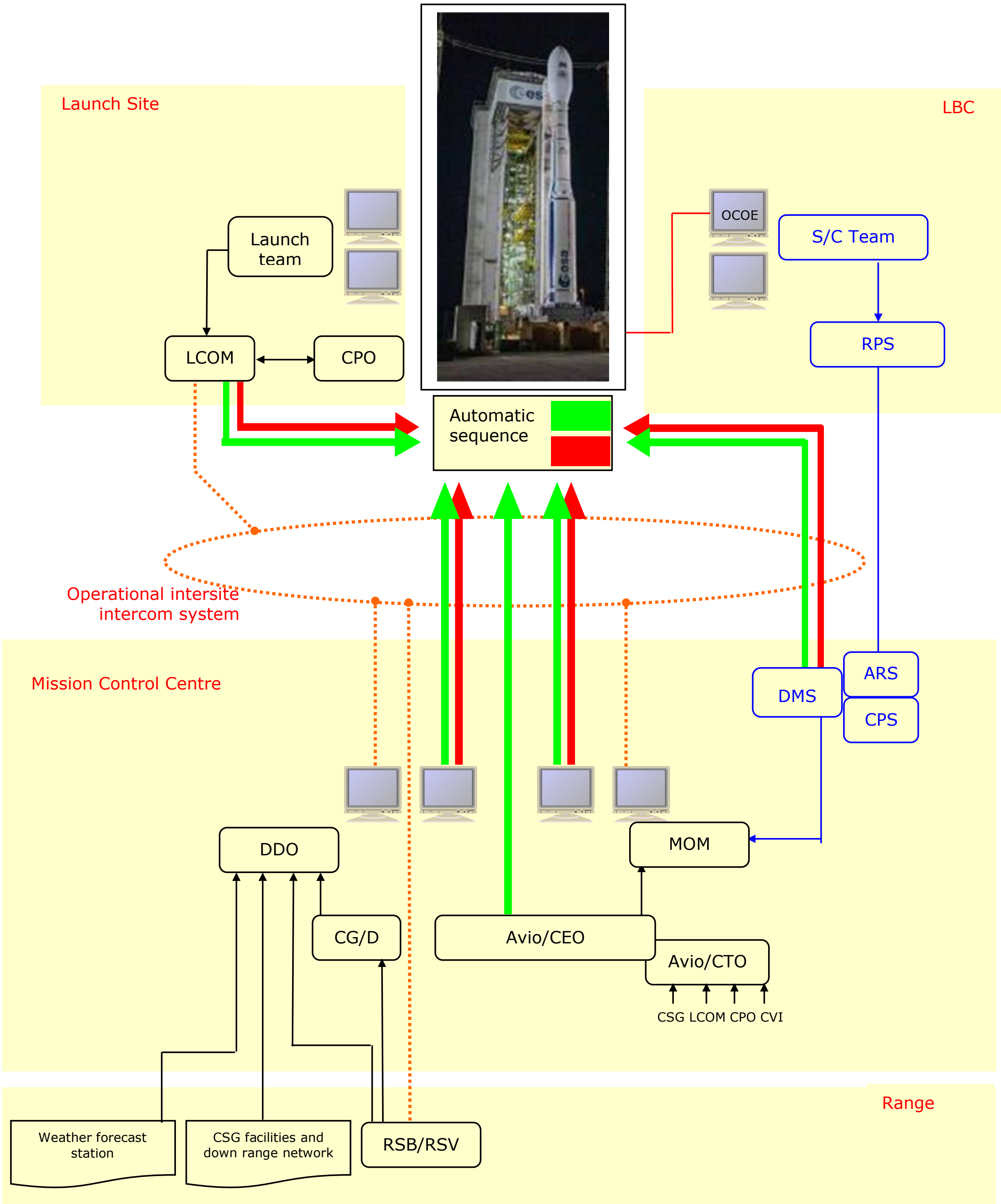


Figure 7.5.3.2.a – Countdown organization

7.5.4. Launch campaign meetings and reviews

7.5.4.1. Introduction

The launch preparation is carried out in permanent interaction between the Customer, the launch vehicle team and the Range team. This interface is under the responsibility of Avio's Mission Operations Manager. More formal meetings and reviews take place in major milestones of the operational process.

7.5.4.2. Spacecraft pre-shipment review

Avio wishes to be invited to the spacecraft pre-shipment or equivalent review, organized by the Customer and held before shipment of the spacecraft to French Guiana.

Besides spacecraft readiness, Avio can present Launch base and launch vehicle readiness status.

7.5.4.3. Spacecraft transport meeting

Avio holds a preparation meeting with the Customer before the spacecraft transportation to French Guiana. The readiness of the facilities at the port of entry (Felix Eboué International airport or Dégrad-des-Cannes international harbor), and at CSG, for the spacecraft's arrival, as well as the status of import formalities and of road transportation means are presented.

7.5.4.4. EPCU acceptance review certificate

Upon request, before the spacecraft's arrival in the EPCU, Avio (with CNES/CSG support) can deliver an acceptance certificate for the EPCU.

This certificate attests that the facilities are configured following SPORT requirements.

7.5.4.5. Range Operations Organization Meeting

At the beginning of the campaign, the Mission Operations Manager presents Avio's and Range's organization dedicated to the mission.

7.5.4.6. Combined Operations Readiness Review (POC RR)

The objective of this review is to demonstrate the readiness of the spacecraft, the flight items and the CSG facilities to enter Combined Operations. It addresses the following main points:

- The readiness status of the spacecraft;
- The mass of the spacecraft in its final launch configuration;
- The readiness of the PAC items (adapter, fairing): preparation status, nonconformities and waivers overview;
- The readiness of the launch base;
- information on the launch vehicle preparation;
- Organization and responsibility for Combined Operations.

7.5.4.7. Launch Readiness Review (LRR)

The Launch Readiness Review is held one day before launch and after the launch rehearsal. It authorizes the beginning of the final countdown and launch. This review is conducted by Avio. The Customer is part of the review board.

The following points are addressed during this review:

- Readiness status of launch vehicle, on-board software, consumables and launch pad including status of nonconformities and waivers, results of the dress rehearsal, and quality report;
- Readiness status of the spacecraft, of its GSE, of voice and data spacecraft communications network including ground stations and control centre;
- Readiness status of the range facilities (communications and tracking network, weather forecast, safety…);
- Presentation of countdown operations and Go/No-Go criteria;
- Presentation of public relations activities.

7.5.4.8. Post-flight debriefing (CRAL "Compte-Rendu Après Lancement")

The day after the actual launch, Avio draws up a report to the Customer, on post-flight analysis covering flight event sequences, evaluation of launch vehicle performance and injection orbit and accuracy parameters.

7.5.4.9. Launch service wash-up meeting

At the end of the campaign, Avio organizes wash-up meetings.

The technical wash-up meeting addresses the quality of the services provided from the beginning of the project and up to the launch campaign and launch.

The contractual wash-up is organized to close all contractual items.

7.5.5. Summary of a typical launch campaign

7.5.5.1. Launch campaign timeline and scenario

The spacecraft's campaign duration, for spacecraft autonomous operations from spacecraft's arrival in French Guiana until handover to Avio for the start of the Combined Operations, shall not exceed fifteen working days, as a standard.

The spacecraft shall be available for Combined Operations eight working days prior to the launch day, at the latest.

A typical spacecraft operational time schedule is shown in Figure 7.5.5.1.a.

The spacecraft check-out equipment and specific COTE (Check Out Terminal Equipment) necessary to support the spacecraft/launch vehicle on-pad operations shall be made available to Avio and validated, two days prior to operational use according to the approved operational documentation, at the latest.

All spacecraft Mechanical & Electrical Ground Support Equipment (MGSE & EGSE) shall be removed from the various high bays and from the launch pad according to the following schedule:

- in PPF: equipment packed within 24 hours after spacecraft transfer to HPF;
- in HPF: equipment packed within three working days after PAC transfer to Launch Pad;
- at Launch Pad and LBC: equipment made ready for return shipment within three working days after the launch.

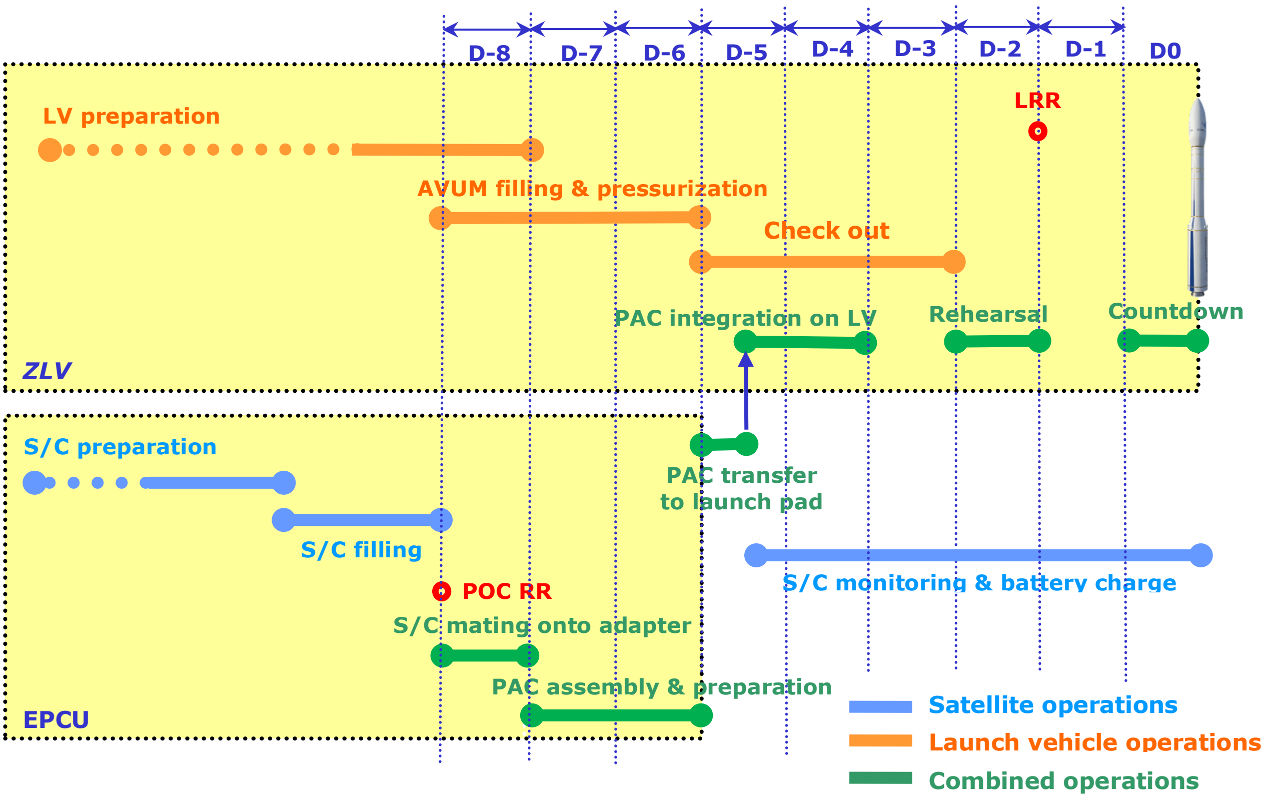


Figure 5.5.1.a - Typical Vega C launch campaign schedule

7.5.5.2. Spacecraft autonomous preparation

Phase 1: spacecraft arrival, preparation and check out

The spacecraft and its associated GSE arrive at the CSG through one of the port-of-entry described in Chapter 6.

Unloading is carried out by the airport or harbour authorities under the Customer's responsibility in coordination with Avio and CNES/CSG. Equipment should be packed on pallets or in containers and protected against rain and condensation.

After formal procedures, the spacecraft and GSE are transferred by road to CSG's appropriate facilities on the CSG transportation means. On arrival at the PPF, the Customer is in charge of unloading equipment and dispatching with Avio and CNES/CSG support. The ground equipment is unloaded in the transit hall and the spacecraft, in its container, is unloaded in the high-bay airlock of the PPF. If necessary, pyrotechnic systems and any other hazardous systems of the same class can be stored in the pyrotechnic devices buildings of the Pyrotechnical Storage Area (ZSP "Zone de Stockage Pyrotechnique"). Hazardous fluids are stored in a dedicated area.

In the Spacecraft Operations Plan (POS), the Customer defines the way his equipment should be arranged and laid out in the facilities. The Customer states which equipment has to be stored in an air-conditioned environment. Other equipment is stored under the open shed.

Autonomous operations and checks of the spacecraft are carried out in the PPF. These activities include:

- Installation of the spacecraft checkout equipment, connection to the facilities power and operational networks with CSG support;
- Removal of the spacecraft from containers and deployment in the clean rooms. This also applies to flight spare equipment;
- Spacecraft assembly and functional tests (non-hazardous mechanical and electrical tests);
- Verification of the interface with launch vehicle, if needed, such as: electrical fit check, etc.;
- Battery charging.

The duration of such activities varies with the nature of the payload and its associated tests.

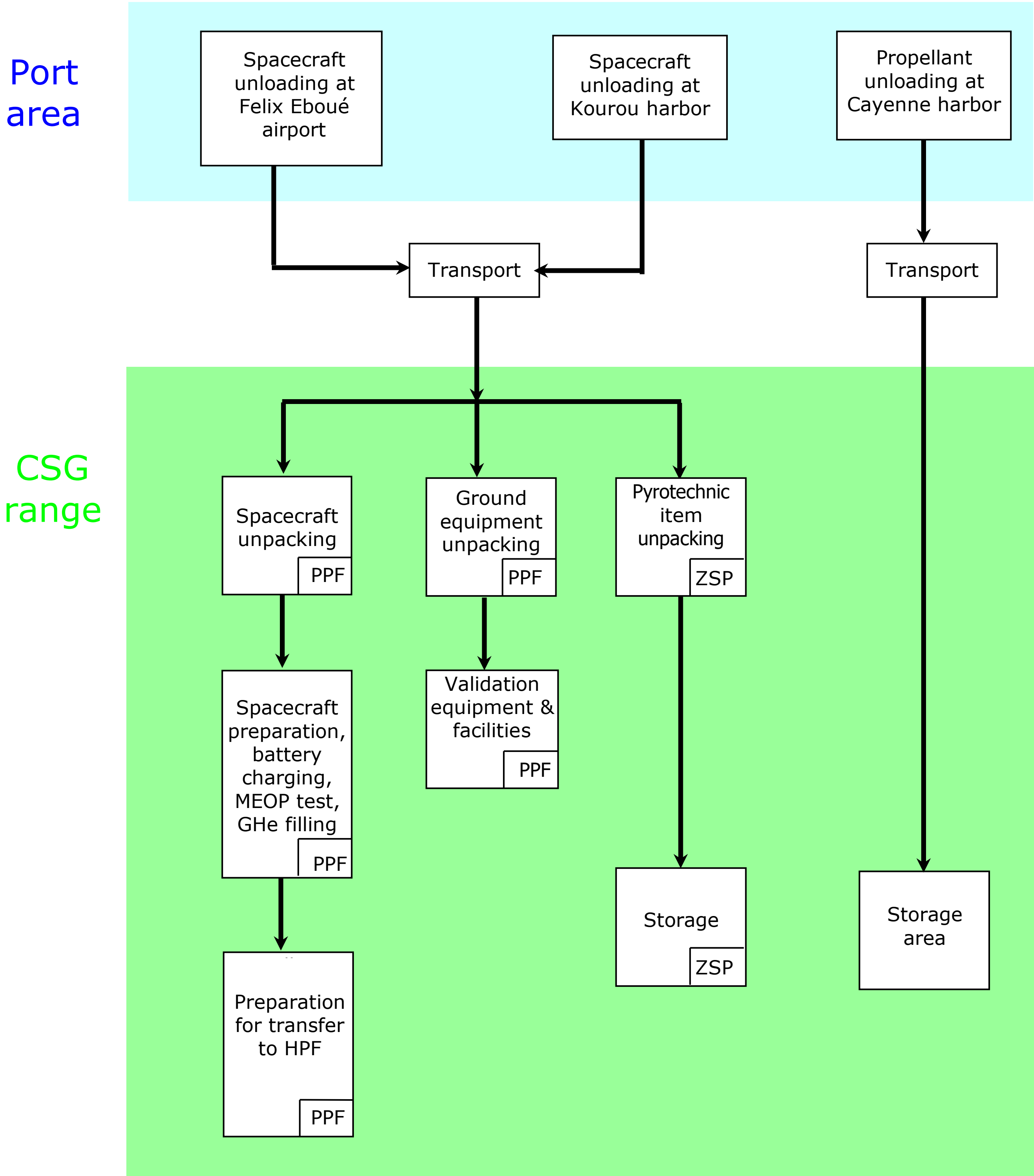


Figure 7.5.5.2.a – Spacecraft standalone operations phase 1 – Typical flow diagram

Phase 2: spacecraft hazardous operations

Spacecraft filling and hazardous operations are performed in the HPF. The facility and communication network setup are provided by Avio with CNES/CSG support.

The pyrotechnic systems are prepared and final assembly is carried out by the spacecraft team.

CNES/CSG brings the propellant drums from the storage area to the allocated HPF facility. The spacecraft team carries out the installation and validation of spacecraft GSE, such as pressurization and filling equipment and setup of propellant transfer tanks.

The Customer fills and pressurizes the spacecraft tanks to flight level.

Hazardous operations are monitored from a remote-control room. CSG Safety Department ensures safety during all these procedures.

The integration of hazardous items (category A pyrotechnic devices, etc.) into spacecraft is carried out in the same way.

Weighing devices are available for Customer in HPF.

Spacecraft batteries may be charged in HPF, if needed, except during dynamic hazardous operations.

Fluids and propellant analyses are carried out by CNES/CSG laboratories upon Customer's request as defined in the SPORT.

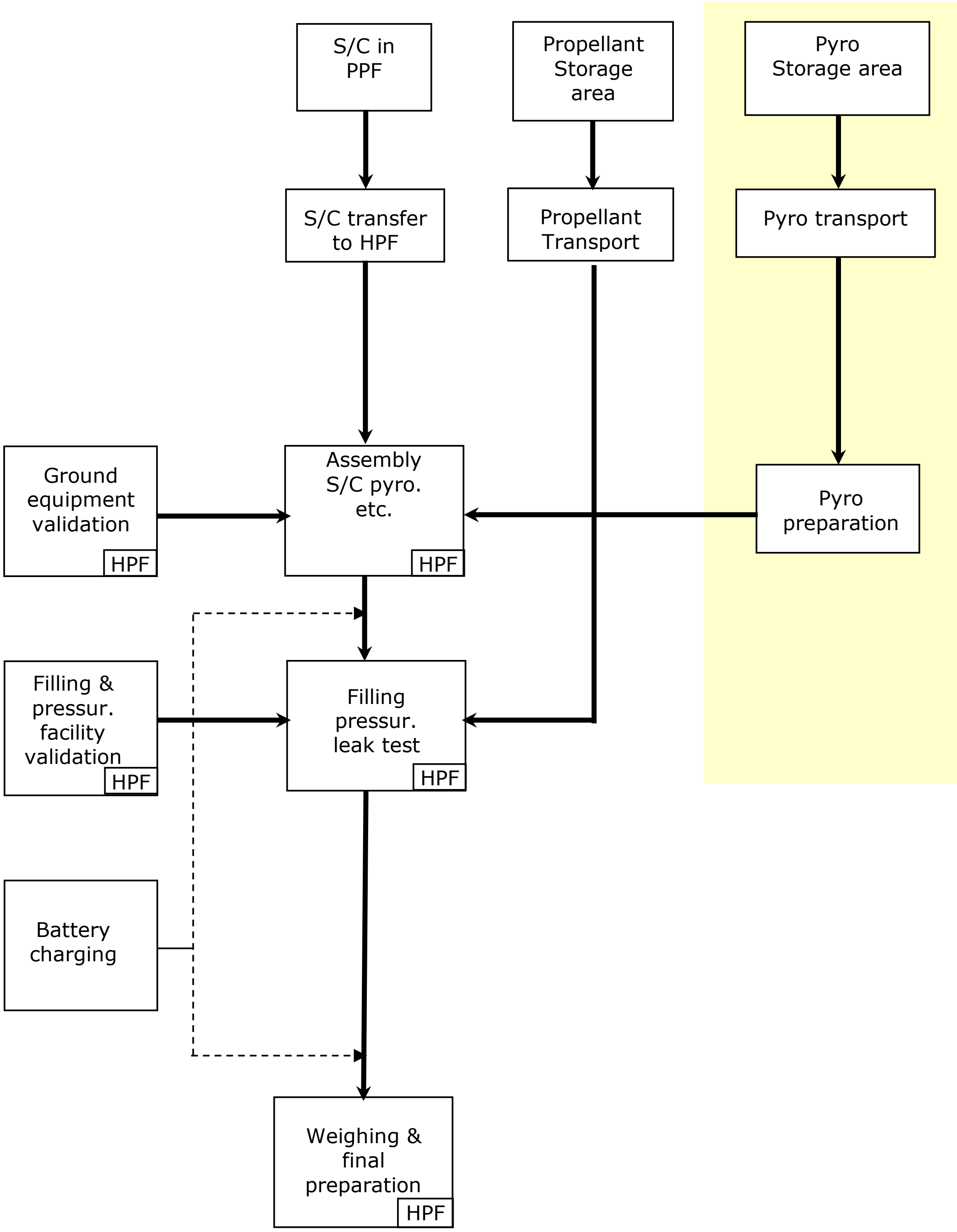


Figure 7.5.5.2.b – Spacecraft standalone operations phase 2 – Typical flow diagram

7.5.5.3. Launch vehicle processing

The first stage (P120) is transported to the mobile gantry, in flight position, by road. The final acceptance tests of the first stage are performed in the mobile gantry, after finalization of its integration.

All other elements (Z40, Z9, AVUM+, fairing, adapter…) are nominally transported by boat from Europe to Kourou harbour. Then, they are transferred by road to the Vega C Launch Complex, within their own container. Those stages arrive fully integrated and tested (except pyrotechnic devices).

The pyro igniters are transported as separate deliveries and are integrated in Kourou.

The launcher is integrated in vertical position on the launch table in the mobile gantry.

The propellant loading of the AVUM+ is performed through the mobile gantry.

The Payload Assembly Composite (PAC) is integrated in HPF and transported to the mobile gantry by road.

7.5.5.4. Combined Operations

7.5.5.4.1. Operations in HPF

The spacecraft matting on its adapter and the fairing closure are carried out in the HPF under Avio's responsibility. After delivery of all these parts to HPF and their verification and acceptance, the Combined Operations Readiness Review authorizes the Combined Operations. The Combined Operations include the following activities:

- Final preparation of the spacecraft;
- Mating of the spacecraft onto the adapter and associated verification;
- Constitution of the Payload Assembly Composite (PAC) with encapsulation by the two fairing halves;
- Umbilical lines verification.

7.5.5.4.2. Transfer to the launch pad

The PAC is transferred by road to the Launch Pad. The duration of this transfer is typically three hours.

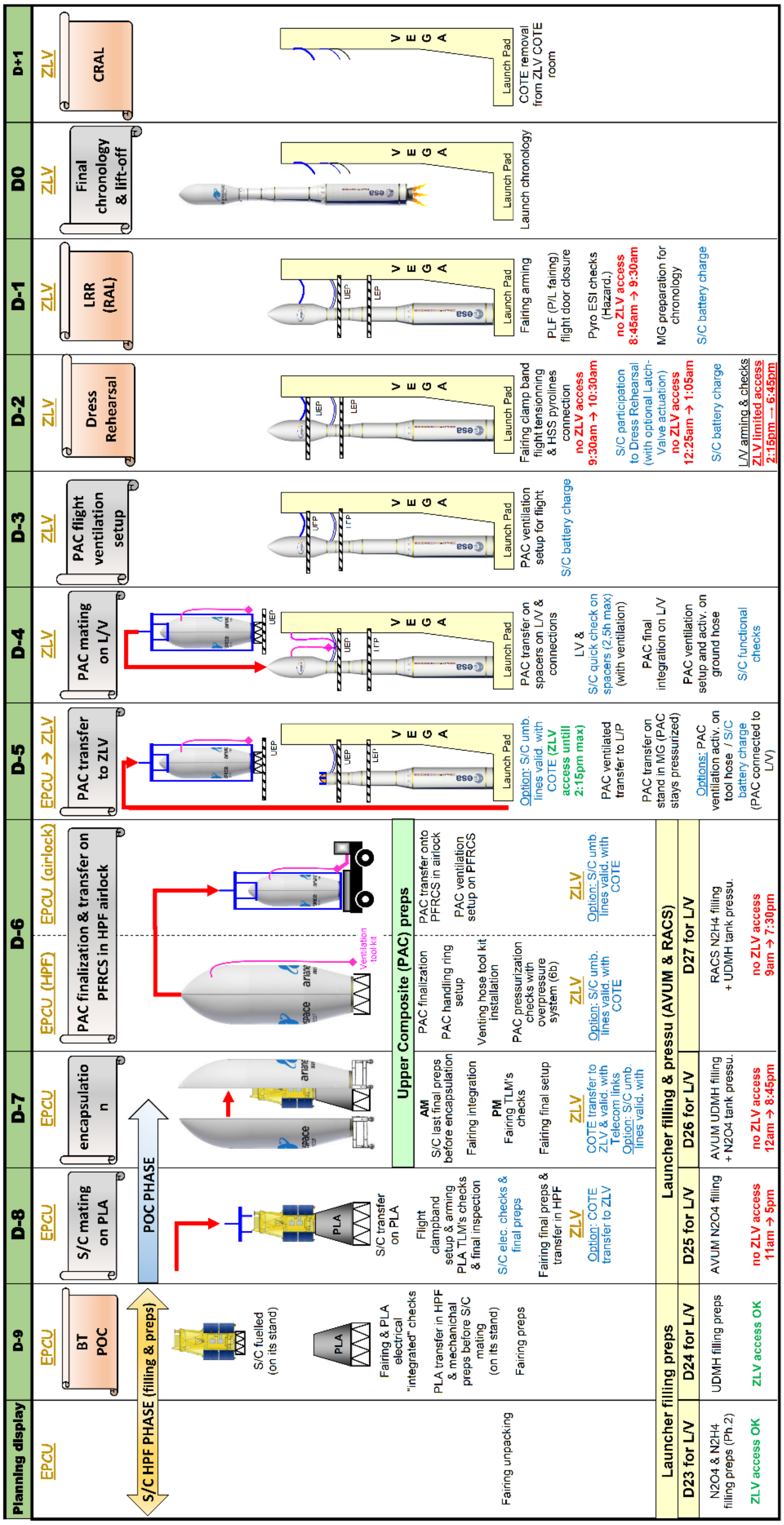


Figure 7.5.5.4.2.a – Standard Combined Operations Plan (single launch)

7.5.5.5. Launch pad operations

7.5.5.5.1. Launch pad preparation activities

The setup of spacecraft COTE and the verification of the launch pad ground segment are performed as early as possible in the campaign. A countdown chronology rehearsal based on the launch countdown procedures is conducted to allow teams to get familiar with procedures.

7.5.5.5.2. PAC final integration on the launch pad

After its arrival on the launch pad, the PAC is hoisted on the Payload access platform (PFCU "Plate-Forme Charge Utile") by the mobile gantry travelling crane and installed temporarily on spacers. The ventilation umbilical connection and electrical connections between PAC and launcher are performed in this configuration. After this intermediate step on spacers, the PAC final mating on launch vehicle is performed.

7.5.5.5.3. Launch countdown rehearsal

The launch countdown rehearsal implies the activation of the major part of the electrical and mechanical on-board and ground sub-systems involved in launch, together with spacecraft systems and ground network. The main objective of this rehearsal is the verification of the interfaces and the training of the spacecraft and launch vehicle teams to launch procedures.

7.5.5.6. Launch countdown

The major countdown activity starts approximately eight hours before lift-off. During this time, the Customer performs the final spacecraft preparation and verification, according to agreed slots during the final countdown. The spacecraft's final RF flight configuration set up must be completed before H_0-1h30m and remains unchanged until 20 s after separation.

- **Spacecraft switch-on to internal power**

  Switch from external to internal power is performed so that the spacecraft is ready for launch in due time, preferably before entering in the automatic sequence.

- **Launch vehicle automatic sequence**

  The automatic sequence is initiated at H_0-4min.

- **Launch vehicle countdown hold**

  In case of stop action during the final sequence, the countdown clock is set back to H_0-4min. When necessary, the spacecraft can be switched back to external power.

- **Spacecraft countdown hold or abort**

  The Spacecraft Authority can stop the countdown until H_0-8s.

7.6. SAFETY ASSURANCE

7.6.1. General

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

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

CNES/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 Authorities. These approvals cover payload hazardous systems design, all transportation and ground activities that involve spacecraft and GSE hazardous systems, and the flight plan.

7.6.2. Spacecraft Safety Submission

In order to obtain the safety approval, the Customer has to demonstrate that his equipment and its utilization comply with the provisions of the Safety Regulations. Safety demonstration is accomplished in several steps, through the submission of documents defining and describing hazardous elements and their processing. Submission documents are prepared by the Customer and are sent to Avio providing adequate support in relation with CNES/CSG authorities.

The time schedule for formal Safety Submissions shows the requested deadlines, working backwards from launch date L as presented in Table 6.2.a.

A safety checklist is given in the Payload Safety Handbook (PSH) to help with the establishment of the submission documents.

Safety Submissions	**Typical schedule**
Phase 0 – Feasibility (optional) A Customer willing to launch a spacecraft containing innovating systems or subsystems can obtain a safety advice from CSG through a preliminary 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.	After the contract signature and before PMA kick-off
End of Phase 1 submission	Not later than PMA Review or L-12 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.	As soon as it becomes available and not later than L-12 m
End of Phase 2 submission	Not later than L-9 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.	Before campaign preparation visit or L-6 m
Approval of the spacecraft compliance with CSG Safety Regulation and approbation of the procedures for autonomous and combined operations.	Before spacecraft fueling at latest

Table 6.2.a – Safety Submission time schedule

7.6.3. Safety training

The general safety training is provided to the Customer before or at the beginning of the launch campaign. On the arrival of the launch team at CSG, a specific training can 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, is given to the appointed operators, including operations rehearsals.

7.6.4. Safety measures during hazardous operations

The spacecraft authority is responsible for all spacecraft and associated ground equipment operations.

The CSG Safety Department's 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 representative, which in return takes all steps 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 gives the relevant clearance for any hazardous operations.

Upon request from the Customer, the CSG can provide specific protection equipment for members of the spacecraft team.

In case the launch vehicle, the spacecraft and, if applicable, its co-passenger, imposes crossed safety constraints and limitations, Avio, together with CNES/CSG support, coordinates the respective Combined Operations and can restrict the operations or access to the spacecraft for safety reasons.

7.7. QUALITY ASSURANCE

7.7.1. Avio's quality assurance system

To achieve the highest level of reliability and schedule performance, the Avio's Quality Assurance system covers the launch services provided to Customer and the launch vehicle hardware development and production, including suppliers.

Avio quality rules and procedures are defined in the company's Quality Manual.

The system is based on the following principles and procedures:

A. Appropriate management system

The Avio organization presents a well-defined decisional and authorization tree. The Quality directorate is responsible for establishing and maintaining the quality management tools and systems, and setting methods, training and evaluation activities (audits). The Quality directorate representatives provide uninterrupted 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

Avio registers the modifications or evolutions of the system and procedures, in order not to affect the hardware reliability and/or interfaces compatibility with spacecraft.

C. Quality monitoring of the manufacturing

Avio conducts regular supply chain assessment and monitoring to check:

- the maturity status of the process and tooling,
- the quality of the product and its timely delivery,
- correct application of configuration and quality management rules.

Management of technology changes: In the Vega C exploitation phase, the changes are minimized in order to ensure stable and reliable production.

During the launch campaign, upon Customer's request, specific meetings may be organized with the Launch Vehicle and Quality Authorities, as necessary, to facilitate the understanding of the anomalies or incidents.

The system is permanently under improvement thanks to the Customer's feedback during the launch services wash-up meeting at the end of the mission.

APPLICATION TO USE VEGA C LAUNCH VEHICLE

Appendix 1

The Customer interested in launching on Vega C shall provide to Avio the information described in this appendix.

The following Application to Use Vega C Launch Vehicle will preferably be provided, duly completed, in Microsoft Word format, along with a Gantt-chart of spacecraft preparation schedule, a CAD model (*.stp format) and all relevant electronic files (Microsoft Excel format).

A1.1. SPACECRAFT MISSION SUMMARY

<table>
<tr><td>Name:</td><td>Operator:</td></tr>
<tr><td>Manufactured by:</td><td>Platform type and/or heritage:</td></tr>
<tr><td colspan="2">DESTINATION
Please select: Earth Observation, Scientific, Meteorological, Navigation, Telecommunication, In-Orbit Testing/Demonstration, Others</td></tr>
<tr><td colspan="2">MISSION & PAYLOAD
Provide purpose & brief description of the payload</td></tr>
<tr><td>MASS
Indicate spacecraft masses
Total mass at launch: ___ kg
Total propellant mass: ___ kg</td><td>LIFETIME
Indicate spacecraft lifetime in orbit
___ years</td></tr>
<tr><td>INJECTION ORBIT
Indicate type of orbit, acceptable range for Local Time of Ascending Node, altitude
Type of orbit:
LTAN:
Altitude:</td><td>DIMENSIONS
Indicate spacecraft dimensions
Stowed for launch:
H ___mm L ___mm W ___ mm
(H in the direction of separation)
Deployed on orbit:
H ___mm L ___ mm W ___ mm</td></tr>
<tr><td colspan="2">COMMUNICATION SUB-SYSTEM
Indicate frequency band for TM, TC, and payload
TM:
TC:
Payload:</td></tr>
<tr><td colspan="2">GROUND STATION NETWORK
Indicate envisaged ground stations, for LEOP phase and operational phase
Ground stations for LEOP phase:
Ground stations for operational phase:</td></tr>
<tr><td colspan="2">ELECTRICAL POWER SUB-SYSTEM
Provide a brief description of the batteries (type, capacity, battery operating lifetime)</td></tr>
<tr><td colspan="2">PROPULSION SUB-SYSTEM
Provide a brief description of the propulsion system: type of propellant, number of tanks</td></tr>
</table>

A1.2. SPACECRAFT READINESS SCHEDULE & DEVELOPMENT PLAN

Envisaged launch period:	*Provide planned launch period.*

Main milestones:
Provide a Gantt-chart of the spacecraft design, manufacturing and tests schedule with at least the following main milestones: - System CDR: - Start/end of spacecraft integration: - Start/end of spacecraft test campaign(s): - Flight Acceptance Review (FAR):

Development plan:
Prepare a file containing all the documents necessary to assess the spacecraft development plan with regard to compatibility with the Launch System: It shall include, at least: - Spacecraft environmental test plan: overall qualification logic, static, sine and acoustic tests, approach for shock, description of the models and assessment on their representativeness, tests configuration, etc. [The Customer will have to provide the tests reports at a later step in the course of the launch preparation. Refer to Appendix 2 for a summary of the documents and models to be provided in the course of the mission preparation.]

A1.3. MISSION CHARACTERISTICS

A1.3.1 Orbit description

Indicate targeted 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)
Type of orbit	*Please select: SSO, inclined LEO, equatorial LEO*	
Local Time of Ascending Node – LTAN (for SSO)	*__ h __ min __ s*	
Altitude	______ ±______ km	__________ km
Inclination i	______ ±______ deg	_________ deg
Eccentricity e	______ ±______	__________
Argument of perigee ω	______ ±______ deg	_________ deg

A.1.3.2 Launch time/window

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

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

A1.3.3 Flight and spacecraft separation conditions

A1.3.3.1 Spacecraft separation conditions

- **Separation mode and conditions**

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

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

- **Separation attitude**

Indicate required orientation at separation.

The 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 injection time, as defined below:

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

For circular or nearly circular orbits, the orientation at separation should be specified with respect to the [U, V, W] inertial reference frame related to the orbit at spacecraft separation time. The U and V axes are then defined as follow:

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.

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

A1.3.3.2 Attitude during ascent phase, prior to spacecraft separation

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

A1.3.3.3 Other conditions

If any, indicate any other spacecraft limitations including:

- *maximum acceptable aerothermal flux,*
- *any flight duration limitation,*
- *any constraints for ground station visibility,*
- *etc.*

A1.3.4 Sequence of events after spacecraft separation

Describe the sequence of events after the spacecraft separation from the launcher, including:

- *on-board computer switch-on,*
- *telemetry emitters switch-on,*
- *propellant system priming,*
- *Attitude Control System switch-on,*
- *any deployments (solar generators, booms, etc.),*
- *etc.*

A1.4. SPACECRAFT DESCRIPTION

A1.4.1 Spacecraft systems of axes

Provide a description of the spacecraft system of axes with a sketch.

The axes are noted Xs, Ys, Zs and shall form a right-handed trihedron.

By convention, the origin of the axes (O) shall be the geometrical center of the mounting plane of the spacecraft.

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

A.1.4.2 Spacecraft geometry in the stowed configuration

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

Additionally, provide:

- *detailed drawings of the interface with adapter, including manufacturing tolerances;*
- *detailed dimensional data (including manufacturing tolerances, any MLI, electrical harness…) for the spacecraft's critical elements, that is the spacecraft's closest parts to the fairing, carrying structure and adapter: solar array panels, deployment mechanisms, etc.*

Spacecraft CAD reference	

Spacecraft dimensions	**Stowed configuration**		
	Along Xs	Along Ys	Along Zs
	___ mm	___ mm	___ mm

A.1.4.3 Spacecraft geometry in in-orbit configuration

Provide drawings in in-orbit configuration (with all antennas, solar arrays, and any other appendages deployed).

Spacecraft dimensions	**In-orbit configuration**		
	Along Xs	Along Ys	Along Zs
	___ mm	___ mm	___ mm

A1.4.4 Spacecraft mass properties

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

	Mass (kg)	**CoG coordinates (mm)**			**Coefficients of inertia matrix ($kg.m^2$)**					
	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

The above data shall correspond to the following definition:

- 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 case of spin separation mode, provide additionally:

- *Range of major/minor inertia ratio,*
- *Dynamic out of balance.*

A1.4.5 Fundamental modes

Indicate fundamental modes of spacecraft:

Fundamental modes	S/C (Hz)	Specification (Hz)
Xs axis	____	≥ 12
Ys axis	____	≥ 12
Zs axis	____	≥ 20

A1.4.6 Propellant/pressurant characteristics

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		Xs		
of propellant		Ys		
loaded tank		Zs		
Slosh model under 0 g	Pendulum mass	(kg)		
	Pendulum length	(m)		
	Pendulum	Xs		
	attachment	Ys		
	point	Zs		
	Fixed mass (if any)			
	Fixed mass	Xs		
	attachment	Ys		
	point (if any)	Zs		
	Natural frequency of fundamental sloshing mode (Hz)			
Slosh model under 1 g	Pendulum mass	(kg)		
	Pendulum length	(m)		
	Pendulum	Xs		
	attachment	Ys		
	point	Zs		
	Fixed mass (if any)			
	Fixed mass	Xs		
	attachment	Ys		
	point (if any)	Zs		
	Natural frequency of fundamental sloshing mode (Hz)			

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

A1.4.7 Mechanical interfaces

- **Interface geometry**:

Provide a drawing with detailed dimensions and nominal tolerances showing:

- *The spacecraft interface ring;*
- *The area allocated for spring actuators and pushers;*
- *The area allocated for microswitches;*
- *Umbilical connector locations and supports;*
- *Any equipment in vicinity of the separation clamp-band (thrusters, antennas, MLI, etc.).*

- **Interface material description**:

For each spacecraft mating surface in contact with the launcher adapter and the clamp-band, indicate material, roughness, flatness, surface coating, rigidity (frame only), inertia and surface (frame only) and grounding.

A1.4.8 Electrical interfaces

Provide the following:

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

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

- The umbilical links status at umbilical connector extraction, at LO (preferably in an electronic file, Microsoft Excel format):

S/C connector pin allocation number	Function	Max voltage at LO (V)	Max current at LO (mA)	Remarks
1 2 3 …				

- Any demand for links during flight (optional services).

A1.4.9 Radioelectrical interfaces

A1.4.9.1 Spacecraft telecommunication sub-system(s) general description

Provide the spacecraft telecommunication system(s) main characteristics:

- *description of spacecraft 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).*

A1.4.9.2 Spacecraft telemetry (TM) and telecommand (TC) systems

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

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								

A1.4.9.3 Radio link on ground & Transmission plan

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	TBD		TBD	
Countdown before LO	TBD		TBD	
After LO until 20s after separation*	OFF		OFF	
In orbit (or in transfer orbit)	TBD		TBD	

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

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

A1.4.9.4. Spacecraft ground station network

Provide the list of ground stations to be used for spacecraft acquisition and early operations after spacecraft separation from the launcher.

Ground stations	#1	…
Station name		
Localization (Town / Country)		

A1.4.10. Other spacecraft characteristics

Provide any other spacecraft 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, spacecraft electrical field susceptibility levels and spacecraft sensitivity to magnetic fields.*

A1.5 OPERATIONAL REQUIREMENTS

A1.5.1 Provisional range operations schedule

Provide the Spacecraft Operations Plan or the list of main operations, with description and estimated timing.

Identify all hazardous operations.

A1.5.2 Facility requirements

For each facility used 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, current, # phases, frequency, category);*
- *RF and hardline requirements;*
- *Support equipment requirements;*
- *GSE and hazardous items storage requirements.*

A1.5.3 Communication needs

For each facility used for spacecraft preparation (PPF, HPF) provide communication needs (office communications and operational communication).

A1.5.4 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);*
- *A definition of the spacecraft container and associated handling device (constraints);*
- *A definition of the spacecraft lifting device;*
- *In case the adapter is provided by the customer, a definition of adapter interface;*
- *A definition of spacecraft GSE (dimensions and interfaces required);*
- *Dispatching list.*

A1.5.5 Others

A1.5.5.1 List of fluids

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

A1.5.5.2. Chemical and physical analysis to be performed on the range

Indicate for each analysis: type and specification.

A1.5.5.3. Safety garments needed for propellants loading

Indicate number.

A1.5.5.4. Security requirements

If any, provide specific security requirements.

A1.5.6. 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 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 at 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

A1.6 SAFETY ASPECTS

A1.6.1. Spacecraft hazardous systems and operations

Provide a list of:

- *the spacecraft hazardous system (propellant, electro-pyrotechnic devices, batteries, laser, ionizing sources, etc.);*
- *the intended hazardous activities for spacecraft preparation during spacecraft launch campaign at CSG (spacecraft handling, propellant loading, battery charging, deployment tests, etc.).*

A1.6.2. Safety submission

The Customer will be asked to provide Safety files for safety submissions, according to Payload Safety Handbook ref. 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 fueling equipment
AC1	Bipropellant propulsion system
AC2	Valve command and control circuit
AC3	Corresponding ground segment equipment and fueling 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
D2E	Ionizing radiation – Ground segment equipment
O	Documentation
GC	Miscellaneous

A1.7 MISCELLANEOUS

Provide any other specific requirements for the mission or spacecraft preparation.

STANDARD SERVICES DESCRIPTION Appendix 2

(Main provisions of the standard SOW)

Within the framework of the Launch Service Agreement (LSA), Avio as Launch Service Provider and Launch Operator conduct standard services.

This appendix presents the standard service, a synthesis of Avio technical commitments and of Customer commitments, the typical documentation and meetings, and the General Range Service (GRS) to support spacecraft operations during the launch campaign at CSG.

Other services, to cover any specific Customer's requirements, can be provided as options at the time of the LSA signature or ordered separately.

A2.1 AVIO TECHNICAL COMMITMENT

Avio provide the following Launch Services using the Vega C launch vehicle as described in the latest issue of the Vega C User's Manual:

- Overall Launch Services management
- Launch Vehicle hardware and software supply
- Systems Engineering
- Launch Vehicle Operations
- Support for **Customer** insurance coverage

A2.1.1 Launch Service management

Avio shall provide overall management for the Launch Services as described in the chapter 7 of the Vega C User's Manual. Avio's Mission Director (MD) will be the single point of contact between the Customer and Avio:

- General Contract Management: Contract amendments, payments, master schedule, planning, configuration control, action items and milestone monitoring, documentation, reviews, meetings, co-passenger management (if any), etc.
- Launch Vehicle Production including quality plan, specifications, hardware and software adaptations as needed, tests, acceptance…
- Mission Analysis
- Interface tests: Mechanical and electrical fit-check
- Launch Base Operations
- Ground and Flight Safety: Interface with CSG safety authorities (CNES) for safety submissions

A2.1.2 Launch Vehicle hardware and software supply

Avio supplies the hardware and software to carry out the Launch Vehicle mission, in compliance with mission/launcher requirements:

- Vega C Launch Vehicle
- Launch Vehicle propellants
- Fairing
- Spacecraft adapter/separation system
- Carrying system if any depending on the Payload Assembly Composite (PAC) configuration
- Mission logo: two identical stickers, size 1.6x1.6 m (artwork to be supplied by the Customer)
- Fairing radio-transparent window: available as an option
- Fairing access door: available as an option
- Flight program
- Spacecraft side adapter interface umbilical connectors (DEUTSCH)
- Ground electrical connectors (CANNON) for cables A and B manufacturing (cables used for combined electrical validation during fit-check and launch campaign operations)

A2.1.3 System Engineering

Avio provides the following system engineering:

- Interface management: Interface Control Document (DCI) configuration control
- Mission analyses: preliminary and final loops (final analysis is carried out in the final flight configuration): Trajectory, Performance and Injection accuracy analysis, Separation analysis (kinematics, clearance, collision avoidance), Dynamic Coupled Loads Analysis (MCLA), Electromagnetic and Radio-Frequency Compatibility Analysis, Thermal Analysis (TCLA, during final loop only)
- Support to spacecraft design compatibility verification: support for spacecraft environmental tests: review of the test plan, support during the spacecraft tests (sin, acoustic), review of the test results
- Post-flight analysis: observed orbit parameters and launch vehicle attitude at spacecraft separation, flight evaluation report

A2.1.4 Launch Vehicle Operations

Avio supplies the following services before and during the Launch Campaign:

- Launch Vehicle Operations
- Combined Operations: assembly, integration and checkout of spacecraft on Launch Vehicle flight structures (adapter, carrying system (if any), fairing…)
- Countdown rehearsal (at L-2 working days): operational rehearsal with participation of spacecraft(s) and Launch Vehicle, countdown sequence training with simulated flight sequence (activation of all Launch Base resources)
- Countdown execution: up to lift-off

A2.1.5 Support for Customer insurance coverage

Avio prepares and delivers technical documentation and/or presentations as a response to launch-system-related questions, which may be asked by insurance underwriters and/or brokers to the Customer as part of the process required to set up spacecraft insurance coverage.

A2.2 CUSTOMER TECHNICAL COMMITMENT

To allow Avio to timely prepare the launch, the Customer shall make available technical data, models and documentation, a comprehensive overview of the spacecraft development, integration and tests planning, and deliver the spacecraft and associated means in French Guiana as defined in the latest issue of the Vega C User's Manual.

At the Launch Base, the Customer and its subcontractors shall manage and perform all spacecraft activities related to the spacecraft preparation for launch.

The Customer's responsibility for documentation and meetings is described in § A2.3.

A2.2.1 Hardware supply

- Spacecraft
- Spacecraft Propellants: Customer is encouraged to bring at least one spare drum of each propellant
- Spacecraft Simulator or Breakout Box, representative of the spacecraft electrical systems in interface with the Launch System: Used for electrical validations during fit-check and launch campaign
- Mechanical and Electrical Ground Support Equipment, as necessary to operate the spacecraft on the Launch Base, including COTE (Check Out Terminal Equipment): two sets of ground harness (cables A & B) are recommended to connect the Customer's COTE to the spacecraft or spacecraft simulator during the electrical link validations.

A2.2.2 Schedule obligations

The **spacecraft** shall be made available to Avio for the combined operations, at the latest, **eight** (**8) working days** prior to the Launch (TBC depending on the Launch configuration). The applicable date will be defined in the Combined Operations Plan approved by the Customer.

The spacecraft **Check-Out equipment** (COTE) necessary to support the spacecraft/launch vehicle on-pad operations shall be made available to Avio, and validated, at the latest, **two (2) working days** prior to operational use according to the approved Combined Operations Plan.

After spacecraft transfer to the filling hall, the Payload Processing Facility (PPF) shall be evacuated of all Ground Support Equipment (GSE) within one (1) working day after departure of the spacecraft.

All spacecraft mechanical and electrical support equipment shall be removed from the various facilities, packed and made ready for return shipment. within three (3) working days after the launch.

A2.2.3 Spacecraft propellants and hazardous products

Spacecraft propellants shall be provided by the Customer and/or his subcontractors. The spacecraft propellants shall be delivered to the CSG at the earliest two (2) months before and at the latest two (2) weeks before the spacecraft launch campaign.

The Customer and its subcontractors are responsible for the transport of the propellants to French Guiana (Cayenne harbor) in compliance with the International Maritime Dangerous Goods (IMDG) rules. In particular, specific attention shall be paid to the proper labelling of propellant drums and transport containers, as well as to any certificate validity.

Disposal of hazardous products at CSG is not authorized and wastes must be repatriated by the Customer after the launch campaign. The residual propellants and hazardous products must be shipped back within one (1) month after the end of the spacecraft launch campaign.

A2.3 DOCUMENTATION AND MEETINGS

This chapter describes the list of typical documentation and meetings.

A2.3.1 Documentation

A2.3.1.1 Interface Requirements Document (IRD)

The Customer shall issue the Interface Requirements Document (IRD), which shall contain the spacecraft-to-launch-system interface requirements and all the information necessary for the correct execution of the launch services. The Customer can also use the Application to Use Vega C Launch Vehicle available in Appendix 1.

A2.3.1.2 Interface Control Document (DCI)

Avio will issue the Interface Control Document (DCI) between the spacecraft and the launch system. The DCI will be maintained under formal configuration control until the launch. As soon as approved by both Avio and the Customer, it will become the unique working document for all technical interfaces between the spacecraft and the launch system.

The DCI Issue 0, based on the IRD, will be released after the IRD review and prior the Preliminary Mission Analysis Kick-off meeting.

The DCI Issue 1, will be released just after the Preliminary Mission Analysis Review (PMAR).

The DCI Issue 2, will be released just after the Final Mission Analysis Review (FMAR).

A2.3.1.3 Systems Engineering Documentation

The Customer and Avio will issue input and output data related to the Mission, the Qualification and Acceptance process of the Spacecraft, Operations and Safety, respectively. These documents as described in tables below are intended to:

- Specify mission requirements;
- Demonstrate the compatibility of the Vega C mission with the Customer's requirements;
- Demonstrate the compatibility of the spacecraft with the Vega C ground and flight environment and specifications.

The documentation deliverables between Avio and the Customer are summarized in the following tables.

Except otherwise specified, "L" represents the first day of the latest agreed Launch Term, Launch Period, Launch Slot or Launch Day, as applicable (time is given in months). EDC is the Effective Date of Contract.

A2.3.1.4 Documentation, models and data to be provided by the Customer

The Customer shall deliver to Avio the documentation, models and data listed in the table hereunder. Models and reports shall be provided according to the applicable specification.

The delivery date can be modified according to the Customer's mission schedule and spacecraft development, manufacturing and tests planning.

#	Document	Date	Avio action❶
1	Spacecraft-to-launch-system Interface Requirements Document (IRD)	EDC+1	R
2	Spacecraft preliminary CAD model	EDC+1	R
3	Spacecraft dynamic model (preliminary)	EDC+1	R
4	Spacecraft mechanical environment test plan	EDC+1	A
5	Preliminary spacecraft Operations Plan (POS)	EDC+1	R
6	Spacecraft Safety Submission phases 1 and 2	EDC+1 to L-9	A
7	Spacecraft thermal model ❼	L-11	R
8	Spacecraft fragmentation model	L-11	R
9	Spacecraft dynamic model (final) ❼	L-10	R
10	Updated spacecraft data for final mission analysis ❼	L-10	R
11	Spacecraft operations procedures applicable at CSG & Safety Submission Phase 3	L-5	A
12	Final spacecraft campaign planning	L-5	R
13 **14**	Environmental tests: instrumentation plan, notching plan, test prediction for Sine test plan and for acoustic or random test	- ❷	A
15	Spacecraft final Launch Window	L-3	R
16	Spacecraft mechanical environment tests results	- ❸	A
17	Launch campaign containers & crates packing list	- ❹	R
18	Final spacecraft mass ❺	- ❻	R
19	Orbital tracking report (orbit parameters and attitude after separation)	L+2 weeks	I

❶ A ⇨ Approval; R ⇨ Review; I ⇨ Information

❷ One month before spacecraft tests

❸ One month after spacecraft tests

❹ At the latest two weeks before the start of the launch campaign

❺ Including spacecraft wet mass, spacecraft dry mass, propellant mass breakdown (if any)

❻ Before beginning of Combined Operations

❼ The Customer shall provide those models and data no later than the dates mentioned in the table.

A2.3.1.5 Documentation to be issued by Avio

Avio shall deliver to the Customer the documentation listed in the table hereunder.

#	Document	Date	*Customer action* ➊
1	Interface Control Document (DCI): Issue 0 Issue 1, rev 0 Issue 2, rev 0	 EDC+3 PMAR+1 FMAR+2 weeks	 R A A
2	Preliminary Mission Analysis summary	EDC+5.5	R
3	Preliminary Operations Meetings Documents	First Ops Mtg	R
4	Final Mission Analysis Documents (including Final CLA and Thermal Analysis report)	L-4.5	R
5	Overall Campaign Planning	L-4	R
6	Combined Operations Plan	L-4	A
7	Countdown sequence	L-4	R
8	Safety Statements: Phase 1 & 2 replies Phase 3 reply	 3 months after each submission To be closed during the launch campaign	 R R
9	Injection Data (orbital parameters and attitude data prior to separation)	30 min after separation	I
10	Launch Evaluation Document	➋	I

➊ A ⇨ Approval; R ⇨ Review; I ⇨ Information

➋ 1.5 months after Launch, or 1 month after receipt of the orbital tracking report from the Customer, whichever is later.

A2.3.2 Meetings

A2.3.2.1 Interface meetings

The Customer and Avio agree to meet as necessary to allow for good and timely execution of all activities related to the preparation of the launch.

The responsible managers of the Customer and Avio shall agree upon exact dates, locations, agendas and participation at least one week in advance.

A2.3.2.2 Launch vehicle reviews

In addition, the Customer will be invited to the following launch vehicle reviews:

- Launcher Flight Readiness Review (LFRR) prior to the start of the Launch Campaign: to authorize the start of the Launch Vehicle campaign;
- Integration Readiness Review (IRR) prior to the start of the Combined Operations: to authorize the start of the Combined Operations between the launch vehicle and the spacecraft;
- Launch Readiness Review (LRR) at D-1 before the launch: to authorize entering the finall countdown and to proceed with the launch;
- Immediate Post-Flight Review at D+1.

The complete review documentation will be handed out to the Customer at each of these reviews.

A typical content of the different reviews is described below. The description of the reviews below is not exhaustive and is susceptible to modification, after agreements between the Parties. Any changes to the contents or dates below listed will not require a change to the Statement Of Work (SOW).

#	Meeting	Date❶	Object❷	Place❸
1	**Contractual Kick-off Meeting**: Project management – Project milestones – Organization – Security & Confidentiality aspects – communications protocol	EDC+1	M-E	C
2	**IRD Review & Preliminary Mission Analysis Kick-off**: Presentation of the Vega C mission analysis computations and methods First review of the DCI Issue 0 Revision 0	EDC+1	M-E	P or M or T
3	**Preliminary Mission Analysis Review (PMAR)**: Presentation of preliminary analyses results DCI review	EDC+6	M-E-S	P or R
4	**DCI issue 1 signature**	EDC+7	M-E-S	T
5	**Preliminary Operations meeting / Site survey**: Review of the Spacecraft Operations Plan (POS) - Review of Spacecraft requirements wrt facilities (SPORT) - CSG support - Telecommunications network – Logistics – Safety submission phases 1 and 2 - Launch base & Launch pad facilities visit	L-11	M-O-S	K
6	**Security Review – if required**	L-10	M-O	K
7	**Final Mission Analysis Kick-Off**: Review and validation of all inputs necessary for the final studies DCI review	L-9	M-E	T

8	**Final Mission Analysis Review (FMAR):** Trajectory – Performance – Injection accuracy – Separation & Collision avoidance – Thermal, dynamic, EMC environment – Authorization to start the flight program production – Spacecraft qualification status DCI review	L-4	M-E	P
9	**DCI issue 2 signature**	L-3.5	M-E	T
10	**Final Campaign Preparation Meeting:** Campaign preparation status - Satellite Operations Plan (POS) - Interleaved Operations Plan (POI) - Combined Operations Plan (NT-190) - Electrical links check-out (NT-41) Safety submission status SPORT finalization and signature	L-3.5	M-O-S	P or T
11	**Communication & VIP Tour Preparation Meeting**	L-3	M	C or T
12	**Launcher Flight Readiness Review (LFRR):** Launch vehicle and launch system status Spacecraft status	L-2	M	P or R or T
13	**Range Configuration Review:** Review of the range facilities used for the spacecraft launch campaign at the start of the campaign	❹	M-O-S	K
14	**Integration Readiness Review (IRR):** Launch vehicle and launch system status Spacecraft status	❺	M-O-S	K
15	**Launch Readiness Review (LRR):** Launch vehicle, launch system and launch pad readiness status Spacecraft readiness status Launch range readiness status	L-1 day	M	K
16	**Financial Wrap-up meeting**	L-1 day	M	K
17	**Immediate Post flight review**	L+1 day	M	K

❶ Meeting target dates are given, taking into account the respective commitments of both parties for the delivery of the documentation as described above. Dates are given in months, relative to L, where L is the first day of the latest agreed Launch Term, Period, Slot or Day, as applicable. EDC is Effective Date of Contract.

❷ M ⇨ Management; E ⇨ Engineering; O ⇨ Operations; S ⇨ Safety

❸ P ⇨ Paris; R ⇨ Roma (Colleferro); K ⇨ Kourou; C ⇨ Customer Premises; M ⇨ Manufacturer Plant; T ⇨ Telecon

❹ To be held at the spacecraft team's arrival in Kourou

❺ To be held the day before the agreed day for starting the Combined Operations.

A2.4 GENERAL RANGE SUPPORT

The General Range Support provides the Customer, on a lump sum basis, with a number of standard services and standard quantities of fluids.

The standard duration for spacecraft standalone operations is **fifteen (15) working days** from the spacecraft's and associated equipment's arrival in French Guiana up to the spacecraft handover to Avio for the start of the Combined Operations.

Any request for additional services and/or supply of additional fluids exceeding the scope of the GRS can be accommodated, subject to negotiation between Avio and the Customer.

A2.4.1 Transport services

- Spacecraft & equipment transport from French Guiana Port-of-Entry (airport or harbor) to CSG and return:
  - Subject to advanced notice and performed nominally within normal CSG working hours (2 shifts of 8 hours per day, between 6 am and 10 pm from Monday to Friday). Availability outside normal working hours, Saturdays, Sundays, and public holidays subject to negotiations and agreement with the local authorities.
  - Limited to one spacecraft container and 12ft x 20ft pallets (or equivalent) in one shipment (airplane or boat).
- Spacecraft transport within CSG: CSG inter-site transport of the spacecraft can be either inside the spacecraft container or using one of the CNES/CSG Payload Container (CCU).
- Spacecraft's equipment transport within CSG.
- Payload Assembly Composite (PAC) transport, from EPC to Launch Pad.
- Logistics Support: Support for shipment and customs procedures for the spacecraft and its associated equipment.

A2.4.2 Payload preparation facilities

Facilities are dedicated to the Customer on the following basis:

Range operations	Normal working hours are based on two Shifts of 8 hours per day, between 6:00 am and 10:00 pm from Monday to Saturday. Work shifts out of normal working hours, Sunday or Public Holiday are possible, but subject to negotiations and agreement of Local Authorities (no shifts on Sunday and Public Holiday in hazardous zone).	
Facilities	Spacecraft Preparation (clean room) Filling Hall (if needed) Lab for check-out stations (LBC) Offices and meeting rooms	350 m^2 310 m^2 110 m^2 for 25 people
Access to the facilities	Restricted to authorized personnel only, permanently controlled by Range Security. Clean rooms are permanently monitored by a CCTV camera.	
Access outside normal working hours	Access to Offices and LBC beyond normal working hours is authorized. Access to clean rooms beyond normal working hours is authorized with the following restrictions: - Advanced notice - No range support provided - No hazardous operations or external hazardous constraints - No crane utilization - No changes to the facilities configuration Details about those access restrictions will be provided at the Operations meetings.	
Schedule restrictions	Launch Campaign Duration Extension is possible, but is subject to negotiations. The evacuation of Ground Support Equipment (GSE) from the clean room shall be completed within one working day after departure of the spacecraft from the facility. Spacecraft Ground Support Equipment must be packed and removed from the facilities within maximum three working days after the launch. The transfer of the spacecraft and its associated equipment to the spacecraft filling facilities, if propellant loading is needed, shall not be performed earlier than two weeks before the Combined Operations start.	
Uninterruptible Power Supply (UPS)	LBC HPF Launch Pad	≤ 30 kVA ≤ 20 kVA ≤ 20 kVA
Calibration equipment	As necessary	
Storage	Any storage of equipment during the launch campaign Propellant drums storage	

A2.4.3 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).

A2.4.3.1 Office communications

Service	Type	Remarks
Ethernet	CAIMAN network, 100 Mbps	Office IP and operational network, dedicated and secured VLAN, plug type RJ45
Internet access	VDSL or SDSL	Four points of access with associated routers
CSG Telephone	CSG internal and external communication	Personal access code available
Wi-Fi		
Video conference	Shared with other users	

A2.4.3.2 Operational communications

Service	Type	Remarks
Ethernet	CAIMAN network, 100 Mbps	Office IP and operational network, dedicated and secured VLAN, plug type RJ45
Bare fibers	Direct point-to-point optical fiber link	Two bare fibers
Umbilical link	Copper lines	72 lines from spacecraft umbilicals to EGSE
Reference time synchronization	IRIG-B protocol	
Closed-Circuit TV		
CSG telephone	Point-to-point telephone	
Intercom system		Two loops
Beep/pager system		Four beepers

A2.5 ANALYSES

Service	Type	Remarks
Chemical analyses	Propellant except xenon	Available as an option
	Gas & fluids particles	Available as an option
	Clean room organic deposit	Continuous, one weekly report
Particle count	Clean room monitoring	Continuous, one weekly report

A2.6 OPERATIONS

Service	Type	Remarks
Spacecraft weighing	Weighing performed by CSG (equipment and personnel) Calibrated weights	Available as an option
Adapter fit-check	Mechanical and / or electrical	Included as a standard upon spacecraft arrival at CSG, if not performed prior to the launch campaign

A2.7 FLUID DELIVERIES

Fluid	Type	Quantity
GN2	N50 dedicated local network and/or B50 bottles	Available at 190 bar
GHe	N55 dedicated local network	Available at 200 bar
LN2	N30, local production	
IPA	MOS-SELECTIPUR	
Water	Demineralized	
Oxygenated water	H_2O_2	

A2.8 OTHER SERVICES

Video transmission	Complimentary live broadcast of the launch in Europe or U.S.A. with: • Live feed of the launch, including views of the Jupiter control room, launcher on the pad and the launch itself; • Voiceover commentary in English. Other location or any additional awareness raising services can be proposed as option.

A2.9 FREE-LANCE SERVICES

Service	Type
Customer and spacecraft contractor assistance	For booking Kourou hotels or other housing, rental cars, personnel & luggage transport from/to Felix Eboué international airport, flight reservations, banking, etc, through Free-Lance Services support. Optionally, Free-Lance can offer support for launch campaign team leisure activities.

DETAILED MECHANICAL INTERFACE REQUIREMENTS

Appendix 3a

VAMPIRE 1194

SINGLE LAUNCH CONFIGURATION

In this configuration, the Payload Composite Assembly is composed of:

- The main Passenger;
- Its VAMPIRE 1194 adapter;
- The fairing.

The VAMPIRE 1194 adapter (structure, low-shock clamp-band device and ejection system) is developed and manufactured by Beyond Gravity.

This appendix provides the mechanical interface requirements applicable to the main passenger with Ø 1194 mm interface to be integrated on a VAMPIRE 1194.

For single launch configuration (one main passenger), the standard adapter is the VAMPIRE 1194 with a low-shock 1194 clamp-band.

The VAMPIRE 1194 is mainly composed of:

- A structure;
- A clamping device;
- An ejection subsystem;
- A membrane.

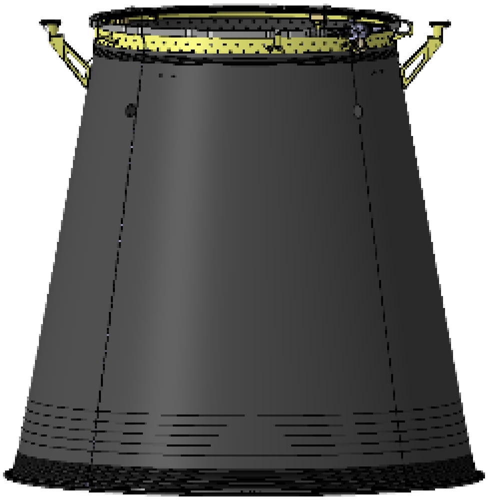
The VAMPIRE 1194 structure comprises the following main parts:

- Conical shell:

  It is a monolithic structure of CFRP, made on Fiber Placement technology, with an integrated upper and lower flange. The lower interface at 1920 mm provides the interface with the interface ring on top of the AVUM+ upper stage, where the fairing is also mated. The assembly between the adapter and the launch vehicle is achieved through a bolt interface composed of 144 holes ØM8.

- Upper ring:

  This ring is the direct interface with the payload. The assembly between the adapter and the payload is achieved through a clamp-ring separation system.



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 Clamp Band Opening Device (CBOD) pyrotechnically initiated. The CBOD is specially designed to generate low shock levels. Finally, a set of catchers secures safe behavior and parks the clamp-band on the adapter.

The VAMPIRE 1194 is designed and qualified to support a payload of 2 500 kg centered at 2.0 m from the separation plane.

The clamp-band maximal tension that can be reached is 49.9 kN.

The spacecraft is forced away from the launch vehicle by 4 to 12 actuators.

The force exerted on the spacecraft by each spring does not exceed 1 500 N.

The constraints for the positioning of separation springs and umbilical connectors are as follows:

- 4 to 12 separation springs equally spaced on ∅ 1161 mm;
- 2 umbilical connectors located on ∅ 1578.25 mm, 180° apart.

The maximum mass of the complete VAMPIRE 1194 adapter system (including Remote Telemetry Unit RTU-5) is 113 kg.

The adapter is equipped with a set of sensors that are designed to monitor the spacecraft environment. It also holds the electrical harnesses necessary for spacecraft umbilical links, for spacecraft separation commands and telemetry data transmission. The umbilical harness will be tailored to user needs (refer to § 5.5).

The angular positioning of the spacecraft with respect to the adapter is ensured by the alignment of engraved marks on the interfacing frames at a specified location to be agreed with the user.

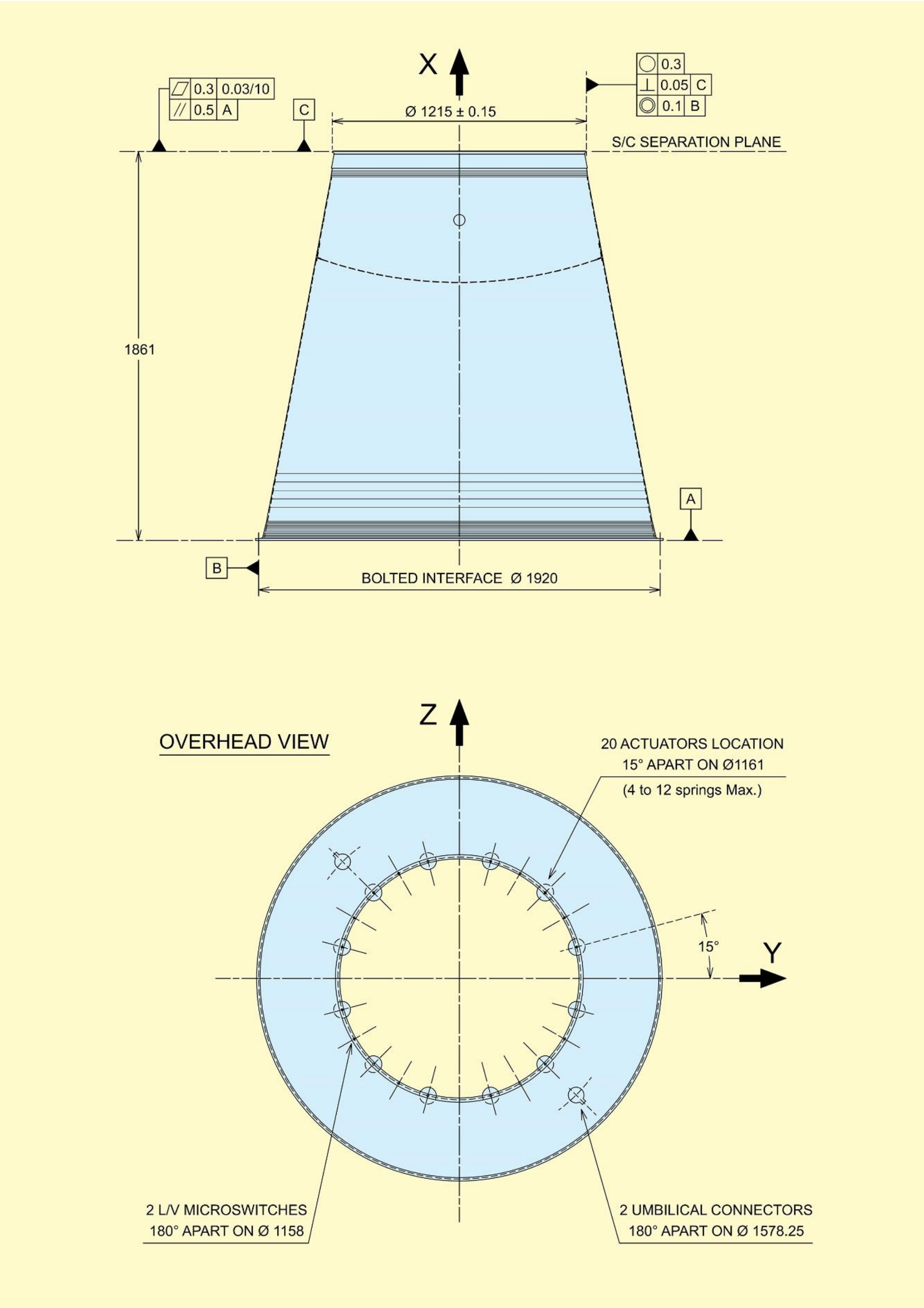
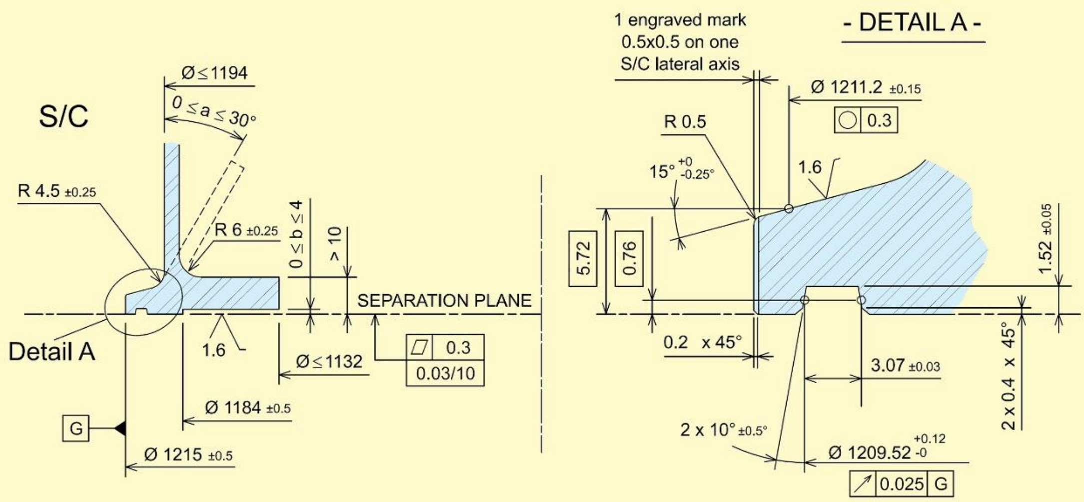
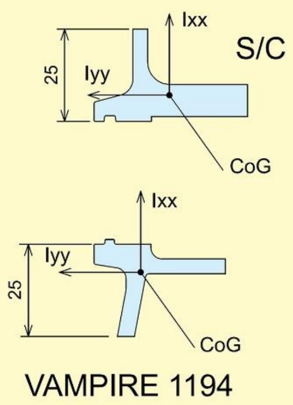


Figure A3a.1.a – VAMPIRE 1194 – General view





	VAMPIRE 1194 Upper frame	S/C Rear frame
MATERIAL	7075 T 7451	Aluminum alloy
COATING For surfaces in contact between S/C and ACU frames	ALODINE 1200	See 5.5.4.1
For others surfaces	ALODINE 1200	Chromic acid anodizing
STIFFNESS		
Applicable length mm :	25	25
Section area mm^2 :	274	230 < S < 550
Inertia Ixx mm^4 :	20517	12000 < Ixx < 65000
Iyy mm^4 :	10818	7500 < Iyy < 25000

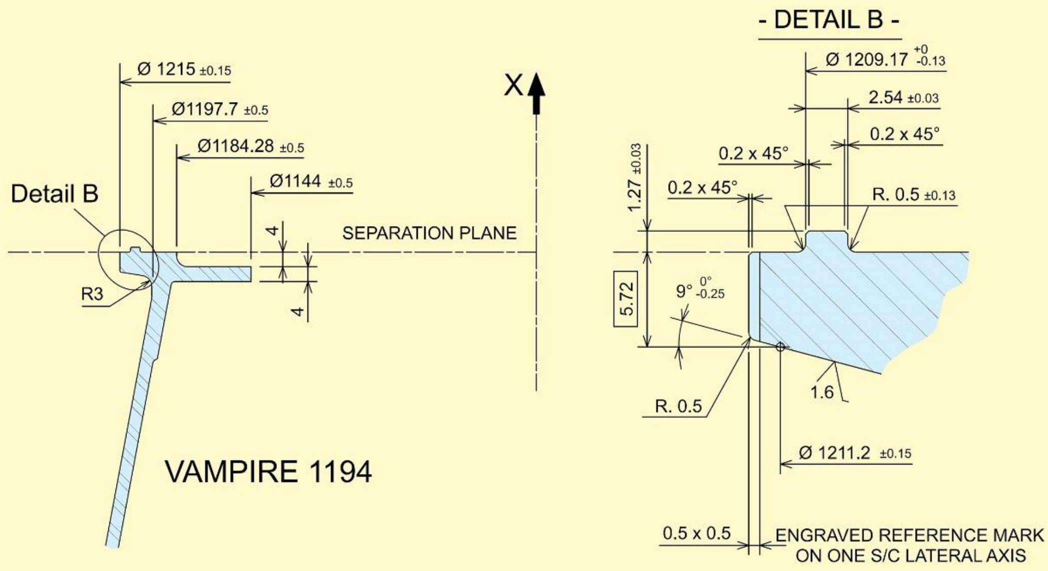


Figure A3a.1.b – VAMPIRE 1194 – Interface frames

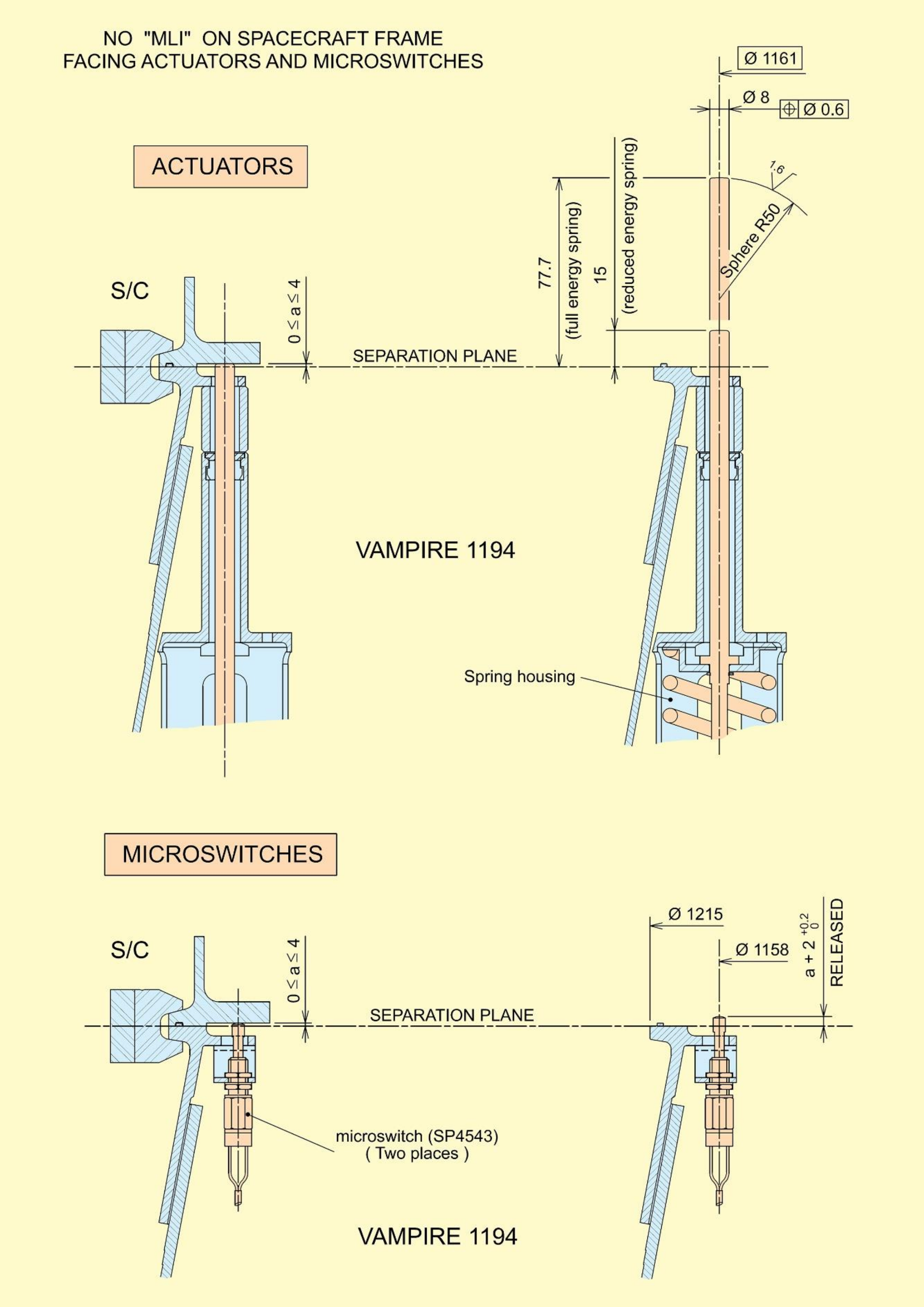


Figure A3a.1.c – VAMPIRE 1194 – Actuators and microswitches

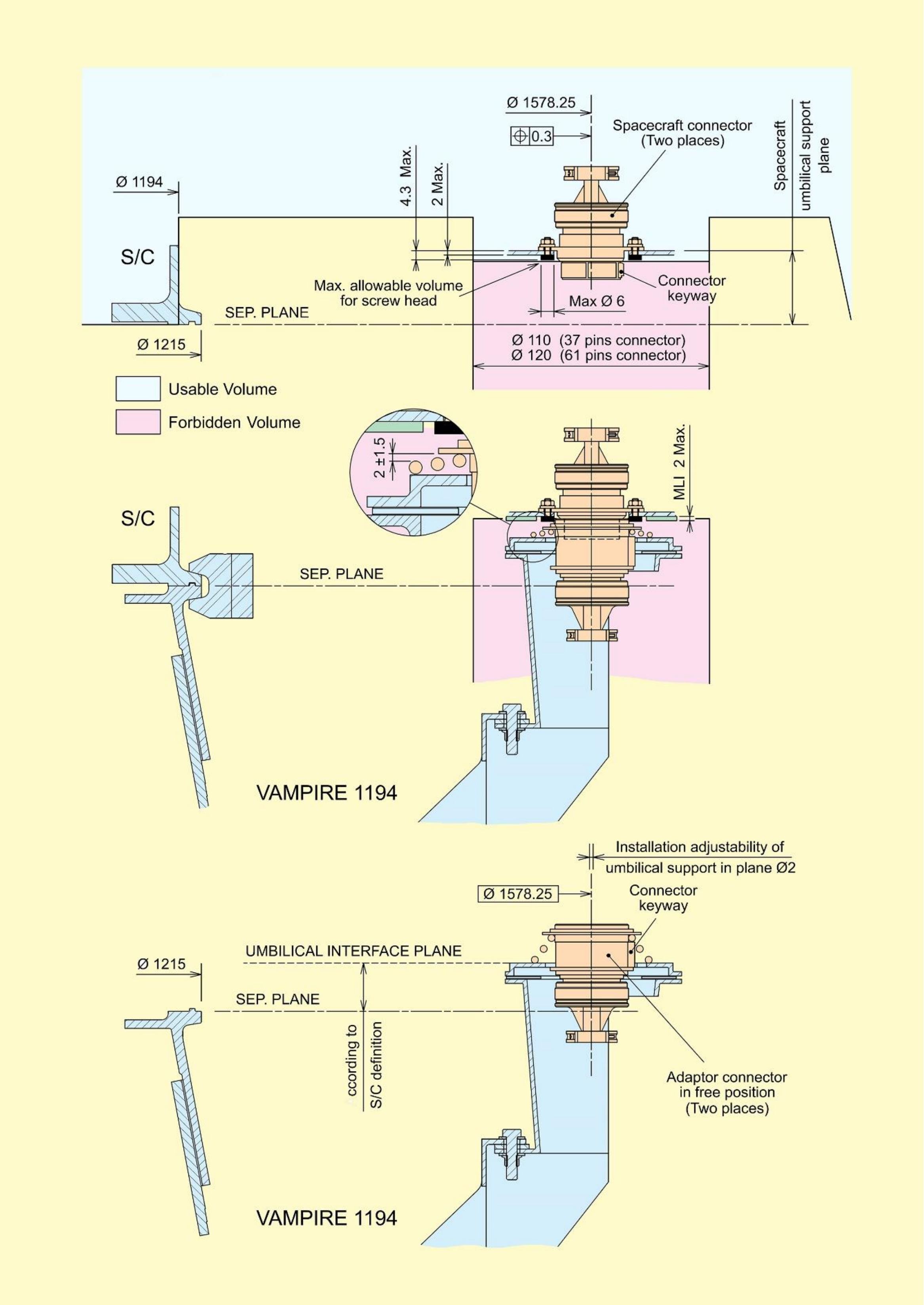


Figure A3a.1.d – VAMPIRE 1194 – Umbilical connectors

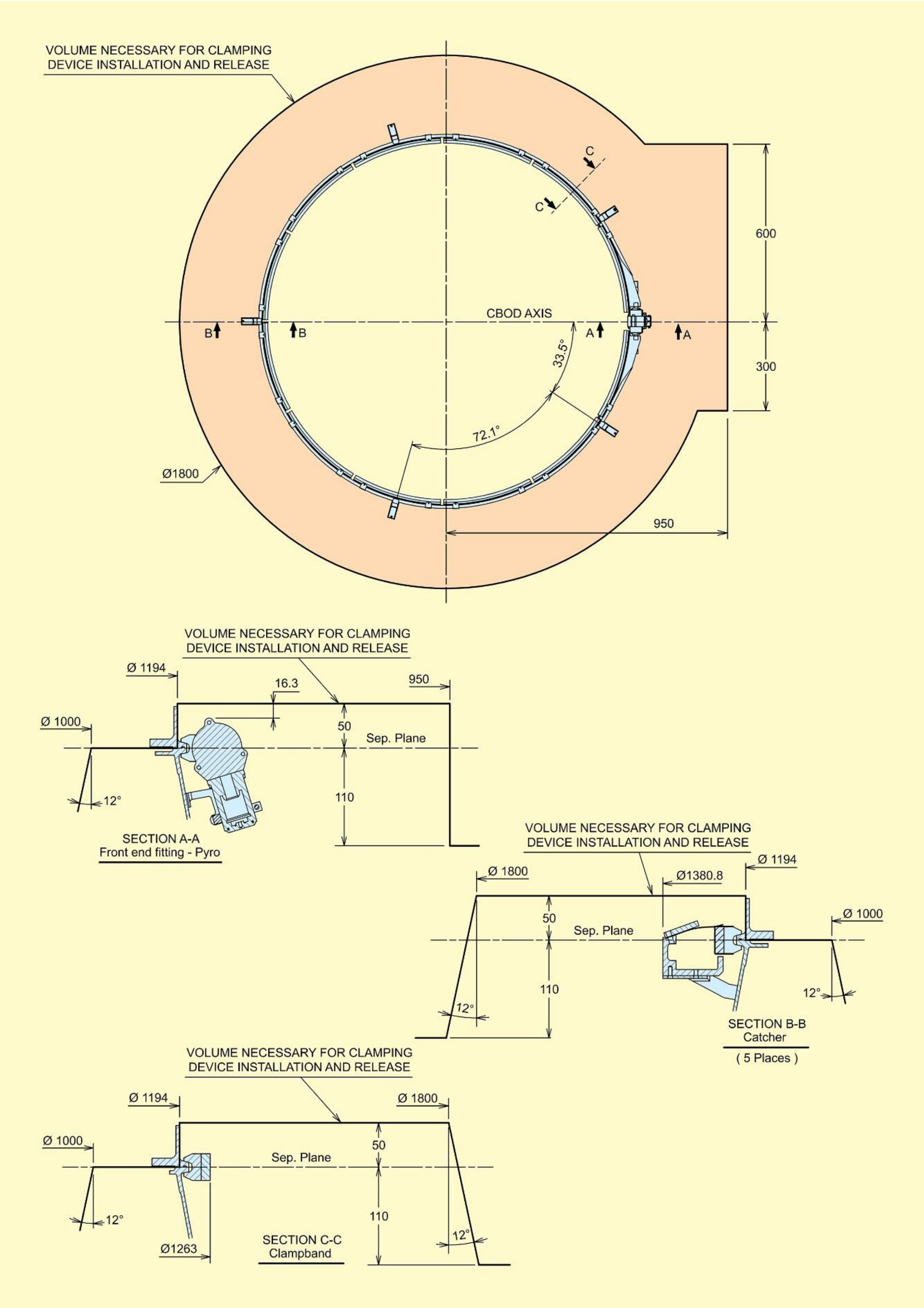


Figure A3a.1.e – VAMPIRE 1194 – Clamping device interface

DETAILED MECHANICAL INTERFACE REQUIREMENTS — Appendix 3b

INTERFACE RING 1194 (IR 1194) with HEX-1 module

SINGLE LAUNCH CONFIGURATION WITH AUXILIARY PASSENGERS

In this configuration, the Payload Composite Assembly is composed of:

- The main passenger;
- Its IR 1194 adapter;
- The HEX-1 module (with auxiliary passengers attached on the six faces);
- A conical VAMPIRE structure (with its membrane);
- The fairing.

This IR 1194 structure and the HEX-1 carrying system are developed and manufactured by S.A.B. Aerospace, while the conical VAMPIRE structure is developed and manufactured by Beyond Gravity.

The low-shock 1194 clamp-band device and the ejection system are provided by Beyond Gravity.

This appendix provides the mechanical interface requirements applicable to the main passenger with Ø 1194 mm interface to be integrated on an IR 1194.

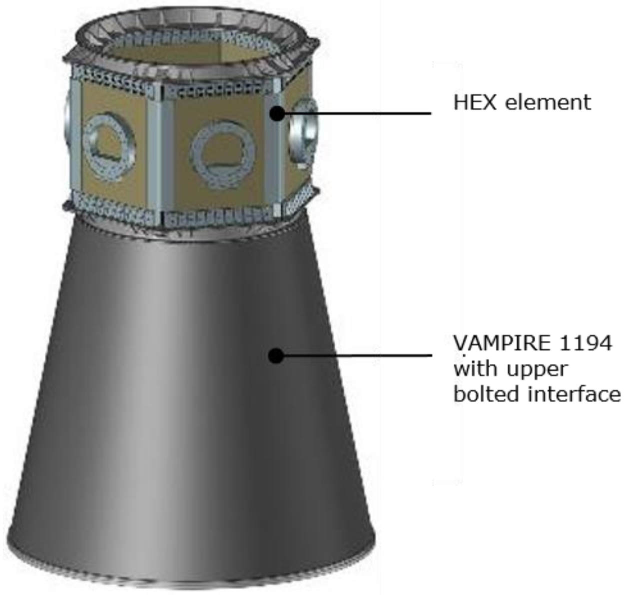
All the mechanical interface requirements are identical to the requirements for a single launch configuration with a VAMPIRE 1194 (refer to appendix 3a) **except for the location diameter of the ejection pushers**.

[NB: Refer to the SSMS Vega C User's Manual for the interface specifications applicable to the auxiliary passengers.

For single launch configuration with auxiliary passengers accommodated on an HEX-1 module, the standard adapter for the Main Passenger is the Interface Ring 1194 (IR 1194).

The IR 1194 is mainly composed of:

- A structure bolted to the upper HEX-1 upper flange;
- A 1194 clamping device;
- An ejection subsystem.



The HEX-1 element is composed of an aluminum lower interface ring, six sandwich panels, connecting brackets and an aluminum upper ring. Six positions are available to accommodate up to 6 very small spacecraft (mass < 70 kg) or up to 12 cubesats deployers.

The conical VAMPIRE structure is similar to the VAMPIRE 1194, but with upper ∅ 1226 mm bolted interface.

The IR 1194 and HEX-1 structures are designed and qualified to support a main spacecraft up to 1 500 kg centered at 1.5 m from the separation plane, and 6 auxiliary passengers up to 70 kg each.

The IR 1194 clamp-band maximal tension that can be reached for the main spacecraft is 49.9 kN.

The spacecraft is forced away from the launch vehicle by 4 to 12 actuators, bearing on supports fixed to the spacecraft rear frame.

The force exerted on the spacecraft by each spring does not exceed 1 470 N.

The constraints for the positioning of separation springs and umbilical connectors are as follows:

- 4 to 12 separation springs equally spaced on ∅ 1140 mm;
- Two umbilical connectors located on ∅ 1578.25 mm, 180° apart.

The maximum mass of the IR 1194 and HEX-1 assembly is 210 kg and the maximum mass of the conical VAMPIRE system (including Remote Telemetry Unit RTU-5) with upper ∅ 1226 mm bolted interface is 100 kg.

The carrying structures are equipped with a set of sensors that are designed to monitor the spacecraft environment and with the electrical harnesses necessary for spacecraft umbilical links, spacecraft separation commands and telemetry data transmission.

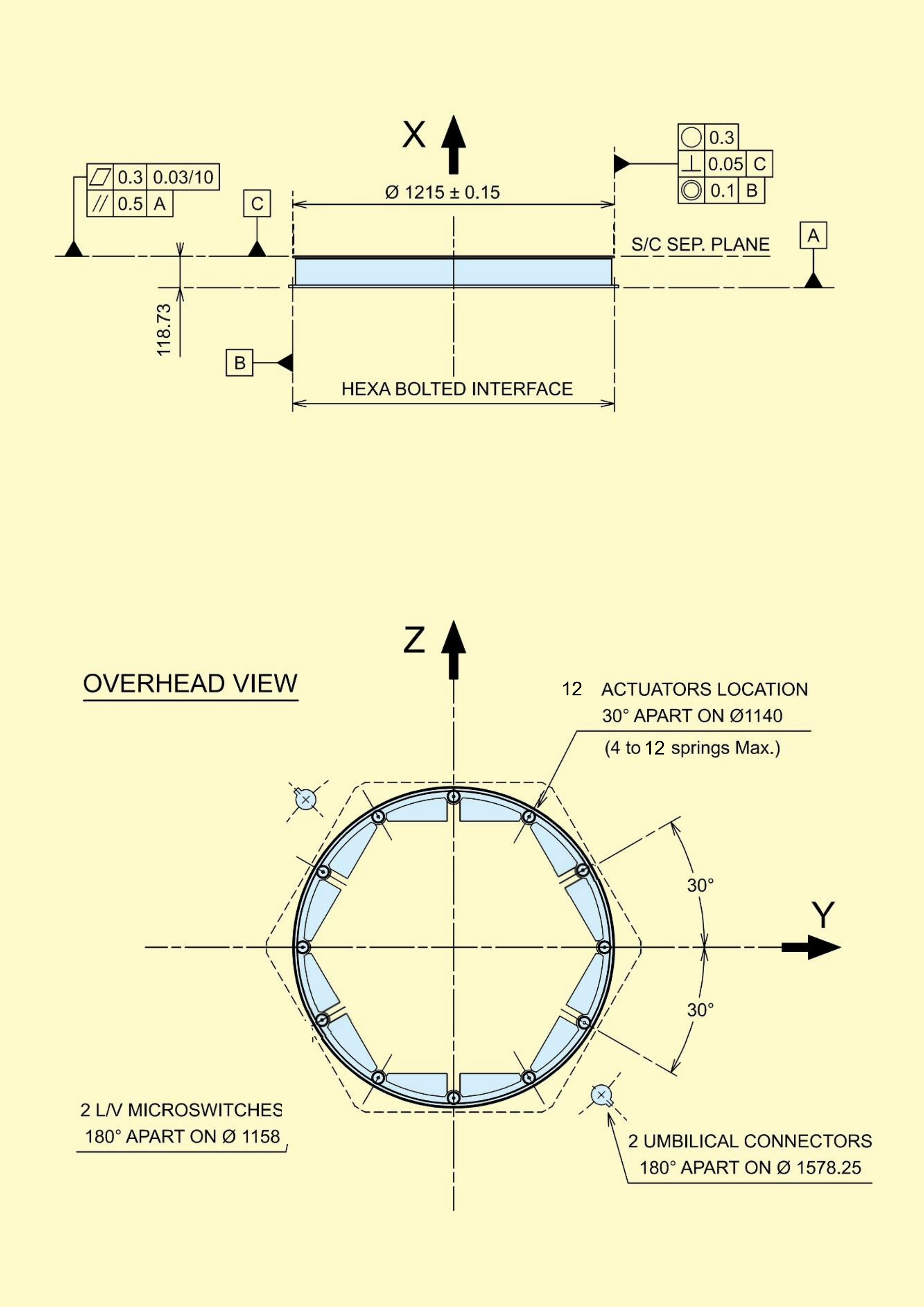
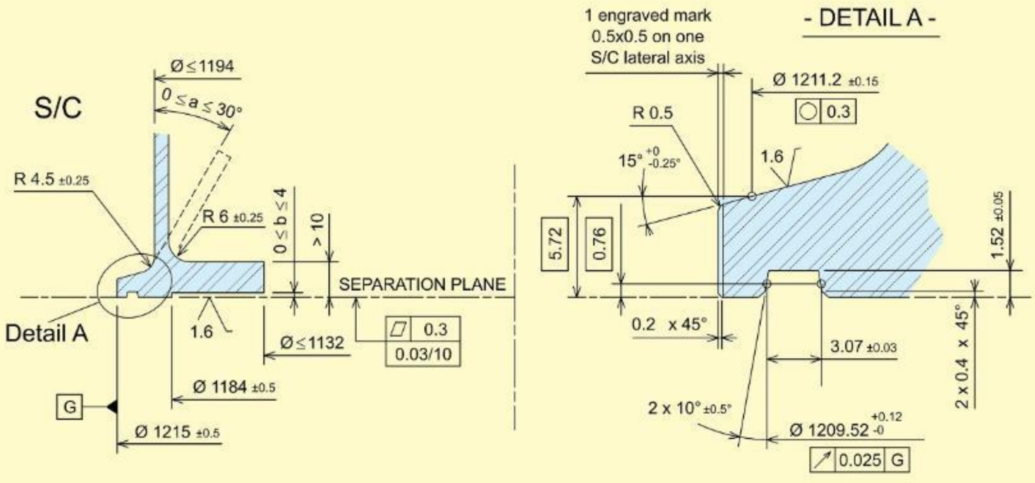
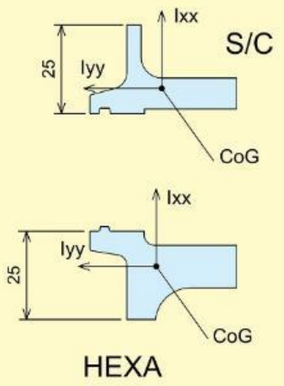


Figure A3b.1.a – IR 1194 – Upper position – General view





	HEXA Upper frame	S/C Rear frame
MATERIAL	AL6082 T6	Aluminum alloy
COATING For surfaces in contact between S/C and HEXA frames	ALODINE 1200	See 5.5.4.1
For others surfaces	ALODINE 1200	Chromic acid anodizing
STIFFNESS Applicable length mm : Section area mm^2 : Inertia Ixx mm^4 : Iyy mm^4 :	 25 389 304646 (TBC) 22086	 25 230 < S < 550 12000 < Ixx < 65000 7500 < Iyy < 25000

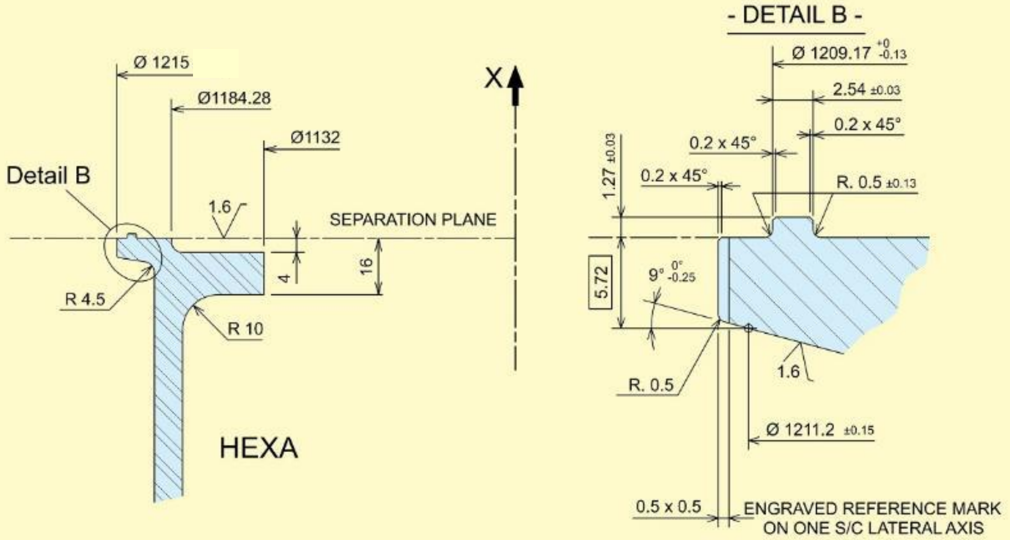


Figure A3b.1.b – IR 1194 – Upper position – Interface frames

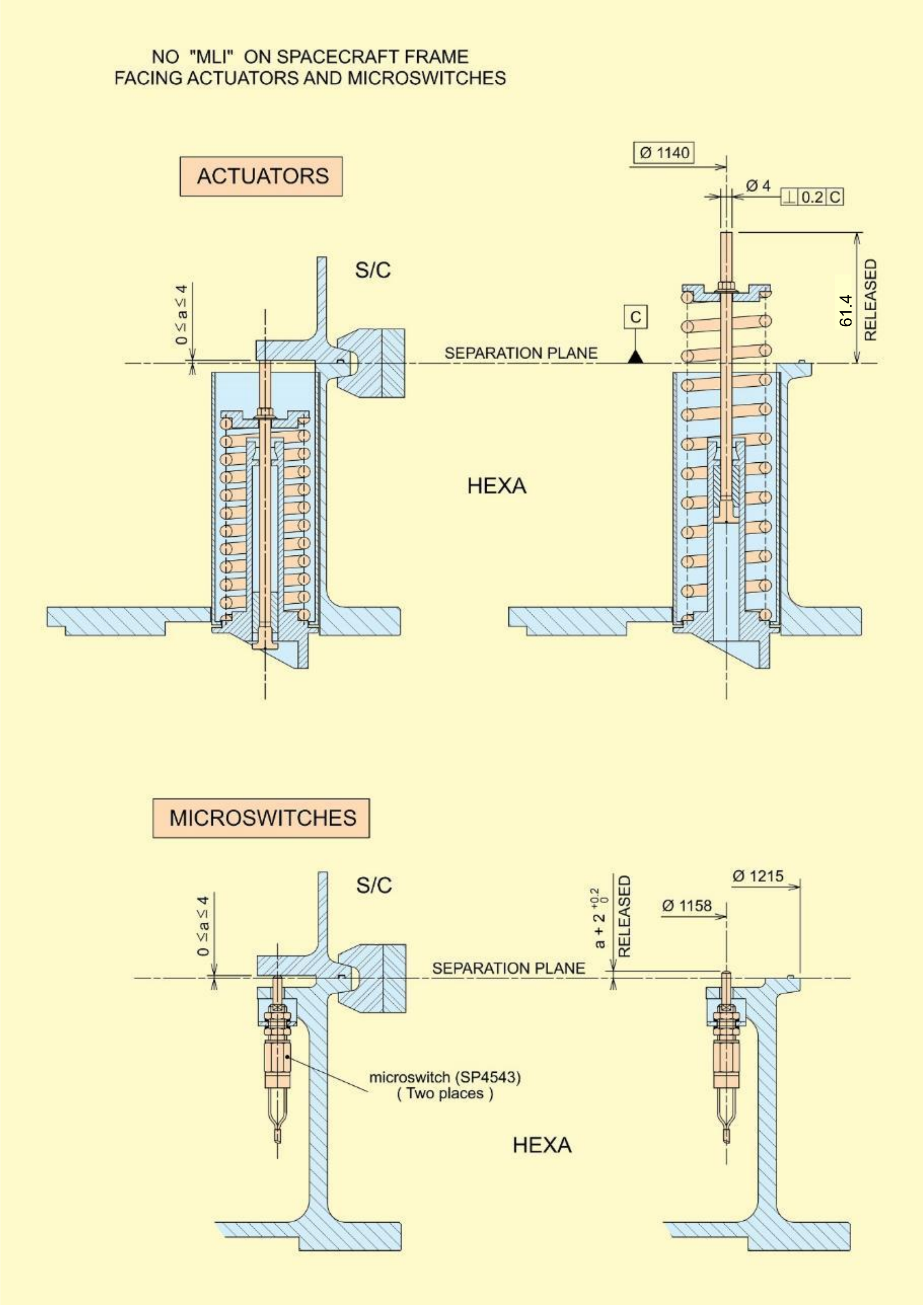


Figure A3b.1.c – IR 1194 – Upper position – Actuators and microswitches

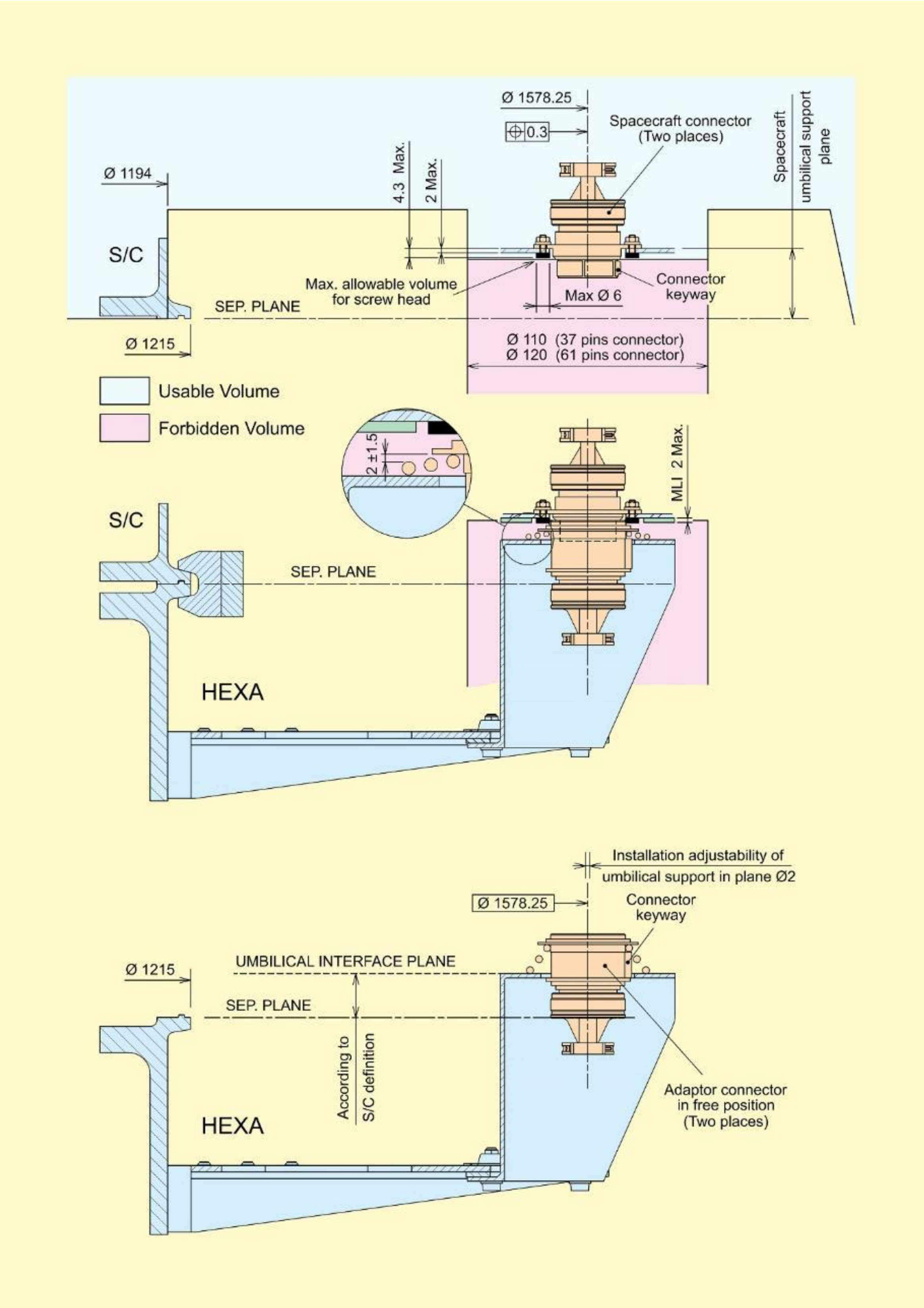


Figure A3b.1.d – IR 1194 – Upper position – Umbilical connectors

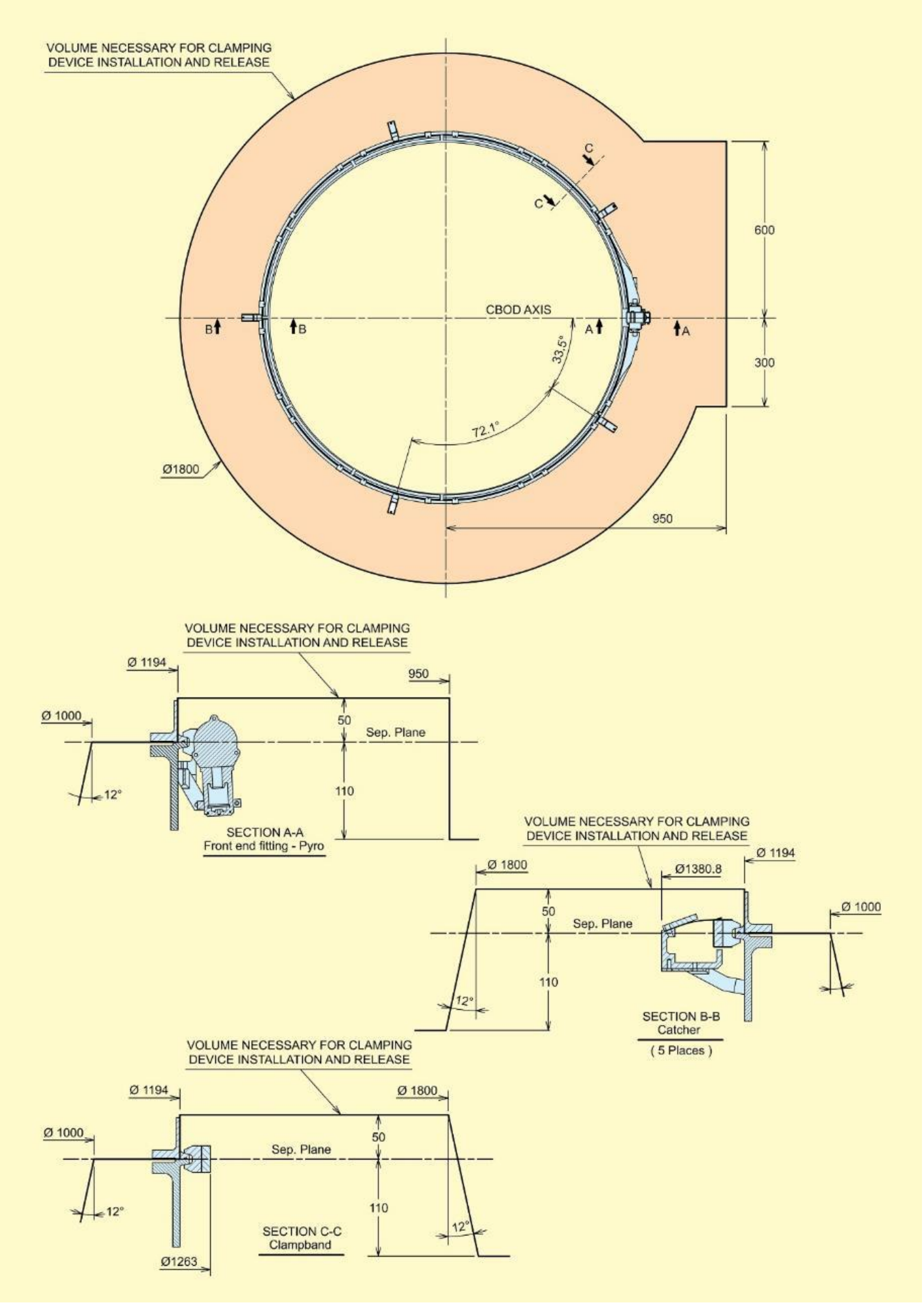


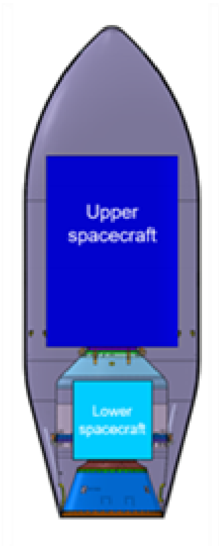
Figure A3b.1.e – IR 1194 – Upper position – Clamping device interface

DETAILED MECHANICAL INTERFACE REQUIREMENTS

Appendix 3c

ACTIVE RING 1194 (AR 1194) on VESPA+R dual launch carrying system

DUAL LAUNCH CONFIGURATION – UPPER PASSENGER



In this configuration, the Payload Composite Assembly is composed of:

- The upper passenger;
- Its AR 1194 adapter;
- The VESPA+R carrying system (with smaller passengers at inner VESPA+R position);
- The fairing.

The AR 1194 adapter, including the low-shock LPSS 1194 clamp-band device and the ejection system, and the VESPA+R carrying system are developed and manufactured by Airbus DS Spain (ADSM).

This appendix provides the mechanical interface requirements applicable to the upper passenger with Ø 1194 mm interface to be integrated on an AR 1194.

All the mechanical interface requirements are identical to the requirements for a single launch configuration with a VAMPIRE 1194 (refer to appendix 3a) **except for the springs characteristics and positions**.

[NB: Refer to the SSMS Vega C User's Manual for the interface specifications applicable to the micro and/or mini satellites accommodated in inner position of the VESPA+R carrying structure.]

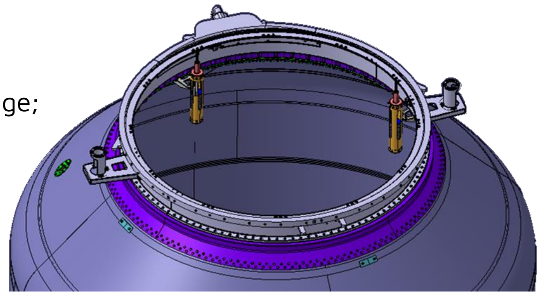
This carrying structure is qualified for ground and flight operations on the Vega C launch vehicle. It provides the interface with the satellites with low-shock separation system.

The carrying structure is equipped with a set of sensors that are designed to monitor the spacecraft environment. It also holds the electrical harness that is necessary for umbilical links as well as for separation orders and telemetry data transmission.

In dual launch configuration using the VESPA+R carrying system, the standard adapter for the upper passenger is the Active Ring 1194 (AR 1194).

The AR 1194 is mainly composed of:

- A structure bolted to the upper VESPA+R upper flange;
- A low-shock LPSS 1194 clamp-band;
- An ejection subsystem.



The VESPA+R carrying system is inherited from the VESPA+ carrying system which flew successfully several times on Vega. It allows to embark one large passenger in upper position, together with, in lower position, one mini satellite or a cluster of small spacecraft. It is mated on the AVUM+ upper stage. The VESPA+R 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 (Ø 1194 mm interface).

The separation of the upper part of the VESPA+R structure is achieved by means of a clamp-band with 4 up to 12 springs.

The AR 1194 and the VESPA+R carrying system is designed and qualified to support, in upper position, a passenger up to 1 700 kg centered at 2.2 m from the separation plane.

The clamp-band maximal tension that can be reached for the upper passenger (Ø 1194 mm interface) is 30 kN.

The spacecraft is forced away from the launch vehicle by 4 to 12 actuators.

The force exerted on the spacecraft by each spring does not exceed 590 N.

The constraints for the positioning of separation springs and umbilical connectors are as follows:

- 4 to 12 separation springs equally spaced on ∅ 1161 mm;
- 2 umbilical connectors located on ∅ 1578.25 mm, 180° apart.

The maximum mass of the AR 1194 is 25 kg, while the typical mass of a fully equipped VESPA+R carrying system (with upper and lower adapters and including Remote Telemetry Unit RTU-5) is between 340 and 450 kg depending on the inner and upper configuration.

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Table A3c.1.a – AR 1194-1226 – General view

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Figure A3c.1.b – AR1194-1226 – Interface frames

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Figure A3a.1.c – AR1194-1226 – Actuators and microswitches

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Figure A3a.1.d – AR1194-1226 – Umbilical connectors

T B D

Figure A3a.1.e – AR1194-1226 – Clamping device interface